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SPECIAL ISSUE: COMMUNICATION DESIGN FAILURES

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CELEBRATING FAILURE

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ABSTRACT

This introduction to the special issue Communication Design Failures questions why failure is so hidden in design. It suggests that much can be learned from reflection on failure in its many guises and that failure points to gaps in knowledge and process. Failures want remedies, whether through empirical research, trial and error or pragmatic adjustment of process. The articles within this issue point out functional pitfalls in communication and process strategies—all the articles are pragmatic.

You may well wonder why *Visible Language* is doing a special issue on Communication Design Failure—a special issue that will encompass not one but three issues. The call for papers must have struck a chord in the respondents as many fine papers were submitted. Communication design failure is often ignored or glossed over because it is entwined with many hard to disentangle variables. It is avoided or hidden as a face-saving strategy, or because it lacks definition and reflection on its causes. There is a saying that "you are only as good as your last project"—so designers just keep moving on. Failures are, of course, relative to the perspective one brings to the situation; they are not often total failures, but can be examined as symptomatic of design problems, oversights or change in the context of expectation and performance.

Long ago in graduate school, I (Sharon) took a course in perceptual psychology. The professor wryly observed that there was no journal of negative results, so experimental psychologists went down blind alleys that others had explored but been unable to share and communicate. Our tendency is to celebrate success and build upon it. But failure is a powerful learning opportunity—if we have courage, a reflective turn of mind and the time to explore what went wrong. It is in this spirit that we offer these issues of the journal.

"PROFESSIONAL" PERFORMANCE

Design typically engages in "professional" performance for three reasons: performance patterns are taught in school, clients often have no time or money for research or experimentation within a design genre and professional societies award incremental advancement in their competitions. These deserve a closer look. Success in design school is framed in terms of aesthetics, technique and project models from popular trade magazines. There is little adventure in education. Clients, who do not support research or deeper investigation, do not have time for failure; designers perform within the conventional framework of their situation. The professional performance that results is safe and pre-conceived—in this context innovation would be astounding; yet, innovation is increasingly desired by business and a population tired of unsolved, intractable problems. Competitions and awards mark success in a conservative way and they feed the trade magazines with performance patterns for school, practice and industry. The cycle from school to professional performance and award is closed to any serious exploration of failure.

In contrast to these factors, glorious failures are rare. In such a case, it is designers who take the risk and spend the time to connect with true learning that requires incubation, exploration and reflection on project development.

Predictable failure can be prevented, but the context in which design is performed is changing. Large and complex projects use a multi-disciplinary approach that engages a team of people with various perspectives. Stakeholders are now more commonly considered and they too have needs and expectations as a diverse group. User studies bring practical information about context and habits of use that may contradict perceived wisdom. Cross-cultural applications open unusual communication needs. Projects can metamorphose in mid-stream due to technological change, the emergence of a new competitor, an economic downturn or other unforeseen event.

FAILURE FUNCTIONS

Failure points to a gap in our understanding. The gap, if recognized, supports change and investigation with the expectation that the failure (whatever it may be) can be circumvented or overcome with new thinking. Another gap exists between research results and their application in design performance. This also requires reflection and sometimes trial and error, as design is a situated practice and research results can be overly general or specific and difficult to understand in a new or specific other context.

Design cannot rely on critics to point out failure as design is not much subject to such a perspective. Critics are usually outsiders with a passion for their subject, but they seldom have deep process knowledge or an ability to remedy the failure. Designers, as insiders, are better positioned to understand the variables that contribute to failure and they can imagine and even produce the remedy. We shortchange ourselves as a practicing community by ignoring failure.

PARADOXICAL SUCCESS

Success breeds failure. The previously mentioned professional recognition from awards that contribute to the conventions others follow (incremental small steps) support group think in a comfort zone. Success becomes bound by social conventions with the repetition of "success" in communication patterns becoming too expected, lacking the surprise that becomes attention getting and memorable. Artists and designers are subject to becoming trapped by their success; they are unable to move on as clients hire their successful style—their look or reputation. They are locked into a mental model with celebrity as a creative and intellectual dead-end.

Success is about the mainstream, but we are suggesting that it is peripheral ideas that might open new territory. Arthur Koestler's theory of bisociation (1964) comes to mind. In it he discusses the edge where two seemingly incompatible ideas rub together, creating a friction that supports a new insight. It can be interdisciplinary or very different perspectives on something. It is more risky than staying neatly in a special context, respecting the norm. The stages of success and failure are cyclic and not conclusive—they are risky. Failure or success can be in the eye of the beholder, particularly when various stakeholders enter the situation.

CONTEXT CHANGE

In education, an extremely reverent system insisting on nearly blind respect for the encrypted information held in libraries, culled and protected by gatekeepers, is being challenged as too slow. Until now, information was precious, valuable and not abundant. Digital technology has opened a floodgate of information. What is now scarce is attention. Pressured by time and the compression of space (see Harvey, 1990, for a cogent discussion of compression; see Appadurai, 1996, for a discussion of the complexities of globalization) access to information can become a burden because it is excessive. Now it is easier than ever to ignore failures and move on, avoiding recognition of mistake or miscalculation. But with this disappears opportunities for learning and developing new approaches or knowledge.

The communication design field has been rehearsed to function primarily within the traditional framework of advertising or institutional and corporate communication. Meanwhile, we increasingly recognize that there is not one disciplinary field without great need to solve specific communication problems; this opens multi-disciplinary collaboration (Poggenpohl and Sato, 2009). Design has an open invitation to participate on a much larger scale and within much broader categories. Designers should not be surprised that in entering the unknown they will also encounter failure, but that is not reason enough to avoid beginning the adventure.

Observations on failure or success are always tentative. The following articles share knowledge that is missing within the community of design practice. We seek to learn from each other, to support an investigation of failure and to develop an intellectual standing in design in relation to other disciplines. We are not speaking of design snobbery, but a legitimate standing based on understanding where we go wrong and where we are right. One thinks of the Eames (1982) *Powers of Ten* as an innovative successful outcome, based on integrated science and visual understanding that provided surprise; an aha moment. Or one thinks of *Visionary Architecture* (1999) as a celebration of idea.

Like other disciplines, design needs to share research, reflect on process and projects; codify its knowledge resources to become a resource for other designers and those in other fields. Recognition of failure breeds opportunities for future success.

The articles in this special issue can be examined through their character in portraying semantic, syntactic or pragmatic issues in design performance. None of the following articles stress syntax, but all examine the pragmatics of design process and a couple of them add semantic aspects from a user perspective. The pragmatic turn of attention in these articles may signal an understanding that doing design and expectations for design performance are changing.

In Michael Doherty's article, 'Realist' stakeholder analysis in design, he argues for the fundamental importance of identifying all stakeholders and their different perspectives, needs and expectations; such identification and analysis effects process and outcome of design. A generalized population of user or audience is no longer sufficient as design takes into consideration cultural difference and the extended network of association in which design takes place; from client to shareholder, to marketer, to distributor, to multi-disciplinary team member, to technical facilitator and so on. Design is the meeting ground for many participants; design itself is only one perspective among many.

Len Singer's article, Product communication form, failure and safety, underpins its discussion of failure with Edward T. Hall's anthropological theory and a sensitivity to user expectations in the examples that translate theory into specific and concrete situations.

In these examples form speaks, providing expectation that is not realized and its resulting confusion. While there has been some discussion of product semantics, its use generatively has often been unsatisfactory. Here, using the semantic perspective analytically, we see clearly the safety issues that slipped by the designers.

The trio of Carolyn Barnes, Simone Taffe and Lucy Miceli in their article, Multiple information failure: A case of different investments in form and content in graphic design, develop the need for clear and agreed to design process by all stakeholders with a particular emphasis on decision-making. The case is about changing to a 'green' implementation for cleaning procedures in childcare situations in Australia; it is about behavior change on the part of the childcare workers, and ultimately on the dismissal of what was learned from those whose behavior needed to change. Support for 'green' change, as pragmatically understood by the childcare workers, was ignored by hierarchical decision-makers, causing a lack of implementation. The article focuses on user study and its translation into design action that is thwarted by non-consultative decision-making.

Alex Roesler examines a critical and historic communication failure, that of Three Mile Island. While well documented and analyzed, the article looks at the dynamic nature of the system and the problem of operator understanding and intervention. He develops a time-line that shows how quickly the accident developed and the confusion and stress the operators had to deal with. In retrospect, the various signals lacked systematic coordination and hierarchy causing difficulty in decoding the event. An underlying problem was that possible causes of system failure were not thoroughly developed. Such a high-risk technical communication requires multiple perspectives to ensure problem recognition and remedial action to provide maximum safety for all.

Another trio, Joyce Yee, Matthew Lievesley and Louise Taylor discuss in their article, Recognizing risk-of-failure in communication design projects, an analytical process in which failure is anticipated and managed, then subject to a reflective post mortem. Because design is accomplished in a dynamic context in which understandings change and contingencies arise, anticipation and reflection on the changing situation is necessary. This pragmatic approach to risk management is reviewed in three case studies that demonstrate the variability of failure.

Stephen Brown's article, Paper prototypes and beyond, explores the tension between early, simple handmade prototypes and later digital ones. He identifies a gap in design development between these two that can cause problems. The case in which he explores this problem is development of a search strategy for an extensive, historical photographic database. He follows the project development and user experience with various prototypes identifying the gap that can cause false assumptions to be made in the early stages, derailing later decisions and driving up project costs. He concludes by suggesting a new tool.

Dietmar Winkler's article, Failure? Isn't it time to slay the Design-Dragon? expands on the pragmatics of design education traditions that are holding design development into more intellectual regions back. He identifies some of the fundamental presumptions and habits that impede an evolutionary future. Seminal historical events in design are noted, and other disciplines are consulted for their view of disciplinary evolution. An outspoken article, the author challenges design education to move past its conventional comfort zone, to step-up to the changing design performance context and to take a leadership role in design's future.

All these articles are pragmatic—like design itself. They emphasize that design is more than just aesthetics or technique—that the product of design is intellectual.

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AUTHOR NOTES

Sharon Poggenpohl is editor and publisher of this journal. With over twenty years experience in graduate design education at notable schools and universities, she now is focusing on writing. With a colleague, she has recently published a collection of international papers on design's present and future initiatives, *Design Integrations: Research and Collaboration* (Intellect Books, 2009).

Dietmar Winkler has decades of experience as a notable communication designer and design educator in the roles of professor, director and dean. His interdisciplinary interests have been to expand narrow traditional visual and form/function literacies to include user-based design in behavioral, social and cultural contexts.

‘REALIST’ STAKEHOLDER ANALYSIS IN DESIGN

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ABSTRACT

The term ‘stakeholder’ is now applied almost ubiquitously in Western society, often serving to provide legitimation for a multiplicity of agendas. For designers there are profound implications for ethical conduct attached to the veracity of stakeholder consultation from which major schemes are often born. Too often stakeholder analysis does not go far enough, restricted to accounts of the ‘self-evident’ or ‘presenting’ surface activity of individuals or groups. The paper develops a rationale for reflexivity in effective design research that remains alive to empirical realities, reflecting constantly upon the interplay between the actors in a particular stakeholder discourse. Objective stakeholder analysis is then discussed as a potential practical application of realist theory. This short paper makes a call for the evaluation of proposed design interventions based on a representation of stakeholders that recognizes the ‘inconvenient’ social realities as well as the purported technical rational arguments that, at the worst extreme, can be exploited as a tool to maintain hegemonic regimes.

On one level 'design' might be performed by anyone, anywhere and on a number of levels; decorating a Christmas tree or perhaps icing a cake.

This paper, however, is predicated upon an assumption that design at the 'professional' level is characterized, in part, by decision making on behalf of others which holds potentially significant consequences for individuals and (or) groups of individuals in (an increasingly global) society. Designers should be and in many cases will be, alert to the responsibilities vested in them by clients, consumers and a whole panoply of interest groups. Being aware of the need for inclusivity, democracy and social justice in design practice, while honorable, does not, however, amount to an instrument for ethical conduct. Here we suggest one possible approach to gaining a 'realist' perspective on the landscape for design which considers the concept of 'stakeholder analysis' as an instrument which holds the capacity to gain a true picture of the interest groups which might be affected by design intervention. We also suggest that stakeholder analysis can be used as a selective tool, consulting with particular groups in order to gain the necessary responses to provide apparent legitimacy for schemes constructed by those wishing to realize their own agendas.

The term stakeholder suggests an individual or group of individuals with something to win or lose in a transaction (in this case a design intervention). Some who fall into this category may be unaware that they are stakeholders, or tacit in the process of consultation, but nevertheless affected by its outcome. Realist research attempts to factor in the needs of these groups as well as recognizing the power agendas held by those who inhabit the 'locus of control.'

The term 'stakeholder' is now applied almost ubiquitously in Western society, often serving to provide legitimization for a multiplicity of agendas. While this short paper recognizes the important role which this social construct can play in attempting to satisfy the needs of a range of individuals and interest groups, I also consider the naïve, indeed, sometimes cynical exploitative use of the term for personal or organizational gain.

It is asserted here that stakeholder consultation can be selective, partial and ideologically driven. The very use of the term intones inclusivity and cross sectional representation, while, in reality, stakeholder consultation is often superficial, descriptive (as opposed to analytical) and designed to provide a 'right of passage' for schemes that serve to propel agendas for capital accumulation or political power. For designers there are profound implications for ethical conduct attached to the veracity of consultative outcomes from which major schemes are often born. Here we suggest a paradigm

which if applied might help to bring some order to the further analysis of a 'hunch' or inference that all might not be as it seems in the pronounced outcome of a consultative process. This might also provide an instrument through which designers might conduct their own analyses of 'real' stakeholder needs.

Indeed stakeholder analysis can provide an excellent tool for characterizing individuals, groups and their interactions in order to establish the existence of social realities. Realist stakeholder analysis extends beyond a superficial appraisal of events, enunciated positions, group exhortation and eulogy, in support of a pronounced (design) intervention.

In the context of this paper the term 'realist' does not refer to 'naive realism'—roughly the view that the world as it appears to us is the world' (Shwandt, 1997, 35). Rather it recognizes that beneath a 'surface realism'; the world as it is seen, there exist realities of a more complex nature. The human interactions, transactions and covert agendas which take place beneath this surface reality, are considered here to be equally 'real'. Indeed, these relations within and between interest groups might be seen as the basis from which the surface reality becomes manifest. The realist approach recognizes that within a social research undertaking (such as significant design activity) there are likely to exist a range of opinions, attitudes and perceptions, often associated with assumed consequences, held by interest groups and individual actors.

Roy Bhaskar is still considered to be one of the foremost exponents of critical realism. Corson (1999) captures the essence of Bhaskar's argument (1986 and 1989) for critical realism as a 'theory of being' (ontology):

> *This theory of being includes as real entities the properties of the social world—especially the reasons and accounts that people use or offer, to direct or effect social or individual behaviour or change. In line with other accounts of scientific realism, Bhaskar (1986) asserts that people's reasons and accounts are 'real' in the sense that their existence and activity as objects of scientific inquiry are absolutely or relatively independent of the inquiry of which they are the objects. They are an emergent or objective aspect of his ontology. The twin tasks of research are to show the existence and then to detail the operation of these mechanisms: to show the hypothetical reasons or accounts to be genuine indicators of the structures that affect people's lives. Bhaskar's critical realism insists that we will only be able to understand and change the social world if we can identify the structures at work that generate those special interests (1989) (Corson 1999, 71 cited in Swann and Pratt, 1999).*

Bhaskar's thinking is adapted here to suggest a potential paradigm for realist stakeholder analysis in design, not only at the level of functionality, but also with regard to the underlying determinants of change and the 'structures at work' within relevant interest groups.

Too often stakeholder analysis does not go far enough, restricted to accounts of the 'self-evident' or 'presenting' surface activity of individuals or groups. In this paper stakeholder analysis is considered to be a practical application of realist theory. The key stakeholders are not regarded simply as independent informants, or necessarily accurate in their singular perceptions of events. Indeed, it might be unrealistic to expect an individual or interest group (for example end users of design output) to possess the practical wherewithal to reflect on events or interrelations occurring within a proposed consumer community and other affected parties.

The realist approach to (design) research must analyze perspectives from representatives of interest groups whose opinions and interests do not necessarily coincide. At one level, in the case of design activity, these interest groups could be said to include anybody and everybody. The key stakeholders, however, are considered to be:

- designers
- end users (who are not necessarily the same as 'clients' and might range from specific individuals and groups to a 'global' audience)
- the government and its subsidiaries
- contracted service providers
- society (the parameters of which would need to be identified in each 'case')
- organic intellectuals (Gramsci, 1971)

As Burgoyne (1994) reminds us, we must consider the extent to which 'powerful groups' (perhaps comprising policy entrepreneurs/organic intellectuals) and 'taken for granteds' must be questioned. We must also remain alert to the potential dangers of accepting a particular version of 'common sense' as articulated by individuals and interest groups attempting to legitimize agendas for action or the maintenance of a particular set of conditions. Hall (1996, 431) reminds us that:

> *It is the terrain of conceptions and categories on which the practical consciousness of the masses is actually formed. It is the already formed and taken for granted terrain, on which more coherent ideologies and philosophies must contend for mastery.*

Stakeholders may take the offensive, or be defensive, seeking to protect their ideas, beliefs and values from perceived threat; or conciliatory, attempting to reconcile their concerns and needs with those of other stakeholders. Stakeholders are characterized within this work, not simply in terms of 'role definition,' but as carriers of ideological positions and material interests. Ideologies do not exist independently, but originate from the interests or problems attached to particular groups, carrying behavioral imperatives; practical measures to maintain established values and beliefs (both offensively and defensively). In some cases individuals will apply 'judgmental rationality' (Archer, et al., 2004), publicly making claims in support of a preferred construction of 'reality.' Consequently the analysis of values, beliefs and behaviors of design stakeholders should not end at the level of the 'self evident'. Burgoyne's interpretation of stakeholder analysis can be seen as a suitable approach in activities of this kind which are:

> *...continuously doubtful of factual, non-controversial data, since these can often be constructions of powerful groups of stakeholders which exclude others. It is questioning these 'taken for granteds' that can lead to the identification of other stakeholders and interests (Burgoyne, 1994, 193).*

REFLEXIVITY IN RESEARCH

The previous section introduced the concept of realism in research and stakeholder analysis as its practical instrument. For stakeholder analysis to achieve more than a surface appreciation of events and their human dimension an external perspective is required, which is both reflective and reflexive; the researcher. From the analysis of socially oriented research, various agendas, meanings and covert ideological and political inferences may be drawn. In relation to design research undertakings, reflexivity allows the researcher to recognize her/his 'situated character' in relation to the project and to address the research questions from 'that' position. The realist, reflexive, approach might be seen as consistent with a project seeking to analyze a set of events presented variously by different stakeholders (e.g., the government, employers, target audiences). Where surface realities do not coincide, the reflexive researcher might probe further, alive to empirical realities and reflecting constantly upon the interplay between the actors in the discourse. Shacklock and Smyth agree that the location of the research, and the situation of the researcher within it, should be honestly addressed:

> *...the process of reflexivity is an attempt to identify, do something about, and acknowledge the limitations of the research: its location, its subjects, its process, its theoretical context, its data, its analysis, and how accounts recognize that the construction of knowledge takes place in the world not apart from it. Indeed, reflexivity in 'critical' research work is important in honestly addressing issues concerning the validation of research findings, as well as those ethical questions which arise from relations between the researcher and the researched that are implicit to the research agenda and the research methods (Shacklock and Smyth, 1998, 7).*

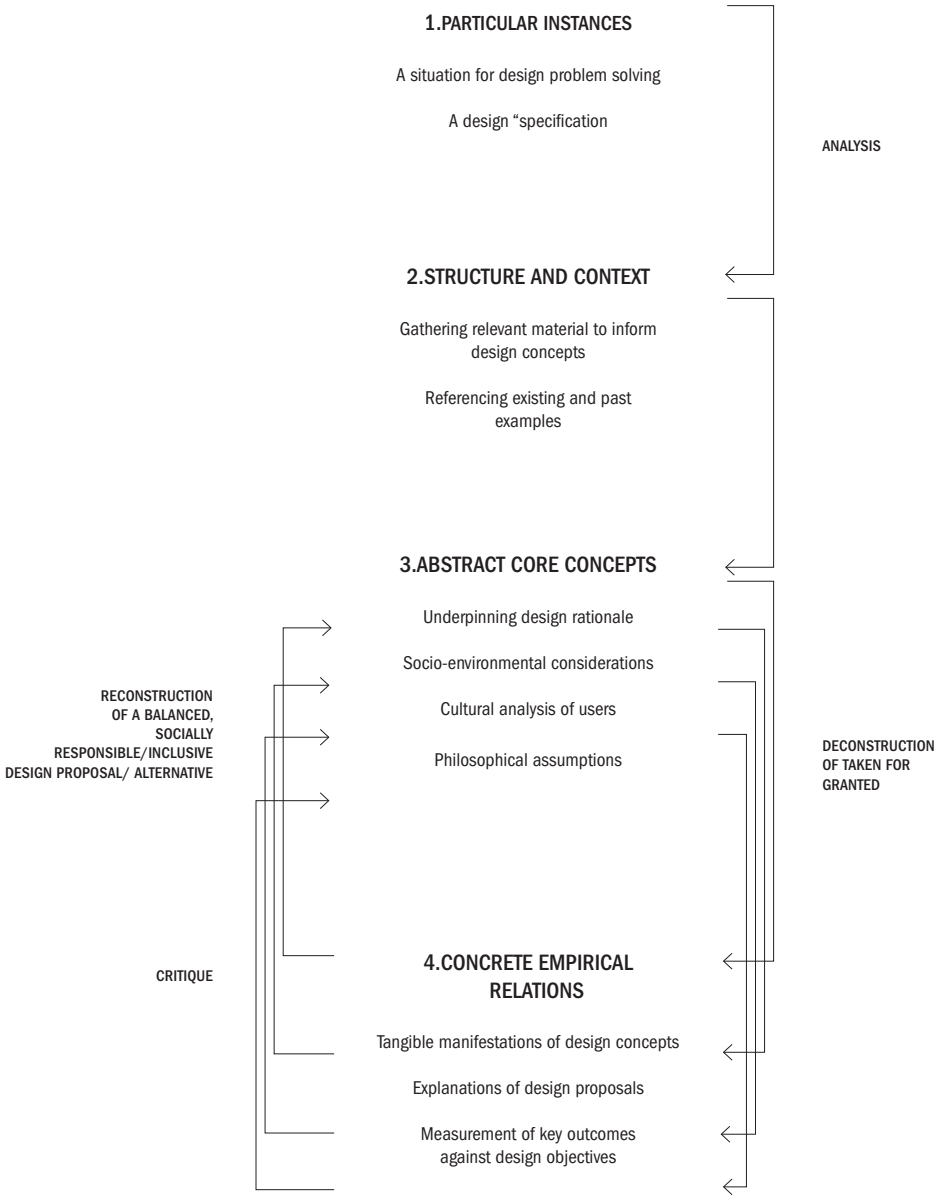
The following diagram is adapted, for use in the design context, from that provided by Harvey (1990) and cited in Shacklock and Smythe (1998) who suggest that reflexive research involves:

> *...a constant shuttling backwards and forwards between abstract concept and concrete data; between social totalities and particular phenomena; between current structures and historical development; between surface appearance and essence; between reflection and practice (Harvey, 1990, 4).*

This thesis also holds that any attempt to 'cleanse' (Shacklock and Smyth, 1998) the inherent human dimension of (design) research would be to reduce it to a series of factual accounts. Indeed initiatives supposedly based solely upon pronounced 'fact' are too often allowed to proceed unchallenged. This paper agrees that:

> *…being reflexive in doing research is part of being honest and ethically mature in research practice that requires researchers to 'stop being "shamens" of objectivity' (Ruby, 1980, 154). To not acknowledge the interests implicit in a critical agenda for the research, or to assume value-free positions of neutrality, is to assume 'an obscene and dishonest position' (Shacklock and Smyth, 1998, 7).*

This study agrees with Shacklock and Smyth; a (design) researcher must have a position; an opinion or perception from which questions arise, in turn a degree of reflexivity provides a capacity to dig deeper, find out more, capitalizing on new discoveries and relating to fresh events within the discourse.


1.PARTICULAR INSTANCES
A situation for design problem solving
A design "specification
ANALYSIS
2.STRUCTURE AND CONTEXT
Gathering relevant material to inform design concepts
Referencing existing and past examples
3.ABSTRACT CORE CONCEPTS
Underpinning design rationale
Socio-environmental considerations
Cultural analysis of users
Philosophical assumptions
RECONSTRUCTION OF A BALANCED, SOCIALLY RESPONSIBLE/INCLUSIVE DESIGN PROPOSAL/ ALTERNATIVE
DECONSTRUCTION OF TAKEN FOR GRANTED
CRITIQUE
4.CONCRETE EMPIRICAL RELATIONS
Tangible manifestations of design concepts
Explanations of design proposals
Measurement of key outcomes against design objectives

THEORY INTO PRACTICE

That which is outlined here suggests a theoretical model with the potentiality for practical application. At the same time it is recognized that not all design opportunities afford the time or resources to enable engagement in detailed theoretical analysis. This paradigm ('realist' stakeholder analysis) might, however serve to provide one potential 'lens' through which reflective design practice may be conducted. Thus, 'realist' stakeholder analysis might constitute one of the many components of critical reasoning in design, which may remain implicit or made explicit, according to personal preference, professional context and availability of resources.

This short paper makes a call for the evaluation of proposed design interventions based on a representation of stakeholders that recognizes the inconvenient social realities as well as the purported technical rational arguments, which too often provide a 'right of passage' for non-inclusive initiatives. At the extremes stakeholder analysis can be exploited as a tool to maintain hegemonic regimes or conversely to scratch beneath the 'surface presentation' of conditions in an attempt to gain an appreciation of the potential effects of significant design activity on those beyond the immediate designer/client transaction.

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Dr Mike Doherty is Head of the Centre for Design Innovation (CDI) and Course Leader of the MA programme Design Context and Practice at University Campus Suffolk. Emerging from a 3-dimensional design background, Mike has developed a particular interest in designing through convergent new media, reflected in having developed the Centre for Design Innovation, established in 2007, that provides an environment for the generation of innovative design content and content analysis. His PhD research explored education, training and associated social factors in design. Through the lens of 'Realist Stakeholder Analysis' Mike asks BA and postgraduate students alike to question the real effects and consequences of design intervention on an increasingly global stakeholder audience.

PRODUCT COMMUNICATION: FORM, FAILURE AND SAFETY

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ABSTRACT

Although the term 'culture' has become a subject of much recent discussion in design, much is due to the promotion and spread of global marketing. But little understanding of its meaning and design implications has, as yet, been explored. This paper examines E.T. Hall's classic theory of *culture as communication* in an effort to introduce cultural theory to current design thought and to examine its role in the development and analysis of design *form*, as well as design *failure* with unintended safety consequences. Illustrated examples of conflicting, confusing or otherwise failed product and graphic design are analyzed to identify hidden, often unlikely, causes and safety hazards. Hall's *Triad Theory of Change* and *Primary Message Systems* are used to help explain the context from which such failures can be further analyzed for discussion and study.

INTRODUCTION

When we think of communication what usually comes to mind are written or spoken words and other symbols to convey information. The same goes for communication design—most often thought of as simply graphic or digital design. But the scope of human communication reaches far beyond visible or spoken language. Nonverbal language, including sign, action and object language, permeates every aspect of our lives and is essential for almost any degree of effective communication. Far more pervasive than once thought, according to the noted nonverbal language pioneer and respected authority, R.L. Birdwhistle, in a typical two person conversation, nonverbal communication is said to account for as much as sixty-five percent of its social meaning (Knapp, 1967). Often hidden, but instinctively understood, gestures, postures, glances, actions and other non-verbal modes of "body language" have recently gained increasing interest and attention. But, ironically, while it often provides essential emphasis and subtle nuance as well as 'color' so meaningful to any verbal conversation, most is lost during translation.

It is estimated that, since gesture language preceded oral communication (speech) by close to a million years, over 700,000 distinct gesture signals were already identified (Pei, 1949). Also, the first records of cave art engravings trace the known beginnings of pictorial representation or graphic design at least 40,000 years ago (Breuil, 1952). The term 'object or product communication' was first recognized in 1956 as a distinct language in Ruesch and Kees' *Nonverbal Communication, Notes on the Visual Perception of Human Communication.* That same year their early classic *The Perception of Human Communication* was the first comprehensive study of nonverbal language and remains today, the reference of choice. Three basic nonverbal forms of codification were identified as sign language, action language and object language—of which many variations of each were since discovered and elaborated by others (Ruesch and Kees, 1956):

Sign Language includes all those forms of codification in which words, numbers and punctuation signs have been supplanted by gestures; these vary from the monosyllabic gesture of the hitchhiker to such complete systems as language for the deaf.

Action Language embraces all movements not used exclusively as signals. Such acts as walking and drinking, for example, have a dual function: on the one hand they serve personal needs, and on the other they constitute statements for those who may perceive them,

Object language comprises all intentional and unintentional display of material things such as implements, machines, art objects, architectural structures and last but not least—the human body and whatever clothes covers it. The embodiment of letters as they occur in books and on signs has a material substance, and this aspect of words also has to be considered as object language.

Of most relevance to this paper, however, is *object language*—the most passive, durable but least noticed and understood, type of non-verbal communication. All objects have *form or shape*. Products of course are also objects—but with a purpose or function, i.e., to work efficiently and safely.

FORM INFORMS

Form can inform, reform and deform. It can also appeal, reveal and conceal. The first impression a user makes upon contact with an object or product is its form or shape—a product's most conspicuous characteristic and a major factor in all design decisions. Indeed, form is the one characteristic that clearly distinguishes architecture, industrial and graphic design from all other design activity. Whether intended or not, active or inactive, products continuously convey information, meaning and values. These values are transmitted through users' intimate contact over time—not unlike "breaking in" an old shoe for optimum fit—the product-user relationship that makes it so personal and hard to replace. So it is with form.

Form can reform. The shoe "learns" or shapes to it's user's contours and needs, i.e., sweat, smell, heat, sound etc. while the user adjusts, learns and "gets used to it" for mutual fit and appeal. It can help direct and guide user actions and shape perceptions and attitudes as to what a product is, was and "wants to be." An object's form is an unobtrusive, hidden, silent information storehouse of considerable archeological as well as design value and interest. Much of this nonverbal information

resides in its surface characteristics and properties as "skin"—the face it presents—with permeable channels to its internal and external environment. Skin is the point of contact where users develop an initial impression and later, intimate relation of dependence and trust. Break that trust and product-life suffers or dies with it when discarded, disused or returned as defective. And if permitted, form can also deform. Form wears, degrades and deforms through long periods of normal use—or misuse and disuse. But also when unintended consequences cause errors compromising fit and comfort or interfere with proper and safe use, then design has failed.

As material culture—encompassing all of technology—from cave art engravings and paintings to highly automated mass-produced digital products of today, man-made objects provide the only continuous record of human cultural evolution to date. Indeed, our cumulative knowledge of human evolution is based on reconstructions of information coded in object language.

This paper examines communication as a cultural, rather than conventional communication theory, a highly condensed symbolization theory having emerged along with the development of communication technology, and prior to the recognition and study of nonverbal and object language and communication; the focus of this paper. When design fails for reasons unknown or difficult to identify, explain or understand, most likely it can be attributed to hidden, or non-verbal, cultural causes. Out-of-aware behavior reflecting levels of consciousness and irrational behavior, as well as complex cultural conditioning can also play a role. Such theories are based on the work of cultural anthropologist Edward. T. Hall, as proposed in his 1956 classic, *The Silent Language* and later in 1966, as elaborated in his companion book *The Hidden Dimension*. Hall was also among the first to recognize and examine the anthropological and historic importance of the approximate evolution of culture, language and tool-making together as communication—key to enabling man to become "human." And, the link between communication, technology and design was to follow.

DESIGN FAILURE

Failure is most often determined by specified quantitative measures, but rarely in graphic or industrial design—other than in relation to marketing objectives. Failure of course, is a relative term subject to the definition and meaning of *success*—another elusive term. For the purpose of this paper, however, design failure will be examined from three perspectives.

Communication Failure

If a conversation between two people, or distributed printed material is misunderstood, confusing, ambiguous or otherwise difficult to understand by its readers, communication has failed—sometimes with serious consequences. Ruesch and Kees (1956) describe the process of communication *success*—and by implication, communication failure if unsuccessful.

> *People communicate by making statements. These statements are signals that are coded in various prearranged ways. When they impinge upon earlier impressions, they become signs. These signs in the strictest sense of the word, exist only in the minds of people, because their interpretation is based on prior agreements. A statement becomes a message [only] when it has been perceived and interpreted by another person. Finally when sender and receiver can consensually validate an interpretation, then communication has been successful.*

Unintended Consequences and Safety

Along with forms' inevitable potential, came style and its commercialization. And in consumption-driven, capitalist society where change and choice is the rule, form becomes a transient, disposable commodity along with quality—that elusive, but important term—and where form often seems to follow fiction in seemingly meaningless pursuit of adventure. Change for change sake may be the elixir of life, but when it leads to harm, especially that which puts public safety at risk, design fails.

Market-created and promoted, style can be rational, irrational or both subject to unexpected consequences, or rewards in an often aimless search for novelty. Form can also hurt—even kill—as well as protect from danger or harm. But form can be therapeutic as well. With built-in cues, barriers and other measures, a product's form can be designed to help monitor and guide users to avoid unintended consequences leading to failure. When such design precautions are ignored or over-looked, design has failed. It goes without saying that of all possible consequences of design failure, safety is most important.

Product Semantics

Among the first detailed papers on the subject, Product Semantics: Exploring the Symbolic Qualities of Form by Klaus Krippendorff and Reinhard Butter remains one of the few that distinguish product semantics from traditional semantic theory by focusing on the operational interface between designer, user and object. They proposed a feedback process to monitor, manipulate, relate and align product form to user perceptions for greater user compatibility and fit, where most errors occur. The process reveals problems or "infelicities" (inappropriate results for the situation or purpose) such as unintentional symbolic incongruities leading to errors, misunderstandings and "potential disastrous mistakes" in the design of emergency equipment for example. But it is largely based on modified information/communication theory and marketing-based professional business models for research that, of course, promotes design. This provides the advertising and design world with rhetorical cultural meaning and rationale where it becomes acculturated long before it reaches the user. The theory omits, however, among other things, the importance of intimate, multi-sensory aspects of product-user relations beyond the simple form, shape and texture model of all products. It also overlooks potentially hidden factors based on culturally-conditioned senses such as smell, taste, weight, vibration, sound, etc., as well as visual characteristics of product operational use distinctive to such situational events (Krippendorff and Butter, 1984).

The Cultural Connection

Hall proposed in 1956 a cultural theory of all human behavior in which language, tool-making and culture evolved approximately together as *inter*dependent communication—the critical event that enabled man to become "human"—where communication is culture (and culture is communication). As such, one cannot speak accordingly about one without the other. Here, Hall and Trager presented a structural analysis of all human behavior as culture, perceived on levels of consciousness, modes of behavior and change. Accordingly, culture, in effect, largely exists on two broad levels of consciousness—from fully aware to unaware, rational to irrational, or overt to covert (subconscious), as revealed not only through dreams but also normal complexities, including the emotional, creative and irrational aspects of everyday life, also, as expressed in nonverbal as well as verbal terms.

Hall also found that behavior has three, rather than two, as previously thought, dynamic cultural characteristics or modes of behavior: *formal, informal* and *technical*, that cycle in a pattern of change from technical to informal to formal and back to technical—where most innovation occurs. Here, in technical mode military, medical and scientific activity for example, originates and develops. In contrast, the informal mode of culture, where rules and conditions are flexible, and style is encouraged and explored, change is most often introduced. If form endures and stabilizes to achieve classic status, it becomes more than a product; it becomes a symbol where tradition largely rules. Religion, also largely a formal belief system of words, actions and objects, including its readings, vestments, buildings, etc., also exemplifies the formal mode of culture. But formal living is also part of everyday aspects of life at home, office, school, shop, military, etc. or any situation where rules and authority are in compliance, and where objects and behavior are seen as essential stabilizing forces only to be questioned or violated at one's risk. To better appreciate this and its consequences, try appearing at a formal event, such as a place of worship or even a formal dinner in your "Sunday (or Saturday) best," but in bare feet, and see what happens. Indeed, conflicts are often fought over formal stability and informal change.

As for design implications derived from Hall's theory of culture as communication made possible by the inventions of language and material culture, design plays a key role in what we think, know and do; more importantly, how we effect and can effect change. Of all the developmental systems Hall proposes, perhaps most directly significant to design is his theory of cultural change. It was observed that The Triad Theory of Cyclical, Cultural Change, with technical, informal and formal reflecting the three levels of culture, corresponded to the historical continuum of cultural process and evolution to provide a cultural perspective from which product life may be viewed as seen in the past, present and future tense.

The Three Levels of Cultural Change

Formal > Past Informal > Present Technical > Future

It follows then that "good design" (yet still another elusive term) recognizes and reflects all three phases of cultural change—with one dominant at any given moment. For designers, manufacturers and businesses, this provides a basic understanding and appreciation of *product change*, and the complex social processes that support, promote and enable it as an important step toward product "quality" in today's highly competitive global markets.

The Primary Message Systems is key to understanding much of Hall's theory of *culture as communication*. This is based on the ten message systems of all related, interactive, bio-basic (rooted in our biological past) human activities that distinguish us as human social beings. This includes all interactive variants of human behavior, summarized in detail in Hall's *A Map of Culture*, an interactive matrix-map of the ten basic message systems as interactive, related and applied to all others (Hall, 1956).

The Ten Primary Message Systems

0 Interaction
1 Association
2 Subsistence
3 Bisexuality
4 Territoriality
5 Temporality
6 Learning
7 Play
8 Defense
9 Exploitation

Of the ten categories, *interaction* (mostly non-verbal communication) and *exploitation* (of natural resources) refer to all of man-made material culture (including technology) and their interactive variants. Hall was among the first to recognize and explore other hidden, but important nonverbal communication dimensions, such as time and space as first presented in *The Silent Language* and later elaborated in his other important classic, *The Hidden Dimension* in 1966. In it he describes the importance and role of culture in shaping behavior as well as buildings, spaces and settings influenced by design—often completely *out of one's awareness.* It was then that Hall coined the term *Proxemics* to describe the study of how space is used, consciously and unconsciously, to establish and maintain human relationships, essentially through nonverbal communication. This has since been widely acknowledged and applied in public and private buildings, spaces, places and other social settings. It includes specialized health-care applications such as geriatric and psychiatric facilities, therapeutic and non-therapeutic, as well as businesses and other commercial enterprises (Hall, 1966).

The following examples illustrate how product form can influence (and be influenced) by cultural factors, to challenge, restrict or otherwise interfere with safe and efficient use of products. An example of conflicting verbal and nonverbal images and messages of form—with apparently unintended consequences is the "Dr. Mailbox ambulance"—parked ready for "emergencies" *(figure 1)*. Although we can laugh at the cynical cultural incongruities of the double meaning, it poses a serious risk to drivers and pedestrians that glance at the vehicle in motion, with or without a siren, often on busy urban streets with little time to safely respond to the familiar ambulance shape, color and design. The medically deceptive, meaningless words "Dr. Mailbox" prominently displayed to replace the word "ambulance" is but a minor distraction, as the vehicle's clear nonverbal message remains and dominates the scene—"make way for the ambulance!" This reveals not only the traffic authorities' incompetence that permits such obvious transgressions, it also confuses the public while compromising the trust and endangering the safety of the community. It also reveals an apathetic public apparently uninterested and unaware of the consequences of such hazards—to say nothing of the apparent lack of legal protection as displayed by licensing the transferred ambulance as is.

The trend to use public buses as moving billboards is another case of conflicting messages. The bus, a public vehicle, becomes a giant, full-time traveling billboard when wrapped as a commercial message *(figure 2)*. Boarding passengers, having no choice of alternative transportation, are in effect compelled to endorse the message it carries as it travels along its network of streets and neighborhoods selling its product. But it also infringes on passengers' rights and interferes with their ability to clearly see out windows, especially at night, when looking for bus stops and stations, street signs and other destination landmarks. Moreover, it creates a claustrophobic effect of being trapped inside an enclosed moving vehicle with strangers, inviting potential crime unseen by passing pedestrians. As a public vehicle, its primary responsibility is of course to its passengers and the public. As such it serves neither—and fails both.

Figure 1
"Ambulance" the danger of conflicting messages.

Figure 2.
Public transportation
or moving billboards?

Although not as serious a public safety issue, but a growing security problem, is the gradual privatization of official government services. The United States Postal Service is offering personalized U.S. stamps displaying almost any picture of choice including family, friends, relatives, pets or anything else *(figure 3)*. We now find school children, for example, *designing* official state license plates. Even Social Security check envelopes are being challenged by the confusion among the growing piles of mail junk with official-looking, carefully copied envelopes masquerading as official government documents to steal attention. One might wonder what in fact is the purpose of a license plate or government document, if not for accurate identification, confidence and security?

Figure 3
Official U.S. Postage Stamps or Personal Advertising?

Or likewise, official Medicare envelopes, designed years ago to be distinguished from other mail, implied a sense of attention and *special importance*. This is now lost in a sea of meaningless advertising among official-looking envelopes that confuse and compete with the genuine for attention. But such seemingly harmless, but deliberate, misinformation can be seen as crossing a cultural divide. All cultures operate on two main levels of consciousness, overt and covert or visible and invisible behavior, expressed through formal, informal and technical stages. When the process is disrupted and the message is misunderstood, the public is harmed and design fails.

A clear example of preventable *mis*information is the danger of accidentally misplacing a small soldering-acid bottle near an identical eye-drop bottle where it can easily be mistaken for the other– both with the same identically-shaped and textured top. This could have dire consequences *(figure 4)*. Here, design attention to distinguish the shape and tactile communication between the two, especially the bottle top, is crucial in preventing such potentially catastrophic mistakes. The indiscriminate and irresponsible practice of packaging both harmful and therapeutic or nutritional consumer products in the same containers, apparently for cost savings regardless of content or purpose, clearly exhibits a lack of design attention to the multi-sensory communication potential in such objects, often critical in interacting safely as well as effectively with users and others.

Figure 4
Bottle shape confusion with catastrophic consequences (soldering acid, left, eye medication, right).

Another example of preventable misinformation is the widely used, peanut-shaped packaging "nuggets." When an open package is left unattended at home, an infant or small child can easily mistake the nuggets for a common foam-like snack food closely resembling its shape, size, feel and texture. And if swallowed, the infant or child could easily suffocate and die *(figure 5)*.

Figure 5
Product shape confusion with catastrophic consequences (snack-food, left, packing materials, right).

CONCLUSIONS

Failure in design often occurs when form is limited only to imagination, inadequate product development (trial and error), irresponsible choices and unaccountability for unintended consequences—from security to fraud to injury and physical harm. Happening all at once it's a *perfect storm*. But strangely, *failure* is rarely mentioned or discussed in architecture, visual, product or industrial design today. This can be attributed to lack of agreement as to what in fact design is and how to measure, if not achieve, success. Awards are often given for "good design" by a juried decision with or without meaningful critique. This should not surprise those in the aesthetic design fields, including architecture, graphic and product design; that must deal with this elusive situation daily. The purpose of this paper was to get inside that process from a cultural perspective and hopefully bring new meaning and light to the creative process itself—another subject long neglected. But after years of serious study and investigation, design research remains unable to bridge the critical gap between conscious and unconscious, or out-of-aware aspects of design. Viewing *design as communication*, acknowledging the nonverbal cultural links that tie humanities, human sciences, technology and design together, provides an historical perspective so lacking in design today. If this paper does nothing more than encourage designers to better appreciate and understand the role and importance of *design*, *as communication*, in making design decisions, it will have succeeded. Despite an apparent lack of technical or detailed description, design as communication is an important and *controlling* part of our lives,

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MULTIPLE INFORMATION FAILURE: A CASE OF DIFFERENT INVESTMENTS IN FORM AND CONTENT IN GRAPHIC DESIGN

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ABSTRACT

This paper considers a sequence of failures in the design of information. It focuses on the Safe and Sustainable Indoor Cleaning study (SASI Clean), a 2007 government-funded study into cleaning practices in Australian childcare centers. Empowerment through participation was integral to the study, childcare workers being seen as collaborators in the investigation, not mere research subjects or informants. They worked with scientists and designers to investigate the nature of childcare as a specific context for cleaning and information delivery and to identify creative responses to its challenges. In respect of design, however, other project dynamics clashed with the frame-changing nature of participatory design. Ultimately, key project stakeholders preferred a failed model of communication, focused on the information to be transmitted over design prototypes oriented to the perspectives and situation of childcare workers, revealing skepticism to claims to knowledge to be both a compelling reason for the use of participatory design and a basic obstacle to the valuing of its results. To explore the complex human and organizational issues associated with the project, the paper uses a case study approach.

INTRODUCTION

It's hard to know when designed communications fail. Effectiveness in graphic design is rarely the subject of objective investigation. Information delivery also spans both the form and content of communications, either of which can fail to resonate with audiences; designers often have little influence over content, when others may feel a strong sense of ownership. In this paper, we discuss the mixed success of a program of participatory design carried out as part of the Safe and Sustainable Indoor Cleaning study (SASI Clean). The study took place in 2007 and investigated resistance to low-chemical cleaning in childcare centers in the Australian state of Victoria. The inclusion of designers in the initiative responded to the failure of existing information to influence childcare centers to adopt low-chemical cleaning. We chose a participatory approach to design for its capacity to focus on the needs and perspectives of childcare workers, but decision-making in participatory design is less clearly defined than in client-focused projects. The vignettes we present suggest that even when all parties to a venture believe they are aiming for the same goals, stakeholders outside the design process can privilege information content over specifically targeted forms of information delivery, highlighting the problem of differential investments in knowledge and information, raising the question of how inclusive participatory design should be.

That many of Victoria's early childhood centers use harsh detergents, disinfectants and surface sprays indicates that information on low-chemical cleaning has had little traction in the sector despite seemingly clear guidelines on its use. The National Health and Medical Research Council publication *Staying Healthy in Childcare* is the sector's primary source of information on cleaning and hygiene, being recommended by the National Childcare Accreditation Council, the Australian Governments' childcare accreditation agency. The document is freely available over the Internet. Its approach to communication embodies functionalism, using factual explanation and standard publication design to present the facts on cleaning and infection control.

Staying Healthy in Childcare recommends diluted detergent for cleaning surfaces outside food preparation areas. It explains that, "Washing germs down the drain is better than trying to kill germs with disinfectant … Most germs do not survive for long on clean surfaces when exposed to air and light. Even in hospitals, the emphasis is on the use of detergent and effective cleaning and drying procedures rather than disinfectant."[1] The publication stresses that to kill germs a disinfectant needs to be the right one, applied to a cleaned surface at the right strength and left for at least ten minutes. Even then, not all germs are eliminated, fewer than 100 germ particles are enough to spread infection.

Staying Healthy in Childcare uses the weight of science to press home its message on protecting against invisible germs. Bruno Latour argues that modern science has socialized the natural world's nonhuman elements, bringing them into new relationships with people.[2] It was science that identified the presence and risk of germs; cleaning products are an example of Latour's argument that science and technology create hybrids of the human and non-human that permeate society.[3] Latour also sees the pragmatics and processes of scientific knowledge dividing the material and human realms into two distinct and increasingly distant zones.[4] The development of the chemicals that comprise cleaning products and the attribution of their uses, benefits and effects is the subject of complex historical processes within the institutions of science, technology and government. Individual pieces of scientific knowledge also conflict with each other. Branches of science and technology have created cleaning compounds and driven their application, while others reveal their risks. Driving the SASI Clean initiative was the prospect that enabling childcare workers to negotiate competing information about cleaning could achieve significant reductions in environmental toxins, packaging waste, embodied energy and sodium in waste-water, within approximately 2,700 childcare centers in Victoria. Each childcare facility also sits at the hub of a broad social network, suggesting the potential to spread low-chemical cleaning further into society through the development of effective behavior change communications.

Contributing to the SASI Clean study were a variety of people and organizations, recognizing that the strategies for promoting low-chemical cleaning were unlikely to come from a single source of knowledge or support. An independent, sustainable cleaning consultant and accredited trainer established and managed the initiative. Microbiologists compared the effect of cleaning products on germs. Environmental scientists researched the active ingredients and health and environmental effects of cleaning products.

Funding for the study came from the Victorian Government. Officials from Sustainability Victoria, the state government's environmental sustainability agency, sat on the study's steering committee, as did others from the National Childcare Accreditation Council and Community Childcare Victoria to ensure project proposals fitted policy directions in that sector. We were recruited to explore the failure of existing information and develop alternative approaches. However, it was envisaged that the primary knowledge about how to change attitudes to cleaning would come from childcare workers. Key aspects of the study were developed in collaboration with staff from four Melbourne childcare centers, building on their needs and perceptions. The microbial testing, for example, compared the efficacy of low-chemical cleaning with current cleaning products on actual surfaces in the centers, the workers seeing *in situ* tests as the most convincing.

PARTICIPATORY DESIGN AS AUDIENCE RESEARCH AND A PHILOSOPHY OF DESIGN PRACTICE

The anticipated goal of the SASI Clean initiative was the development of a social marketing program built around the accreditation of individual childcare facilities as SASI Clean centers. According to Andreasen's classic definition, social marketing is "the application of commercial marketing technologies to the analysis, planning, execution and evaluation of programs designed to influence the voluntary behaviour of target audiences in order to improve their personal welfare and that of their society."[5] There is a clear connection between this definition and Jorge Frascara's representation of graphic design as the creation of visual objects or messages for specific audiences with the aim of eliciting an action or reaction.[6] An issue in both fields, however, is recourse to audience research and the nature of methods used. Bruce Hanington contests the relevance of conventional market research to design in providing limited insight and sitting outside the design process.[7] He nominates two preferable, emerging sets of user research methods, both human-focused and design-centric; those adapted from the social sciences where members of the design team or people themselves investigate the design task in its everyday setting; and innovative, participatory methods that allow people to directly contribute their knowledge and ideas to the design process in ways that are integral to design.[8]

[1] National Health and Medical Research Council. 2005. *Staying healthy in childcare preventing infectious diseases in childcare*. 4th Edition. Canberra: Australian Government and National Health and Medical Research Council, 35. http://www.nhmrc.gov.au/publications/synopses/ch43syn.htm. Accessed 4 February 2007.

[2] Latour, B. 1999. *Pandora's hope*. Cambridge. MA: Harvard University Press, 194.

[3] Latour, B. 1991. *We have never been modern.* Cambridge, MA: Harvard University Press.

[4] Freed, M. 2005. Latour, Lyotard, and the problematics of legitimation. *Journal of Theoretical Humanities,* 10.3, 99-114.

[5] Andreasen, A.R. 1995. *Marketing social change.* San Francisco, CA: Jossey-Bass, 7.

[6] Frascara, J. 2004. *Communication design: Principles, methods and practice*. New York, NY: Allworth Press, 54.

[7] Hanington, B. 2003. Methods in the making: A perspective on the state of human research in design. *Design Issues*, 19.4, 13-18.

[8] Hanington, Methods in the making, 17-18.

It is increasingly understood that how people use things transcends basic function, indicating what they mean to them; providing an insight into the narrative of their lives.[9] The design team spent time in the four facilities observing cleaning and talking to childcare workers about their everyday experiences. In each center, printed and hand-written information on themes including occupational health and safety, children's health and self-esteem, nutrition, recycling and workplace events and procedures covered the walls, exemplifying the art critic Leo Steinberg's idea of the "receptor surface"; any hard surface where information is "received, printed, impressed—whether coherently or in confusion"[10] *(See figure 1).* Steinberg represents such surfaces as analogous to human subjectivity in an era of mass consumption and media, their complexity evoking both the fragmentation and capacity for depth in the human mind. The walls of the centers in the SASI Clean study suggested childcare workers' obligatory mindfulness of many important things, but also the competition for their attention. To better understand their situation and perspectives on cleaning and develop relevant designed responses we organized a sequence of three participatory workshops of three hours each with a group of fifteen volunteer childcare workers. These were spaced three and six weeks apart, with the design team undertaking significant design work around the workshops to prepare for each one and to document and develop ideas coming out of them.

Participatory design has varied philosophical and disciplinary roots, including the Scandinavian tradition of workplace democracy and the computer industry's efforts to better match software products to people's needs and abilities by including everyday users in product development and testing.[11] Today, in fields such as architecture, human-computer interaction, information design, product design and urban design and planning it is increasingly common for the recipients of design to contribute to the design process. There is a thread of graphic design writing—both scholarly and industry-focused—that questions the viability of client and designer-driven communications, but including audience members in graphic design is still at an experimental stage. When we embarked on the SASI Clean study there were few scholarly accounts of its real-world application.[12] In the field of public health, Strickler and Neafsey reported on a project in user-centered design in which designers and social scientists collaborated to develop animated interactive software to prevent drug interactions in older adults, but audience members were not included.[13]

Co-design principles conflict with graphic designers' traditional perception of their enterprise. Drucker and McVarishs' 2009 history of graphic design chronicles designers' assumptions about visual communication and the socio-cultural conditions that have shaped

[9] Busch, A. 2004. *The uncommon life of common objects: Essays on design and the everyday*. New York, NY: Metropolis Books.

[10] Steinberg, L. 1972. *Other criteria*. In *Other criteria: Confrontations with twentieth-century art*. Chicago, IL: University of Chicago Press, 84.

[11] Sanoff, H. 2005. Community participation in riverfront development. *CoDesign*, 1.1, 61-78.

[12] See Forlizzi, J. and C. Lebbon. 2002. From formalism to social significance in communication design. *Design Issues*, 18.4, 3-13. Nini investigates three participatory design methods in a student project for a cookbook for disabled people, but the students involved did not have enough data to be adequately informed about end-users. See Nini, P.J. 2005. Sharpening one's axe: Making a case for a comprehensive approach to research in the graphic design process. *Research Journal of the Australian Graphic Design Association*, 1.2, 1-10.

[13] Strickler, Z. and P. Neafsey. 2002. Preventing drug interactions in older adults: A collaborative study. In Frascara, J., editor. *Design and the social sciences: Making connections*. London, UK: Taylor and Francis, 102-124.

[14] Drucker, J. and E. McVarish. 2009. *Graphic design: A critical history*. Upper Saddle River, NJ: Pearson Prentice Hall. xxii.

[15] Ilyin, N. 1997. Fabulous us: Speaking the language of exclusion. In Bierut, M., W. Drenttel, S. Heller and D. Holland, editors. *Looking Closer 2: Critical writings on graphic design.* New York, NY: Allworth Press. 37.

[16] See Glaser, M. 1997. Design and business: The war is over. In Bierut, M., W. Drenttel, S. Heller and D. Holland, editors. *Looking Closer 2: Critical writings on graphic design.* New York, NY: Allworth Press. 183.

[17] Drucker and McVarish, *Graphic design*, 337-338.

Figure 1
Interior of one of the four centers in the SASI Clean study demonstrating information disposition. Photograph: the authors.

graphic design's aesthetic constructs, production methods and professional discourses and institutions.[14] Key among these, they argue, is the desire for freedom in self-expression, a product of graphic design's long association with art and artists. Alternatively, the privileging of professional expertise in modernity has seen graphic designers' specialist creative skills promoted as the basis for expert solutions to communication problems. For Ilyin, graphic designers' self-representation as artists and experts is a game of exclusion that sees designers playing with the formal languages of graphic design and looking down on clients and audiences.[15] Elsewhere, success in graphic design is linked to its capacity to support commercial profit.[16] In Drucker and McVarishs' study, any challenges to the graphic designer's perceived autonomy and expertise are recent; the end of the era of mass media and consumption, the dissemination of graphic design capacity through computer software and the rise of information and communication technologies seeing everyday people emerge as active shapers of products and services and as cultural producers in their own right are examples. Such changes, they argue, require graphic designers to better understand the "conditions of use" rather than just design "effective or aesthetic displays of useful information."[17]

The emergence of user-centered perspectives in graphic design also builds on theoretical debates that highlight the historically and socially constructed frameworks and reading practices that influence people's response to text and image, suggesting the presence of complex, two-way interactions between people, designed communications and the communication context.[18] The work of the Italian sociologist Alberto Melucci supports this shift. Melucci argues that individuation, self-determination and associated capacities for learning and action are integral to the operation of today's complex, media-saturated societies, which he describes as "networks of high-density information," characterized by manifold, disconnected social realities and diffuse sources of authority.[19] For Melucci, this complexity creates contradiction, indicating a "need for greater integration and intensification of control" as reflected in the proliferation of social institutions seeking to penetrate and control aspects of human life.[20] But today's complex societies exceed direct control. To maintain momentum, they require individuals and groups to operate as "terminals capable of self-regulation … producing, collecting, decoding and exchanging information."[21] To balance control with scope for individuation, Melucci argues societies must shift their "emphasis from the content to the code of social life, from behaviour to the pre-conditions of action."[22] For Melucci, offering individuals the opportunities to communicate, negotiate, produce meanings and make decisions affords them—and society as a whole—a chance to fulfil their potential.

Melucci's arguments suggest that practices like low-chemical cleaning will only become part of peoples' everyday knowledge where externally determined processes support individuals and communities to arrive at their own understanding of and commitment to changed values.[23] Participation in decision-making is one way to mobilize peoples' autonomy, reasoning skill, capacity for conviction and critical practical insight into their own needs and circumstances to precipitate desired social outcomes. Decision-making processes also operate on a symbolic level, indicating values of empowerment and disempowerment; participatory decision-making suggesting a dynamic and inter-individual process of forming commitment to action.[24]

CHILDCARE AS A CONTEXT FOR INFORMATION DELIVERY

Working conditions in the Australian childcare industry raise evident issues of authority, autonomy and subjection that potentially affect receptivity to information. Childcare workers are subject to a raft of externally determined standards imposed through centralized structures and delivered through standardized information forms,

[18] See, for example, Tyler, A.C. 1992. Shaping belief: The role of audience in visual communication. *Design Issues,* 9.1, 21-29.

[19] Melucci, A. 1989. *Nomads of the present: Social movements and individual needs in contemporary society.* London, UK: Hutchinson Radius, 45.

[20] Melucci, *Nomads of the present*, 45.

[21] Melucci, *Nomads of the present,* 45.

[22] Melucci, *Nomads of the present,* 45.

[23] Buechler, S. 2000. *Social movements in advanced capitalism: The political economy and cultural construction of social activism.* New York, NY: Oxford University Press, 148-149.

[24] Melucci, *Nomads of the present*, 163-179.

although they still exercise some control over their labor. Many centers have high staff absenteeism and turnover with the sector loosing significant numbers of workers each year. Lyons shows childcare workers feel conflicted about their employment, deriving high satisfaction from certain aspects of the experience of caring for children, but feeling frustrated over their working conditions.[25] These include lower wages for qualified staff than unskilled workers in many other fields; the difficult, labor-intensive nature of childcare work, which is characterized by high levels of stress and responsibility; limited career paths and low social status; and strong expectations of quality from governments, parents and society.

Australia's Childcare Quality Assurance Process makes workers feel they have inadequate influence over decision-making in their workplace, accreditation entrenching norms and rules so that practices go largely unchallenged.[26] Sims's research into the experience of junior workers in the for-profit segment of the Australian childcare industry depicts cleaning as a lowly, relentless task, one worker commenting:

> *Mainly my responsibilities were to clean, but that's not what I was told at the interview. I was told I would be an assistant for the children ... I was cleaning up lunch, doing the dishes and floors; the whole centre was mopped after lunch, it was all vinyl, it was a pretty big job; then all the bathrooms had to be cleaned which was my job ... After afternoon tea, I would clean up again, as usual do the dishes, tidy everything up ... from 4-6 I was cleaning the centre, doing all the floors, all the vacuuming, toilets, basins.*[27]

This account suggests the difficulty in linking cleaning in childcare to positive change. Arguments for participatory design posit that an investment in process develops shared perceptions between designers and audience members concerning the field of possibilities and constraints in which design will operate, and the objectives to be pursued and ways for achieving them.[28] Acknowledging the capacity of childcare workers to advocate and innovate on their own behalf, the design phase of the SASI Clean study worked directly with childcare workers to develop design responses to the communication task based on their circumstances, self-understanding and potential points of resistance.

[25] Lyons, M. 1997. Work rewards, job satisfaction and accreditation in long day care. *Australian Journal of Early Childhood*, 22.3, 40-44.

[26] Jackson, E. 1996. Work conditions in long day care in the era of accreditation. *Australian Journal of Early Childhood*, 21.2, 17-20; Lyons, Work rewards, job satisfaction and accreditation in long day care, 40-44.

[27] Sims, M. 2002. Junior pay, senior responsibilities: The experiences of junior childcare workers. *Australian Journal of Early Childhood*, 27.3, 7.

[28] See Gronbaek, K., J. Grundin, S. Bodker and L. Bannon. 1993. Achieving cooperative system design: Shifting from a product to a process focus. In Schuler D. and A. Namioka, editors. *Participatory Design: Principles and practices.* Mahwah, NJ: Lawrence Erlbaum Associates, 92; also Grudin, J. 1993. Obstacles to participatory design in large product development organizations, 99-122; Spinuzzi, C. 2005. The methodology of participatory design. *Technical Communication*, 52.2, 164.

THE ISSUE OF CO-DESIGN METHODS

In 1998, Kensing and Blomberg represented participatory design as a "maturing area of research" dominated by three main issues: the politics of design, the character of participation and the nature of methods and tools for carrying out design projects.[29] For Sanders, graphic design today is unquestionably about people designing together, the main challenge for graphic designers being the development of innovative tools to enable people to articulate "those ideas and feelings that are often so difficult to express in words."[30] Ehn uses Ludwig Wittgenstein's idea of language games to approach the issue of methods.[31] Wittgenstein stressed the imperfection of communication systems, challenging the idea that lay participants must fully articulate their needs and desires. For Ehn, design tools such as ideation exercises, visualization methods and prototypes are all representations that enable participants in design to see new dimensions in existing circumstances and practices, how participants' knowledge and creative ideas are applied to design being more important than any single method.

Dodd[32] argues that the nature of the design task indicates methods. We used philosophical perspectives intrinsic to the global SASI Clean study to determine the character of the workshops. A guide was Heron's idea of "cooperative inquiry," which stresses the importance of the inter-subjective exchange of critical knowledge between expert and lay participants in a project and the intent and quality of interaction, Heron explains:

> *In meeting people, there is the possibility of reciprocal participative knowing, and unless this is truly mutual, we don't properly know each other. The reality of the other is found in the fullness of our open relationship … when we each engage in our mutual participation. Hence the importance of cooperative enquiry with other persons involving dialogue, parity and reciprocity in all its phases.*[33]

To enable the childcare workers' knowledge of the context for information delivery to merge with the design team's knowledge of visual communication and design production we strove to replace the usual subject-object relationship of designing *for* an audience with the subject-subject relationship of designing *with* members of that audience.[34]

[29] Kensing, F. and J. Blomberg. 1998. Participatory design: Issues and concerns. *Computer Supported Cooperative Work*, 7, 167-185.

[30] Sanders, E. 2002. From user-centered to participatory design approaches. In Frascara, J., editor. *Design and the social sciences: Making connections*. London, UK: Taylor and Francis, 7.

[31] Ehn, P. 1993. Scandinavian design: On participation and skill. In D. Schuler and A. Namioka, editors. *Participatory design: Principles and practices.* Mahwah, NJ: Lawrence Erlbaum Associates, 41-78.

[32] Dodd, K. 2001. Research and design success. *Design Management Journal*, 12.3, 58-84.

[33] Heron, J. 1996. *Cooperative Inquiry: Research into the human condition*. London, UK: Sage, 11.

[34] Spinuzzi, The methodology of participatory design, 163-174.

[35] Ehn, Scandinavian design, 41-78.

The design workshops included short information sessions that explained various techniques for idea generation and design refinement, including brainstorming, "what if" exercises, SWOT analysis, values analysis and mood boards; the premise being that the main problem with graphic design methods is the absence of audience participation in their use. Time was set aside to discuss cleaning routines, the childcare workers having been shown SASI cleaning practices. Recognizing that locations are never neutral, we carefully considered where to hold the workshops. We thought to conduct them in one of the childcare centers to emphasise the communication context. We decided to hold them in a design studio to minimize the perception of designers as external problem solvers. Here, the arrangement of desks, the priority given to technology, the profusion of source books, magazines, font samples, color swatches, the mock-ups and other, seemingly random clippings pinned on walls evoked the nature of graphic design, potentially demystifying its practice for the childcare workers in much the same way as the walls of the childcare centers spoke to us of their daily experience.

Following Ehn's observation that both ethics and aesthetics are important in participatory design, we chose attractive but inexpensive materials and low-technology processes to encourage participants to engage with the design exercises, which we pitched between work and fun[35] *(see figure 2).* The workshops used a rapid sequence of activities to generate as many ideas as possible and then develop the best, the childcare workers adapting quickly to design in being articulate, imaginative, responsive to the ideas of others, accustomed to shifting quickly between activities and comfortable with the use of cut paper, colored markers, sketching, found materials and collage. The iterative nature of design was stressed throughout so that the childcare workers appreciated that any design ideas we developed further between workshops could be changed. Alternatively, the design team's work following the first and second workshops, which spanned the research and idea generation phases of design and was vital to producing design prototypes for assessment and selection in workshop three. The childcare workers were somewhat reluctant to make design decisions that might appear to reject others' ideas.

Figure 2
Design activity from workshop one in the SASI Clean study. Photograph: the authors.

BARRIERS TO THE ADOPTION OF SAFE AND SUSTAINABLE CLEANING IN CHILDCARE

The global SASI Clean study identified four main hurdles tothe adoption of safe and sustainable cleaning in childcare, each contradicting the notion that information alone is enough to influence people's attitudes and behavior. There was a "strong belief that … disinfectants and/or antibacterial agents will achieve cleaner nappy change tables and hands." There was "a much higher level of concern about the risk to health from the spread of germs, than the risk to health from the methods used to kill them." Indeed, many childcare workers felt that the stronger the cleaning chemicals, the "safer and cleaner" an indoor environment would be. There was a perception that "green" cleaning products are "less effective and more time consuming." Finally, those who suspected the safety of disinfectants had typically begun to use vinegar and essential oils to clean, disinfect and freshen air, perceiving these to be effective, natural products.[36]

The design workshops found additional factors at play. These included uncertainty over which cleaning methods were approved by the national accreditation scheme for early childhood services; concern over not meeting the standards of the Childcare Quality Assurance Process; staff wanting to do the best for the children in their care while needing to be seen to be doing so in the eyes of

parents; a sense that parents expect disinfectants to be used; general information overload in childcare, workers feeling overwhelmed with expert recommendations on how to do most aspects of their job; centers' lack of time to reflect on work practices; difficulty controlling the products used by afterhours contract cleaners; the need to buy cleaning products in bulk to contain costs; little discussion of cleaning practices in childcare training; and the routine nature of cleaning in childcare, which is so constant that how it is done is easily overlooked.

Of course, any piece of information is not received in a vacuum.[37] Each competes with an ever-expanding corpus of contradictory information on standard and green cleaning, cleaning products and infection control, issued from sources ranging from the evidence-based and informative, the commercially motivated and promotional, and the opinionated, uniformed and misleading. For the childcare workers, the language and concepts of advertising were influential here, especially advertising's focus on 99% effective disinfectants and products that make cleaning effortless. The workshops also identified the labelling of cleaning products as a problem. The small point size and cramped layout of labels on commercial cleaning products were too hard to read when caring for children, one worker explaining how this had led to serious mistakes in the dilution of cleaning fluids. *(see figure 3).* Alternatively, improvised labels lacked impact and durability *(figures 4 and 5).*

[36] Gardner, B. 2008. SASI Clean Study Report. Available at http://www.sasiclean.com.au/project_results.html. Accessed 3 March 2008.

[37] Margolin, V. 1997. Getting to know the user. *Design Studies*, 18.3, 227-36.

Figure 3
Commercial cleaning products in one of the four centers in the SASI Clean study. Photograph: the authors.

Figure 4
Improvised sign in one of the four centers in the SASI Clean study. Photograph: the authors.

Figure 5
Improvised labels in one of the four centers in the SASI Clean study. Photograph: the authors.

THE DESIGN PROTOTYPES

Social cognitive theory argues that the interaction between people's perception of empowerment and the context for empowerment strongly influences outcomes.[38] We saw the participatory workshops as producing authentic knowledge and design prototypes that responded directly to the childcare workers' needs, perspectives and situation. The character of inter-subjective exchanges in the workshops was a strong indicator of our success here. When discussions explored the effects of cleaning chemicals, the responsibility workers felt for the children in their care and issues of accreditation, the atmosphere in the workshops became charged. Alternatively, the affective ties that developed between the workers and designers sustained collaboration over the three workshops. Friendliness, frequent humorous exchanges and general openness between childcare workers and designers, as well as growing understanding of each others' skills and experience marked the positive group dynamic that developed during the main business of design and informal conversations in breaks.

Three main understandings emerged from the workshops to shape design recommendations. The first was that the childcare workers disliked the childish imagery often used in information directed at them, which they felt placed them on the same level as the children they cared for rather than addressing them as adults and professionals. They suggested asking children from each center to make drawings about cleaning as a visual resource for design, children's art being an important part of their day. From these drawings, the workshops developed four icons to identify information impact on health, environment, water use and explanations of cleaning products and processes, believing these to be respectful to and engaging for all members of a center community, children, parents and staff *(figure 6)*. The icons' perceived role was to enhance awareness of the key aspects of the information to be delivered and provide a basis for a SASI Clean identity system *(figure 7)*.

[38] Tuuli, M.M. and S. Rowlinson. 2009. Empowerment in project teams: A multilevel examination of the job performance implications. *Construction Management and Economics*, 27.5, 474.

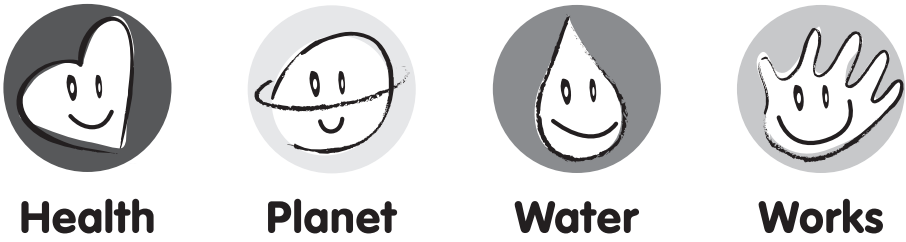

Figure 6
Prototype designs for SASI Clean icons. Copyright: the authors.

Figure 7
Prototype design for a SASI Clean manual. Copyright: the authors.

The second important idea was that information on low-chemical cleaning needed to be configured for a range of tasks and delivery points. A single manual was too detailed for use in the children's rooms by busy staff, but one comprehensive, updatable manual was needed in the director's office to refresh knowledge, explain policy and procedures at accreditation time, and as a reference in selecting cleaning products. Digital technology would be useful to update information, but was not applicable where workers were caring for children. Posters could reinforce a center's commitment to low chemical cleaning, declaring this to parents and at accreditation time, but information on cleaning procedures had to be linked to cleaning tools and products.

The childcare workers also felt that once a facility became an endorsed SASI Clean center and its workers were trained in low-chemical cleaning, permanent staff would not need to consult cleaning information daily. However, cleaning routines could lapse when relieving staff substituted for absent workers, as happened regularly. Relievers needed orientation just as children were arriving at the start of the day, explaining a center's ways of doing things often became a rushed, incomplete process. A shortage of casuals meant that centers had difficulty attracting relieving staff. The workshops recommended that a set of SASI Clean cards be developed to give to relievers to hang from their belt or put in a pocket. These would support the low-chemical cleaning initiative and address the common problem of relieving staff feeling uncomfortable about not knowing what to do, a number of workshop participants having experienced this when they worked as relievers. The customizable cards could include other information about a center, being something casual workers could take away with them, creating a connection with a center that might encourage them to work there more regularly, simultaneously addressing several problems for center staff.

The third innovation to emerge from the design workshops was the potential for dialogue and group activity to encourage commitment to low-chemical cleaning. In exchanging anecdotes, information and opinions during the workshops, the childcare workers became noticeably more positive about the value of low-chemical cleaning, increasing the design team's interest in the information to be communicated. The group decided to design the majority of information materials as digital templates *(figure 8)*. Specific center staff would attend a SASI Clean training program, returning to their centers as cleaning ambassadors with a kit of customizable information materials that staff could use to formulate their own steps for cleaning instead of having these dictated, allowing the innovation on low chemical cleaning to take on individual forms as it spread. We addressed the failure of existing improvized labels by proposing laminated swing tags for bottles of cleaning solution, laminating and color printing being inexpensive technologies found in most childcare centers. There was discussion about whether tags would get in the way during cleaning, but it was felt this would mean they were noticed, while blurred, peeling paper labels were easily overlooked.

Figure 8
Prototype for customizable labels. Copyright: the authors.

THE FORM/CONTENT DIVIDE: STAKEHOLDER RESISTANCE TO THE DESIGN RECOMMENDATIONS

Graphic design is currently challenged to accommodate the broad restructuring of societies around differentiation, diversification and distributed systems, each placing greater emphasis on the human dimension in communication. It is thus not surprising that Carroll describes participatory design as a "major, orienting position in contemporary debates about design methods."[39] In the SASI Clean study, harnessing the capacities of critical reflection and decision-making that characterize the psychological makeup of the modern, autonomous individual seemed crucial when the aim of communication was to influence people to change their attitudes and actions. Otherwise, tasks in the study were divided according to participants' professional expertise, the steering committee meetings providing the common space in which the different disciplines working on the study brokered a collective response to its goals. Nevertheless, the steering committee reflected the centralized, bureaucratic structure of the childcare sector. Childcare workers were not included, although their input into the scientific testing and design created the sense that their views were present.

Ultimately, however, the challenge of engaging with the otherness of other knowledge systems became a barrier to the acceptance of the design recommendations. Members of the steering committee resisted the need to diversify information delivery, preferring a standard manual to be provided for each center setting out the facts about cleaning and standardized wall charts for individual rooms to fix cleaning procedures. The idea to target information to relieving staff was the least accepted proposal, although it was the core issue for the childcare workers. For the childcare workers participating in the design workshops, the fact that outside people could come in and do whatever they liked affected everything in their workplace, encapsulating their feelings of lack of control at work and the hidden emotional dimensions in information delivery. Yet including childcare workers in the design process did not eliminate the question of who decides which, if any, design ideas would be acted on. Bravo arguing that in participatory processes there is "a big difference between making suggestions and making decisions … between having the right to participate and having power."[40]

Heartened by our sense of the success of the participatory workshops, we had not predicted this response from other project stakeholders. We now recognize that when the views and needs of people are given primary importance in design, organizing bodies, project funders and managers can become distanced from design

[39] Carroll, J.M. 2006. Dimensions of participation in Simons design. *Design Issues*, 22.2, 3-18.

[40] Bravo, E. 1993. The hazards of leaving out the users. In Schuler, D. and A. Namioka, editors. *Participatory design: Principles and practices.* Mahwah, NJ: Lawrence Erlbaum Associates, 5.

proposals. Owens, for example, has studied decision-making in seemingly non-hierarchical design teams.[41] He shows that high status individuals have the biggest impact on which designs are produced, not the identification of specific design goals, middle- and low-status contributors have little influence over design. Lacking direct insight into the practical and emotional parameters of the childcare workers' experience, the other stakeholders' limited enthusiasm for the design recommendations risked the success of a future SASI Clean accreditation scheme. Indeed, Lockwood, Bachman, Oldach and Rutter highlight the vital link between people's involvement in design and their ownership of design outcomes through the example of a project where visual displays were designed to save time and enhance the selling process for retail staff. The views of the overworked sales staff were not sought during design and in many instances they didn't even bother to unpack the merchandising displays once delivered.[42] Lockwood and his co-authors argue that how and when people become involved in the design process is as important as the design solution, motivated stakeholders being essential to successful design implementation.[43]

In the SASI Clean study, broad stakeholder involvement in design would have been difficult, the various experts being busy with other facets of the study and their other work. However, the devaluing of the results of a rigorous program of participatory design left us wondering whether childcare workers' participation in the study was mere lip service. Commitment to participatory processes is questioned in other social spheres, suggesting their use is not always to improve outcomes for people, Barnes, Newman and Sullivan report that often "Participants in NGOs, community groups and social movements find themselves invited or encouraged to take part in state-sponsored participation initiatives which aim for consensus building and seek to minimize protest."[44]

Expert stakeholders in the SASI Clean study maintained an allegiance to the content of information on cleaning and infection control. For example, they saw scientific data produced during the study on the efficacy of dilute detergent by comparison to the potential risks of stronger cleaning products as compelling reason for workers to adopt low-chemical cleaning. Yet the characteristics of scientific propositions are defined by the parameters and legitimation methods of disciplinary knowledge. For Jean-François Lyotard the increasing complexity of standards of scientific proof has seen scientific knowledge conflict with the nature of "traditional knowledge or knowledge based on revelation," placing it outside most people's experience.[45] Arguably, the form of information is an issue in influencing cleaning practices in childcare, advertising strategies for

[41] This research is cited in Walton, T. 2000. Design management as a business and academic discipline. *Design Management Journal*, 11.4, 7.

[42] Lockwood, T., T. Bachman, M. Oldach and B. Rutter. 2001. Perspectives on communicating the value of design. *Design Management Journal*, 12.3, 76-83.

[43] Lockwood *et al*, Perspectives on communicating the value of design, 78.

[44] Barnes, M., J. Newman and H. Sullivan. 2006. Discursive arenas: Deliberation and the constitution of identity in public participation at a local level. *Social Movement Studies,* 5.3, 193.

[45] Lyotard, J-F. 1984. *The postmodern condition: A report on knowledge.* G. Bennington and B. Massumi, translators. Minneapolis, MN: University of Minnesota Press, 44.

[46] Gilbert, G.N., and M. Mulkay. 1984. *Opening Pandora's box: A sociological analysis of scientists' discourse.* Cambridge, UK: Cambridge University Press, 40.

the promotion of high-chemical cleaning products is more effective than the factual approach of Australia's National Health and Medical Research Council in promoting low-chemical cleaning. However, the design workshops also found both advertising and science conflicted with the received wisdom of older childcare workers, who reported that in the past it was always believed that fresh air and "elbow grease" solved the problems of dirt and germs.

The SASI Clean study showed poor information design created doubt over the efficacy of low-chemical cleaning in the scientific testing. Childcare workers saw great variance in test results for bacterial loads for surfaces cleaned with existing products in Room 2 and those treated with low-chemical cleaning methods, when in fact the difference was infinitesimal *(figure 9)*. Here, the scientists and designers held conflicting perspectives on the nature and purpose of information and visualization, the scientists' preference for an "empiricist repertoire" in the representation of test results arguably building on a sense that childcare workers, as passive semiotic recipients, would be unlikely to dispute science facts.[46] For us, the needs and preferences of childcare workers defined the form and role of information, ensuring that information would be acted on.

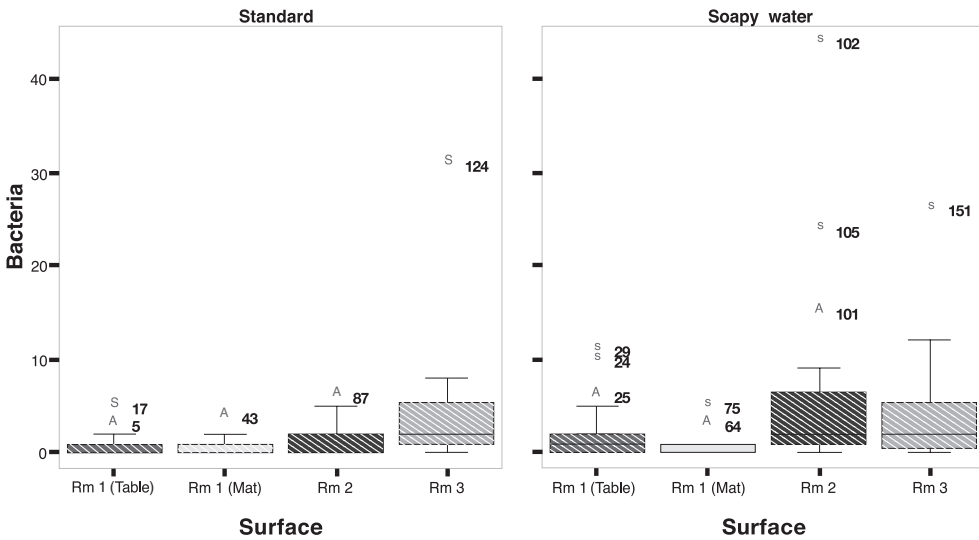

Figure 9
Bacterial load for Total Plate Count Agar for Centre 1. Louise Dunn and Enzo Palombo, Faculty of Life and Social Sciences, Swinburne University of Technology. Reproduced with permission.

CONCLUSIONS

Frascara argues that knowledge of graphic design will only emerge from "the recording of design practice as systematic case studies," though he adds that substantive reflection on methods already in use in graphic design will not arise until designers address their "fear that sharing will 'give away' some perceived competitive edge."[47] The implications of reporting design failures are undoubtedly an additional hurdle to building knowledge in design in this respect. Our mistake in the SASI Clean study was to assume that a public project would inherently favor participatory design; the commitment to socially beneficial outcomes and the absence of the profit-motive naturally would prefer innovative design proposals supported by rigorous audience research.

Pervasive representations of design highlight its social value. Nelson and Stolterman describe design as a form of thought and action that precipitates change, while Cross represents design as a particular set of cognitive processes dedicated to formulating, structuring and solving problems.[48] Frascara describes future graphic designers as advisors, coordinators or guides, who will support users and decision-makers to achieve what is required through their original analysis, creativity, realism and experience in working with people.[49] For Spinuzzi, the broad adoption of participatory design will enable designers to understand the tacit and often overlooked ways in which people conduct and understand everyday activities.[50] Strickler and Neafsey contend there is great scope for designers and design researchers to contribute to audience research in public health communication, given the mounting prominence of visual media and technology.[51]

For us, the use of participatory design in the SASI Clean study modelled a socially engaged form of design practice that responded to the complexity of information delivery by engaging the specificity and diversity of the communication task. But the culmination of the design process coincided with major difficulties in other aspects of the study. Identifying the active ingredients of cleaning products and their confirmed health and environmental effects had become an endless task, complicated by a range of legal issues. Despite information resistance being an important driver for the study, the design recommendations and the considered, people-focused methods used to arrive at them struggled to command attention with the deadline for final project reporting looming. The design prototypes have not been as rigorously trialed as we had hoped. Certain elements of the design proposals and other design work we completed for the study were incorporated by the project manager into a set of SASI Clean

[47] Frascara, *Communication design*, 60.

[48] Nelson, H.G., and E. Stolterman. 2003. *The design way: Intentional change in an unpredictable world: foundations and fundamentals of design competence*. Englewood Cliff, NJs: Educational Technology Publications; Cross, N. 2006. *Designerly ways of knowing*. London, UK: Springer-Verlag.

[49] Frascara, *Communication design*, 8.

[50] Spinuzzi, The methodology of participatory design, 163-174.

[51] Strickler and Neafsey. Preventing drug interactions in older adults, 102-124.

[52] Available at http://www.sasiclean.com.au/pdfs/SASIclean_Guidelines_Protect_ Health_Mar.08_Brief.pdf. Accessed December 9, 2008.

[53] Bayazit, N. 2004. Investigating Design: A review of forty years of design research. *Design Issues*, 20.1, 22.

guides available over the Internet, our icons being used along with generic clip art to embellish information dense pages[52] *(figure 10)*. This outcome suggests that graphic design is often perceived as the decoration of information, not a process integral to determining its conceptual and strategic forms.

In the SASI Clean study, we were confident in our ability to deliver effective, informed designs based on the centrality of the childcare workers to the design process. We neglected the relationship of other study stakeholders to design. Rittel and Webber's 1973 treatise on the cascading nature of design problems describes a chain of questions that can't be defined until their solutions are found, each solution creating new questions to be addressed.[53] In the SASI Clean study, the delivery of the design recommendations revealed the problem of how to communicate the results of participation to other study stakeholders so they would find them compelling. This was a failure based on our assumption that other stakeholders would not question our expertise in design, or the authenticity and importance of the childcare workers' views and situation. Indeed, Owens argues that an emerging task for the designer researcher is to develop strategies to manage perceived differences in status between the various participants and stakeholders in projects, a view our experience in the SASI Clean study confirms.

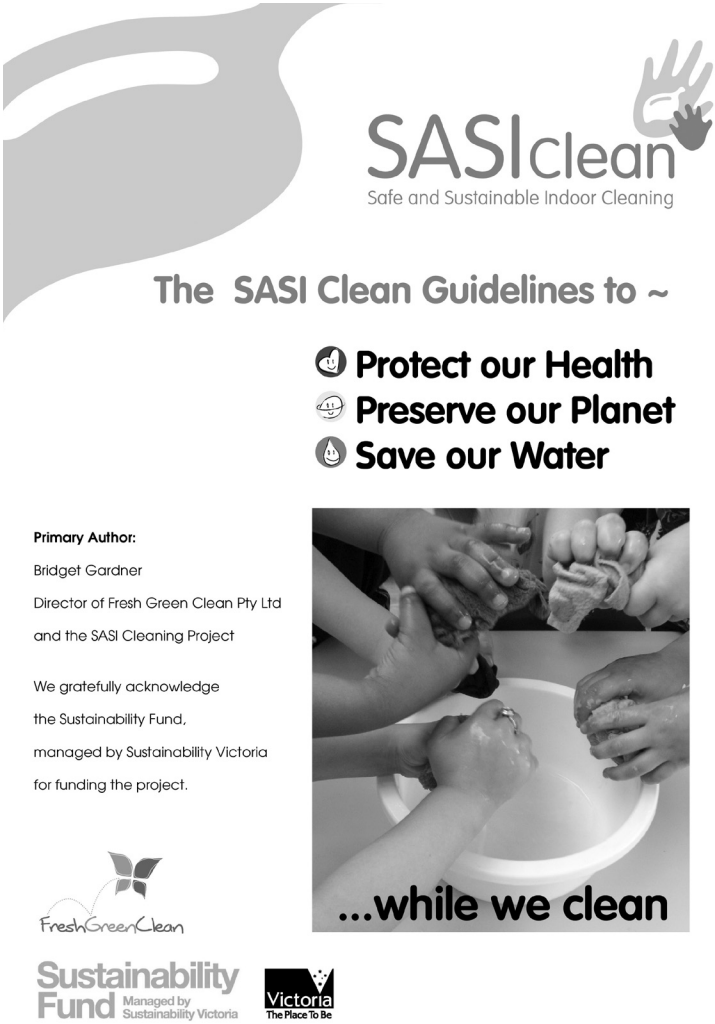

Figure 10
Improvised use of design materials.
http://www.sasiclean.com.au/pdfs/SASIclean_Guidelines_Protect_Health_Mar.08_Brief.pdf.
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LESSONS FROM THREE MILE ISLAND: THE DESIGN OF INTERACTIONS IN A HIGH-STAKES ENVIRONMENT

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ABSTRACT

Complex systems with mediated control at a distance are explored using the Three Mile Island nuclear accident of 1979 as the focus. In such a high-stakes environment, representations of operations are critical to support human-machine interactions and monitor safe operations. A time-line of the critical first minutes of the event is presented and an analysis of operations in the control room from a communication perspective point toward principles for a better design. While the case of Three Mile Island is well documented from an engineering perspective, its relationship to communication design and interaction design provide insight with regard to necessary collaboration across disciplines.

The major difference between a thing that might go wrong and a thing that cannot possibly go wrong is that when a thing that cannot possibly go wrong goes wrong it usually turns out to be impossible to get at or repair.

Douglas Adams, Mostly Harmless – Hitchhiker's Guide to the Galaxy Book 5 (1992)

At 4:00:37 a.m. on March 28, 1979, the Three Mile Island nuclear power plant near Harrisburg, Pennsylvania, encountered problems in the reactor cooling system that initiated the first, and to this day most severe, nuclear accident on U.S. soil. In its course, the second reactor of the plant (TMI-2) underwent a loss of coolant accident that resulted in severe reactor damage and the release of radioactivity into the environment. The release of radioactive material and threat of a nuclear catastrophe drew large-scale public alarm and political attention. Irreversible damage and severe contamination of the plant led to significant clean-up costs. Public protest and the ensuing discussions about safety, open communication and emergency response strategies made the Three Mile Island accident a significant event in the debate on the future of nuclear power in the U.S. The nuclear power industry, regulatory boards, emergency response authorities, the state of Pennsylvania and the nation all found themselves confronted with a technological accident of scale and public impact previously unknown. Extensive accident reports (Kemeny, 1979; Rogovin, 1980) prepared by the government and the Nuclear Regulatory Commission, along with various long-term studies of the effects of the accident, provide multiple, detailed perspectives on its causes, consequences and impact (Walker, 2004).

During investigations in the aftermath of the accident, the design of the control room was identified as a significant cause of the accident. The design and arrangement of information displays and controls in the control room confused operators about what was going on and negatively affected decision-making during critical phases of the accident.

Better integrated visual displays of plant status, safety margins and trends of operations could have prevented this severe nuclear accident which permanently damaged a $900 million nuclear reactor, caused clean-up costs of nearly one billion dollars and potentially could have harmed thousands of people.

Thirty years later, findings from the examination of the control room are still as important as they were when an international community of human factors specialists and systems engineers were surprised by the magnitude of the accident (Woods et. al., 1994). Insights gained from the accident at Three Mile Island have led to better design in the control room systems that followed it, preventing similar breakdowns (with perhaps even larger consequences).

The exploration of the Three Mile Island accident reveals how interaction design and information display in the control room broke down during the dynamic development of the accident when many events took place both sequentially and in parallel at a very fast pace. Poor information representation played a key role in decision making of the control room operators during their response to the many problems that confronted them. The problems emerged rapidly during the initial five minutes of the accident beginning at 4:00 a.m. and caused critical follow up problems for the next 150 minutes during the development of the accident. The patterns of interface failure that occurred during these initial hours of the accident are representative for design challenges in high-stakes work settings where technology supports the work of expert practitioners. Besides nuclear power plants, the observed patterns apply to the design of human-computer interactions in related high-stakes environments such as chemical processing plants, flight deck operations in aviation, the control of space systems and the management of anesthesia during surgery.

The successful design of interactive systems in these high-stakes domains relies on a synthesis of design principles in a concurrent, interdisciplinary design process that converges a) the design of human-computer interactions with insight from research on the complex behavior of technological systems and b) the evaluation of process control systems in work settings and the study of patterns that govern the cognitive aspects of work supported by (computerized) machines. The conditions of work are driven by human factors, the design of artifacts, procedures and organizations that determine training, operations, regulations, maintenance and licensing in the work domain.

When the TMI-2 control room failed to provide effective information representations that guided the response interactions of control room operators three decades ago, researchers and designers realized that they needed better models for the relationship between humans and machines in control rooms. This initiated new types of studies on the relationship between visual information display, human reasoning, interventions and the constraints that technical systems impose on sense-making strategies—as a result, previously engineering-centered approaches to control room design began to open more towards a

Figure 1
The Three Mile Island-2 control room on April 3, 1979 (National Archives photo no. 220-TMI-DE9040061-13).

multidisciplinary approach. Design teams today involve human factors researchers, work study specialists, psychologists and designers. This change happened slowly and was driven by new types of challenges that were the result of the introduction of new technologies at the interface between human operators and automated systems. With the massive deployment of computerized systems into process control that began in the late 1970s and continued to transform all human/machine interaction settings during the 1980s and 90s, Human Factors Engineering shifted focus from physical ergonomics towards psychological human factors and began to address cognitive processes behind reasoning, explanations and expectations. Immediately following the accident, the study into the aftermath of Three Mile Island marked the birth of a new interdisciplinary field in which design converges with research and engineering: Cognitive Systems Engineering (Hollnagel and Woods, 1983). The breakdown of information display and communication in the control room at Three Mile Island alerted designers of information displays and control interfaces to the importance of supporting operators in coping with complexity. This insight was based on studying how operators make sense of events and how they respond to anomalies amidst uncertainty when they monitor and control systems (Rasmussen, 1979; Rasmussen and Rouse 1981; Klein, Orasanu and Calderwood, 1993; Hutchins, 1995a, 1995b; Klein and Zsambok, 1996; Vincente, 1999; Woods and Hollnagel, 2006).

Human-computer Interaction (HCI) as a focus in Computer Science and Engineering, Psychology, and Informatics marks one of the most important movements over the past two decades towards a multidisciplinary science for interactions supported by computerized systems (Card, Moran and Newell, 1983; Carroll, et. al., 2003). In parallel, the formation of Usability Engineering (Rosson and Carroll, 2002) is a response to the need for assessing the effectiveness of interactions during a concurrent, iterative design process. Concurrent design practice (Roesler et. al., 2005) illustrates how a diverse set of engineering, research, and design skills is a central requirement in the development of interaction technologies. One central thread in current advances in HCI is the role of visualization in the communication of complex information, in particular in all instances where information is driven by dynamic change over time. But visual form alone is not the only reason why HCI developers are beginning to collaborate closer with designers—designers contribute new design techniques to the development of software and complex technology that provide early evaluation and feedback for design concepts before realization commitment is made (Buxton, 2007).

While Visual Communication and Industrial Designers are experts in establishing visual systems for non-verbal communication, the emerging field of Interaction Design trains visual designers in developing interaction sequences that are useful, usable and understandable. Interaction Designers draw insight from participatory design techniques such as contextual field studies, rapid prototyping and feedback from concept evaluation in a concurrent and iterative design process. Another area of design expertise is the inherently human-centered perspective in the design of technology systems to elicit understanding of how practitioners and users make sense of new interfaces and interactions. To develop interactive systems in a participatory design approach with prospective users, designers apply rapid prototyping and early mock-ups combined with scenario-based design techniques such as storyboards and video prototypes to elicit feedback about designs in progress. Insight from design field studies, but also empirical findings from experimental studies in HCI and Cognitive Science (Hutchins, 1995b) provide the linkage between research, design and technology. The design of interactions in control rooms is driven by the dynamics of work, comprised by the expertise of operators and advisers, operations procedures and the technology that constrains represented processes and representation media.

Nuclear power station control rooms are a perfect example for a high-stakes environment where design requires an integration of these various design, research and engineering fields—a context where design challenge is characterized by high workload and high cognitive demands. Trained operators apply expert knowledge to interpret current situations, calibrate plans for actions and assess possible future consequences of interventions. From a research perspective, expert domains such as control rooms are well studied and documented, since they present highly structured environments where design and operations failures have severe consequences. Training materials, operations procedures and secondary research are available to guide better design practices and avoid error.

The following section on the sequence of events of the Three Mile Island nuclear accident illustrates the complexity of a high-stakes environment work setting. The accident marks one of the well-documented design failures of interactions between human operators and a complex technological system—a case that illustrates the dynamics of operations during anomaly response. Communication failures that emerged in the course of the accident cannot be attributed to a single design error, nor could the overall failure have been prevented by a single design intervention. The Three Mile Island accident was a systems breakdown that emerged from the alignment of several

critical factors that created an extremely brittle situation in which it was easy to make mistakes. As such, the design problems of the control room illustrate the need for a systematic and interdisciplinary design approach to respond to the multifaceted needs for a better interaction design of process monitoring and useful, understandable and usable information representation.

At the advanced level of information interpretation—such as is captured in the following sequence of events—it is crucial for designers to understand the relationship between information representation, the behavior of the system represented and interpretation strategies that operators apply to find explanations that lead them to coordinate interventions.

THE SEQUENCE OF EVENTS

What went wrong in the control room of Three Mile Island? Many accounts of the accident at Three Mile Island-2 provide oversimplified descriptions of the accident. This is endemic to analyses of complex systems failure (Feltovich, Spiro and Coulson, 1997). When analysts fail to understand the intricacies of a system, they may adopt the point of view that nothing is wrong with the system and resort to 'human error' as a cause for what went wrong with a system that performed as designed. To understand the nature of design error in the TMI-2 control room, it is important to understand what caused the complicated situation and how cascading events had rendered information display in the control room insufficient, which in turn led to misinterpretations and confusion about what was happening. The operators in the control room were forced to make decisions in the face of uncertainty.

In a nuclear power plant, a pressurized water system transports heat from the reactor to electric generators *(figure 4, numbers in the following refer to this diagram)*. In the course of this transport, hot, pressurized water from a contained primary cooling system streams through the reactor core (1) and heats water in a (non-nuclear) secondary system that is coupled via steam generators (3) with the primary system. Steam from the steam generators runs a steam turbine (4) and in turn runs the electricity generators (5) for electrical power generation. After giving off heat in the turbines, the steam is condensed (6), cooled down in the cooling towers (7) of the plant and fed back (8) to the steam generators, where it is heated and converted into steam by the heat from the primary cycle.

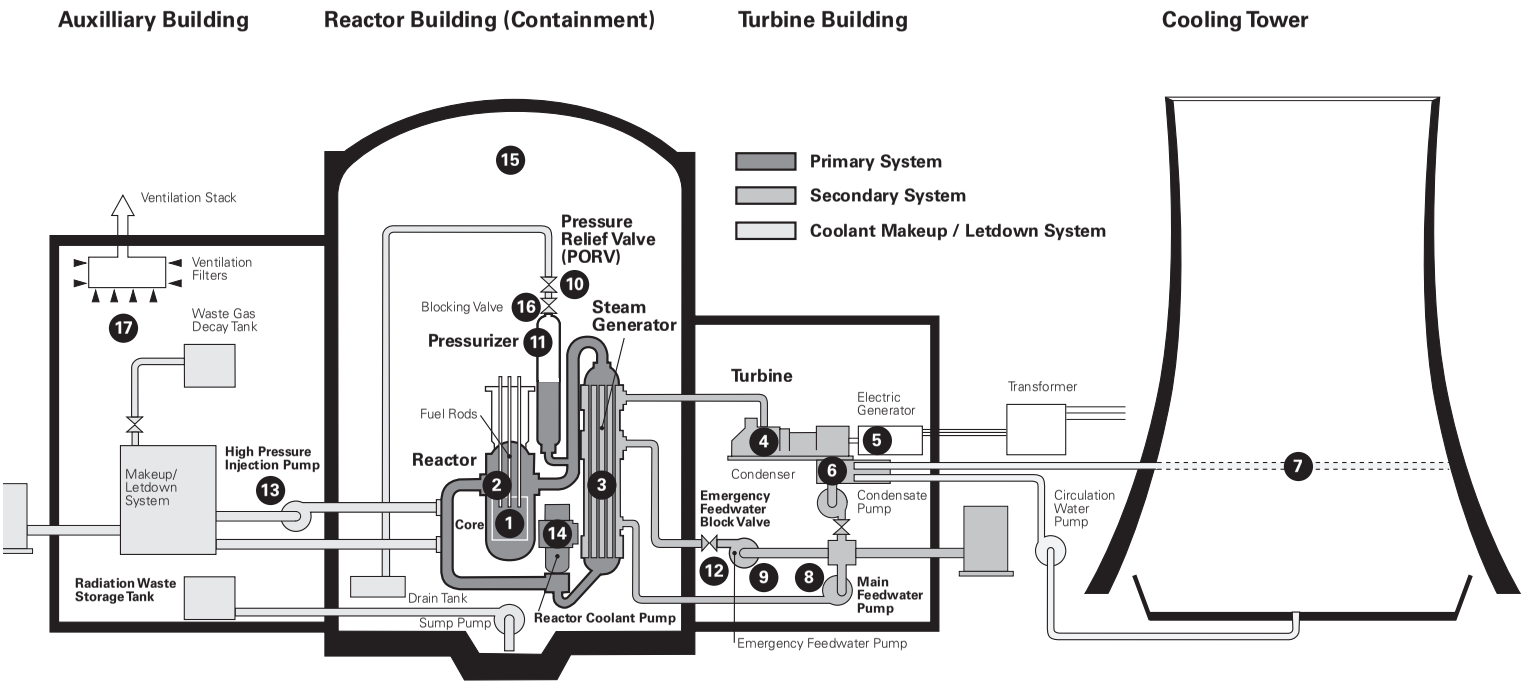


Figure 2
Schematic of the Three Mile Island-2 nuclear power plant (adapted and reprinted from IEEE Spectrum 16, A special report. (November 1979) - (© 1979 IEEE). Reproduced with permission.

The Three Mile Island accident began five hours into the graveyard shift. At 4:00 a.m. on Wednesday morning, March 28, 1979, the two main feedwater pumps (8) in the secondary cooling system for the reactor had been shut down by plant automation. Water flow, into the air system of the plant during maintenance activities in the hours before the accident, might have led to the automatic tripping of the pumps. With the feedwater pumps shut off, the turbine (4) was tripped by the plant safety automation to prevent it from boiling dry, as new feedwater couldn't be added into the steam generators to produce steam for the turbine. Emergency feedwater pumps (9) were started automatically. With the loss of the turbine, heat transfer from the primary to secondary system was stopped. This led to an increase of coolant temperature, volume and pressure in the primary cooling system. A pilot operated pressure release valve (PORV) (10) opened automatically to release pressure. Safety systems automatically initiated a scram (automatic shut-down) of the reactor (2). All this happened within 8 seconds from the main feedwater pump trip.

As a result of the reactor shutdown, temperature and pressure of primary system coolant fell and safe pressure margins were regained. The opened pressure relief valve was designed to automatically close once safe margins were restored—but it did not. Indications in the control room, however, led operators to assume that the valve had closed. Unknown to the operators, the valve status light in the control room indicated not the physical valve state, but the flow of electricity that was applied to open the valve. As soon as the electric current to the valve was switched, the control light on the control room console went off. The valve, which normally would close automatically, was physically stuck in the full-open position. This pressure relief valve would play a critical role in the events that followed.

The water in the primary cooling system was normally contained under high-pressure and very high heat. The high pressure prevented the water from boiling at very high temperatures. With the release valve still open, the primary cooling system lost pressure. Unknown to the operators at this point, the secondary system was not operating as expected, as the emergency feedwater pumps (9) were not able to draw water due to shut downstream valves (12). As a consequence, less heat was extracted from the high temperature primary system, and pressure fell as a result of the stuck-open pressure relief valve. Plant safety features automatically initiated high-pressure injection pumps (13) into the primary system to restore high pressure. During this high-pressure injection, the operators monitored the coolant level in a pressurizer vessel (11). They were instructed during training to avoid a situation in which the pressurizer would completely fill up with coolant, and a rise in pressurizer water level

was expected during high-pressure injection. The stuck-open pressure relief (10) valve was located at the top of the pressurizer vessel (11), and the pressurizer steam bubble that under normal circumstances would prevent the pressurizer from filling with coolant had escaped though the open valve. The pressurizer vessel was filling fast and to avoid the pressurizer from going solid (filling up completely with coolant), the operators bypassed the plant emergency system and throttled the high-pressure injection flow. As a result of the throttling of the pumps, pressure in the primary cooling system could not be restored and continued to fall. Although the reactor was tripped, it still produced decay heat, which increased the temperature of the coolant. Now at low pressure and high temperature, steam bubbles began to form in the primary system around the reactor. Steam has a lower heat conductivity than liquid water, which reduced the cooling of the reactor. The expanding steam bubble at the top of the reactor vessel also led to an expansion of the coolant volume—forcing liquid coolant to rise into the pressurizer vessel.

The operators were confused by a high coolant level reading in the pressurizer vessel and a simultaneously low pressure in the primary cooling system. They were trained to take the water level in the pressurizer vessel as an indicator of coolant availability for core coverage—their first priority in the monitoring of the primary system, as the core had to be covered with coolant to extract heat. Under current conditions, where steam bubbles were forming in a low-pressure, high-temperature coolant—a condition referred to as saturation, pressurizer coolant level, was not an appropriate indicator for coolant inventory. Routine training did not prepare the operators for this assessment, nor for operating the primary cooling system under saturation. They did not have a clear indication that steam was forming in the primary cooling system. They were not aware that the core was undergoing exposure. No instrumentation was available to indicate that the core had entered a particularly critical state.

The high pressurizer coolant level and low pressure in the primary cooling system could have been explained by the fact that the pressure relief valve was stuck open and the pressure was escaping through this steam leak—but the extinguished valve status indicator light on the control room console wrongfully indicated that the pressure relief valve was closed.

Hundreds of alarms sounded in the control room during these first four minutes of the accident *(figure 3)*. In the meantime, the operators realized that the secondary system backup feedwater pumps (9), which were activated by the safety automation after the initial feedwater pump failure, were not able to draw feedwater because of closed downstream valves (12), which were accidentally

left shut after a maintenance activity the day before. The lack of flow was detected 5 minutes into the accident and restored at approximately 8 minutes, but during this time the secondary system side of the steam generators boiled dry. The heat transfer from primary to secondary system was lost.

For the next hour, operators were consumed with bringing the secondary system back into operation. From previous experiences they knew that the secondary system tended to behave unreliably, while the primary system was considered robust. This understanding led them to focus on the recovery of the secondary system, which was complicated by problems in the condenser system (6).

At this point in the accident, the primary system had been in saturation for 54 minutes. The reactor coolant pumps (14) were pumping a two-phase mixture of steam and liquid coolant. This led to reduced flow rates and massive vibrations of the reactor coolant pumps. The operators determined criteria for shutting down these pumps and the criteria were soon exceeded. The operators were now faced with a conflict in keeping the pumps running to maintain primary coolant circulation or shutting them down to prevent losing the pumps altogether due to possible mechanical failure caused by vibration. The pumps were stopped 74 and 101 minutes into the accident, leaving the reactor coolant system without forced circulation. Attempts to establish natural circulation were unsuccessful due to the two-phase combination of the coolant and the low pressure in the primary system; little heat transfer was provided by the slow circulation.

The picture emerged that a steam bubble had formed in the primary system. Upon expansion, the steam bubble began isolating the core from coolant—this led to core exposure and initiated a partial core meltdown. But the operators were not aware of the beginning meltdown, as there were no sensors in the reactor core that could alert them, and no instruments available on the control boards that would directly indicate the health of the reactor. All temperature sensors in proximity to the core were indicating off-range readings of temperature. The operators tried to get information about the reactor status by integrating several information sources, but this process was both difficult and imprecise.

As a consequence of the beginning reactor meltdown, radiation levels increased in the reactor containment building due to steam that continued to be vented through the stuck-open pressure relief valve while primary coolant water became increasingly contaminated with radioactive products released from the melting core. The first radiation alarms in the containment building (15) were triggered at about 150 minutes into the accident.

The operators had realized, 138 minutes into the accident, that the pilot-operated pressure release valve (10) did not close automatically as designed—it was opened 3 seconds into the accident and was supposed to be closed 9 seconds later. Using a back-up blocking valve (16), they closed the PORV manually. This and another series of interventions allowed them to stabilize pressure and reactivate one of the emergency high-pressure injection pumps (13) to add coolant and recover the core. In the meantime, radiation from the containment building had spread into the adjacent Auxiliary Building (17) and had been distributed across the plant. A site emergency was declared at 6:56 a.m. due to severe radiation levels in the entire plant, followed by the declaration of a general emergency at 7:24 a.m. Over the course of the day, in a series of high-pressure injection flows and various depressurization procedures, the operators were able to re-activate circulation in both the primary and secondary cooling systems, leading to a stabilization of the reactor cooling system at 7:50 p.m.—15 hours and 49 minutes after the events that initiated the accident.

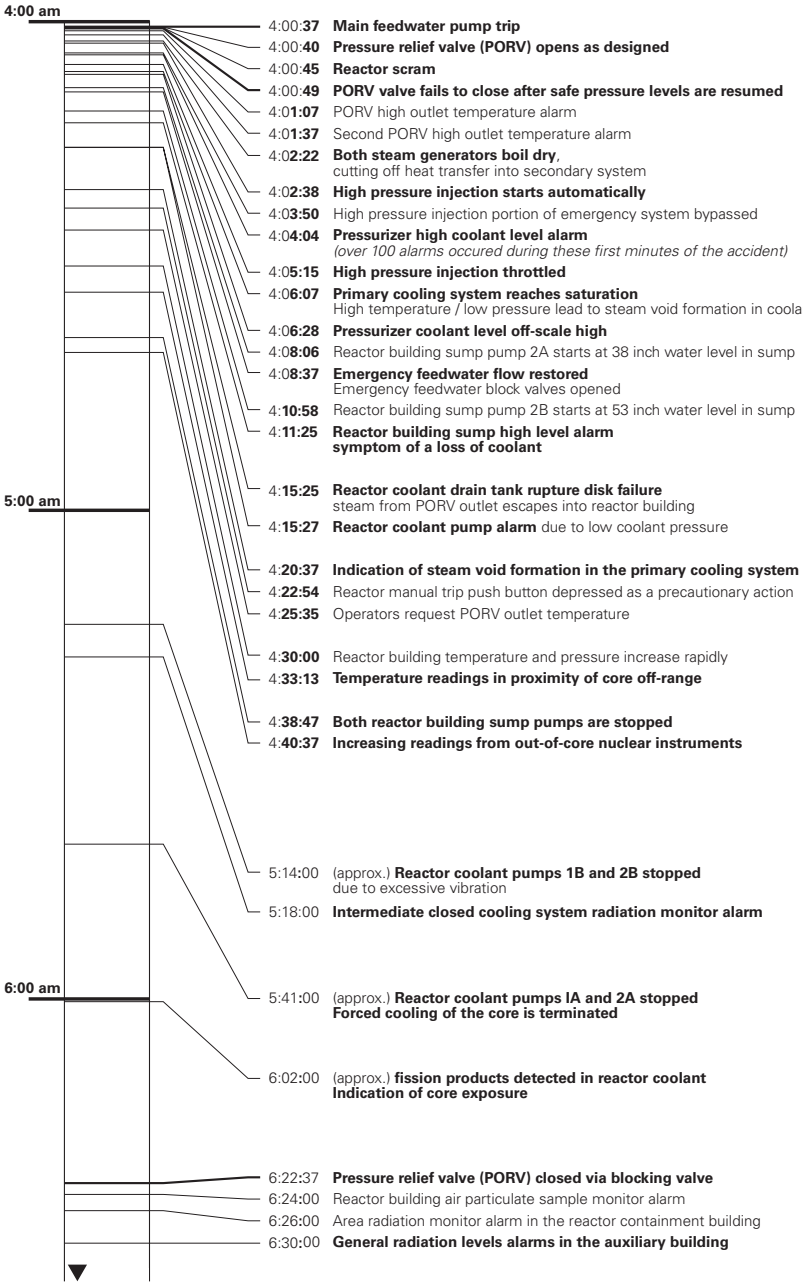


Figure 3
Timeline of a simplified version of the sequence of events during the initial 150 Minutes of the accident. Note the cascading of key events during the initial 5 minutes of the accident (For the detailed sequence of events, see Kemeny (1979), pp. 91-116, available online at http://www.threemileisland.org/downloads//195.pdf).

Even then the problems were not yet over, and in fact, worsened over the following days due to the formation of a hydrogen bubble in the reactor pressure vessel. The hydrogen bubble was the result of a chemical reaction between the exposed core and coolant. Experts were concerned that the bubble could lead to an explosion in the reactor vessel, posing the threat of a massive release of radioactivity into the environment and requiring the evacuation of 100,000 people in the area 20 miles downwind from the plant. This worst-case scenario fortunately did not become a reality, as there was no oxygen in the reactor present to make an explosion possible. During the assessment of the dangers of the hydrogen bubble, experts had found themselves confronted with a new situation, as very little was known about the science of a reactor after extensive core exposure.

It would take almost a month before the reactor was stabilized. Analysis of the reactor core nine years later in 1988 revealed that one half of the core had melted during the early stages of the accident. Many experts were surprised that the reactor vessel had not been breached by the massive meltdown. Today, the reactor remains nonoperational. The damaged fuel was removed in 1993, and the reactor is today in monitored cold storage operation. TMR-1, the other reactor of the plant, which had been shut down for refueling shortly before the accident, remained closed after the accident, but resumed operation in 1986.

THE TMI-2 CONTROL ROOM AS AN OPERATIONS-CRITICAL SYSTEM

Control rooms impose unique design challenges: information that is required to steer processes in the event of a disturbance needs to be presented during the situation when it is needed and in a format that is useful.

The design of a nuclear power plant makes direct observation of events impossible. Buildings, pipes and barriers obscure the key processes, that drive critical conditions. Configurations are large in size and located at a distance. The reactor core is contained in a 36 foot tall reactor pressure vessel made of 9 inch thick steel. It contains 100 tons of nuclear fuel. Two steam generators, each 73 foot tall and the reactor cooling system, comprised of room size pumps, man hole diameter pipes, storage tanks and blocking valves, are controlled remotely. To monitor information from a complex system of components that are spatially distributed but functionally related, thousands of sensors are located across the plant. At Three Mile Island, 2,400 displays represented the read-outs of these sensors.

The control room at Three Mile Island-2 was the product of a bottom-up engineering approach. Because the designers of the plant had assumed that a number of particularly critical operational states were virtually impossible, many displays that might be required to cope with such "impossible" states were not included in the control room design. Instead of integrated displays that indicated the overall safety of the plant, the boards in the control room provided operators with thousands of displays and alarms. Each showed detailed states of separate components. Then the so-called 'impossible' happened.

In an attempt to patch together a larger picture of what was occurring, operators had to compare several displays, sometimes placed in random locations across the 900-square-feet of control boards—all this in the presence of hundreds of alarms being activated one after another first by a root cause, leading to follow-up alarms in the rapid pace of subsequent events that by then were already irreversible. Hundreds of alarms sounded within the initial minutes of the accident. The design of the control room made no consideration for how fundamentally different the operational demands would be during a non-typical situation such as this emergency.

During the formation of steam bubbles in the primary cooling system (an event that transformed operations into a status that was outside operations procedures), the control room performed as designed. Post-accident assessments of Three Mile Island from an engineering perspective state that all information was available in the control room to initiate the appropriate responses (Kemeny, 1979). Interviews with control room operators, however, tell a different story: Bombarded with hundreds of alarms and flashing lights during the first minutes of the accident, the operators were unable to distinguish important information from irrelevant data. Comment of one of the operators on duty during the accident in the early morning hours of March 28, 1979, quoted from the official inquiry following the Three Mile Island accident (Kemeny, 1979): "*I would have liked to have thrown away the alarm panel. It wasn't giving us any useful information.*"

Confusion arose because detail of singular data had been favored over establishing relationships between data in context. During advanced stages of the accident, available information was conflicting and desired information was not available. The designers of the control room had left it to the operators to identify what was important and to ignore what was irrelevant. In the course of several events that required responses, data from thousands of sensors in the plant was displayed on the control boards, but all this data was presented with no particular hierarchy, meaningful spatial association or context

showing its relationship to other data. A computer printer used to log all data read-outs was running hours behind, and the operators had to dump its memory several times to print out reports that they needed (Rogovin, 1980).

Key processes during the development of the accident could not be detected because temporal plots of data trends were not available and a big picture explanation of what was going on depended on the manual correlation of related data streams that were displayed on spatially separated control boards. At the core of these observations lies a dynamic visualization problem that resulted in an ineffective, opaque representation of events at a distance.

What had happened at Three Mile Island was a dire combination of disturbances and failures that the designers of the plant thought was impossible. Insufficient representation of the relationship between these failures, and trends of change resulting from the failures, obscured the severity of the situation.

The accident investigations developed alternative scenarios of the accident that pointed out that the development from disturbance into a serious accident could have been prevented if the operators had been able to detect the wrongfully open release valve (Kemeny, 1979). But this view reflects a typical hindsight bias: In the aftermath of a mistake, one can point to the causes of the error, as all consequences are known and the complete function of the system that has failed has been determined. What made the accident at Three Mile Island so difficult to control as it developed was that the operators were confronted with unclear, incomplete and conflicting information that was insufficient to alert them that they were dealing with a potentially dangerous situation well outside the safe boundary conditions for operations of the plant.

Other significantly complicating factors were the pacing and cascading of events, alarm escalation and the inadequate mapping between physical and functional relationships in the display of data. The combination of these factors led the operators to the formulation of a wrong mental model during anomaly response; this illustrates a deep conflict in the design philosophy of the control room: The control room was designed for normal operations—this rendered it insufficient for the display of operations-critical information during an anomaly when this information was needed the most.

ALARM ESCALATION RESULTED IN DATA OVERLOAD

Within seconds after the initial events of the accident, the control board lit up like a christmas tree. Important information was masked by the sheer quantity of hundreds of alarms that were triggered one after another (Woods, 1995). It was hard to distinguish important information from less relevant data, as critical pieces of information (indicator lamps for the closed valves downstream from the emergency feedwater pumps in the secondary system, for example) were masked by data from follow-up alarms. The operators were consumed by tracking side effects and follow-up complications—this sidetracked them from diagnosing the bigger situation they were in.

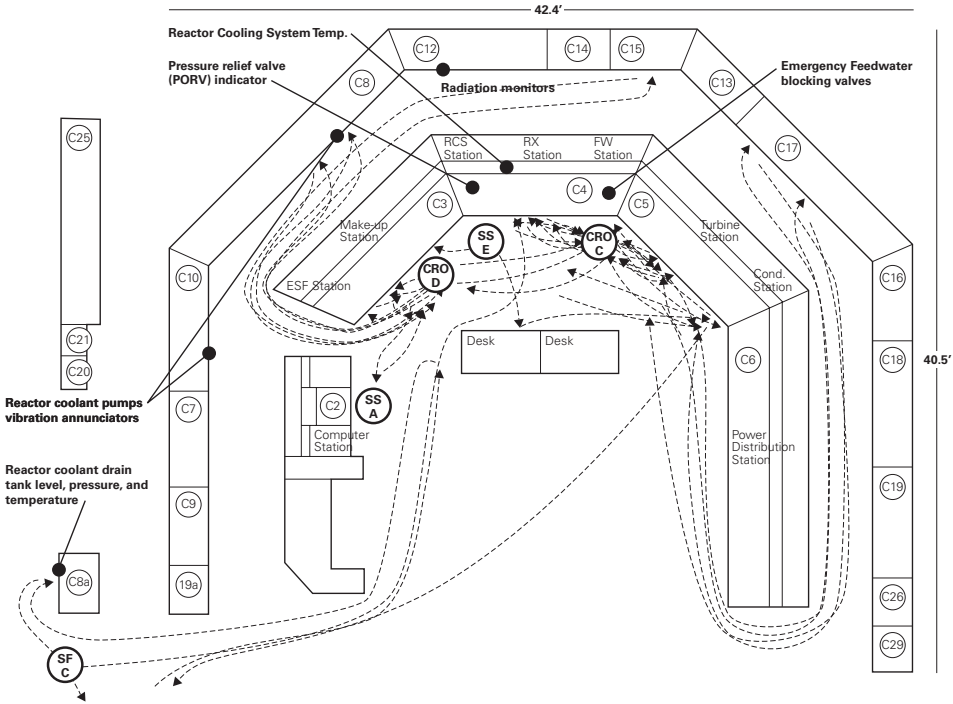
A number of the many alarms that sounded were known to be nuisance alarms, indications of unusual readings that were not operations critical. As a result, other critical alarms were dismissed. One example of this is the reading of the downstream temperature of the stuck-open pressure relief valve. The post accident reports point out that the operators should have realized that the valve was open by noticing an increased temperature reading downstream from the valve. But the operators knew that the valve was leaky, and they were used to high temperature readings downstream from the valve. Since the high temperature reading was discounted as a nuisance alarm, it masked the open state of the very critical faulty pressure relief valve.

INADEQUATE MAPPING BETWEEN PHYSICAL AND FUNCTIONAL RELATIONSHIPS IN THE DISPLAY OF DATA LED TO CONFUSION

The control room of the Three Mile Island nuclear power plant provided the interface for both information display and control interactions with the critical condition of the reactor. The control room provided the visual work environment for the team of operators: two control room operators, a shift supervisor and a shift foreman, who together needed to gather a shared understanding of the situation that was unfolding. This understanding was crucial to formulate plans and implement actions in order to bring the unstable state of the reactor and cooling system back to stable operations. The layout of the control room and arrangement of control panels required the operators to relocate their positions many times during the development of the accident (*figure 4*). Several instruments that required correlation with other instruments could not be monitored simultaneously, as they were located too far apart or were obstructed from the view of the operators by the control console (Malone, 1980). (For more photographs of the TMI-2 control room, including detail views of displays and controls, see the Human Factors review in Rogovin, 1980, Volume 2, Part 2, 573-612, available online as PDF at http://www.threemileisland.org/downloads//202.pdf.)

Several times during critical phases of the accident, operators came to wrong conclusions based on conflicting information displays. Comparison of separate displays was not only complicated by the location of the instruments, but also by the escalating temporal sequence in which changes of data occurred. As an example, backup information cues, that indicated the pressure relief valve indicator light, was a wrongful indication of the valve status from eight different sources, seven of which were indicated within the first and most dense 4 minutes and 30 seconds as the accident unfolded. Comparison between instruments was complicated by the random arrangement of displays and controls. The eight cues were scattered across the 900-square-feet of control panels, requiring the operators to correlate separate displays that were located on distant panels amidst hectic activities in the control room. One of the eight cues was a level indicator for the reactor coolant drain tank overflow. The indicator light was located at the rear of the control panel *(figure 4, C8a)*. The arrangement of displays and controls could have been greatly improved by a better mapping between the displays and the physical location and functional relationship of their corresponding sensors in the plant.

Three Mile Island Unit-2 Control Room
Panel arrangement and operator re-location during the initial 150 minutes of the accident



Control Room Features (approx. numbers)

Panel space ____ **900** sq ft
Controls ____ **1200**
Displays ____ **2400**
Integrated controls/displays ____ **1500**
Annunciators ____ **800**
Maximum viewing distance ____ **48** ft
Maximum walking distance ____ **50** ft

Acronyms:

ESF - Engineered Safety Feature
FW - Feedwater
RCS - Reactor Coolant System

CRO - Control Room Operator
SS - Shift Supervisor
SF - Shift Foreman

Panel Layout

Inner Consoles

C2 Computer console
C3 Auxiliary systems console
C4 Plant control console
C5 Turbine control console
C6 Electric control console

Back Panels (located outside of main control area)

C8a Reactor coolant drain tank panel
C20 Nuclear instrumentation cabinet No. 1
C21 Nuclear instrumentation cabinet No. 2
C25 HV & AC panel

Vertical Panels

C7 Fire detection panel
C8 Coolant systems monitoring panel
C9 Push-pull control panel
C10 Plant equipment temperature recording panel
C12 Radiation monitoring panel
C13 Engineered safety features panel
C14 Control rod drive panel
C15 Containment isolation panel
C16 Turbine supervisory panel
C17 Turbine auxiliary monitoring panel
C18 Staion electric auxiliary monitoring panel
C19 Vital power panel
C19A 500 KV control panel
C26 Diesel generator No. 1 panel
C29 Diesel generator No. 2 panel

Figure 4
Layout of the Three Mile Island-2 control room. Panel arrangement and operator re-location during the initial 150 minutes of the accident.

A better visual organization of the information displays with an integrated approach, showing relationships rather than isolated instances, would have greatly supported the operators' assessment of the most critical events that were going on unnoticed: reactor core exposure and subsequent partial meltdown. But the design relied on the operators to accomplish this integration. In the presence of everything going on, it was unlikely that the operators would have been able to construct an accurate 'big picture' of what was going wrong. The operators were asked to do the impossible.

THE WRONG MENTAL MODEL

Instead of attributing the overheating of the primary system to the fact that too little coolant was present (because steam escaped through the stuck-open pressure relief valve), the operators thought an abundance of coolant was present as a result of adding too much coolant during high pressure injection flow. This wrong mental model led them to underestimate the risk of reactor core exposure. The emergence of this wrong mental model can be explained with the information available at the time in the control room and instructions provided by operations procedures: The most unusual condition during critical phases of the accident was the indication of a high level of coolant (in the pressurizer vessel) and low coolant pressure—this was a set of indications that conflicted with the operations procedures that identified a loss of coolant accident (the type of accident that could lead to core exposure) as a situation during which operators would experience both low level of coolant and low pressure in the reactor cooling system. Instead, at Three Mile Island the high coolant levels at low temperature readings were due to a steam bubble formation in the low-pressure coolant. Under this condition, following operating procedures that used pressurizer level as an indicator for coolant inventory (in other words, whether the core was sufficiently cooled) would not apply (Malone, 1980).

Using the pressurizer level as an indicator of sufficient coolant inventory at the core led the operators to misinterpret the off-range high temperature readings of instruments close to the core. The instruments had started to display off range readings 6 minutes into the accident, but the operators thought that these temperature readings weren't off range, but that the analog instruments had stabilized close to the max reading. They thought core exposure wasn't possible due to the high level coolant indications, but they didn't know that steam formation had taken place, because an instrument that would integrate pressure and temperature of the coolant was not available in the control room.

There were indirect indications that saturation had taken place—these included severe vibrations read-outs from the reactor coolant pumps approximately one hour into the accident. Again, data overload made the detection of this excessive vibration difficult, because the instruments were buried in the large number of other displays and active alarms.

KEY SAFETY INFORMATION WASN'T AVAILABLE

However much the bias of hindsight would argue that all the information to make the right decisions had been available (it had just been difficult to see it on all the vast arrays of instruments and alarms that were constantly sounding), there was one central piece of information that was missing and that the operators could only infer from a number of proximity sensor read outs. The question was 'do we have coolant in the core'? This piece of information was central to the events going on because in light of the wrong mental model, the operators thought that enough coolant inventory would be available to extract heat from the core. But, unknown to them, a steam bubble had formed, exposed the core and pushed coolant into the pressurizer vessel.

Direct sensors at the core, coupled with alarms, would have alerted the operators that the core was exposed. The extreme conditions in the core made this type of sensing expensive, and the plant design assumed that the information of core status could be deduced from sensor read-outs in proximity to the core. As the accident progressed and the operators began to realize that steam formation had been under way, they began to suspect the presence of a steam bubble, but with the data they had available, they could not determine where the steam bubble was.

PLANT OPERATIONS LEFT SAFE BOUNDARY CONDITIONS

The control room was not designed to alert the operators that they had left the safe boundaries of operations. There was no indication in the instrumentation panels that plant operations were in the middle of a dangerous anomaly. During critical sequences in the accident development, the operators didn't realize that they needed the help of experts to cope with the situation they were in. They didn't know that operations procedures were no longer enough to bring the plant back into safety. Distorted information in the control room prevented complete awareness of the situation they were in. Communication lines between the control room and outside world were limited. Several times during the accident, reporters dialed directly into the control room.

The operators were not trained in operating the plant under the conditions they were facing. Analysis after the Three Mile Island accident showed that the control room simulator that was used to train control room personnel was not able to simulate the type of loss-of-coolant accident that actually happened (Kemeny, 1979). In fact, the computing power of the simulator was too limited to simulate the complex sequence of cascading events that affected the thermodynamic system during the accident. Nobody thought an accident of this kind was possible.

CONCLUSION

The larger portion about what we know today about human-computer interaction in high-stakes domains is the result of studies of design efforts gone wrong. Three Mile Island is one example of a number of accidents that have been thoroughly studied and documented. Understanding design error in these cases has produced new knowledge that positions us to better deal with design error in the future.

Design work in technology-intense, high-stakes domains requires the understanding of the reasoning strategies that human operators apply while working with computerized systems that represent tasks at a distance. This entails how the represented system adapts to change during interventions and how its constraints drive interactions—leading the resulting joint cognitive system response to change (Hollnagel and Woods, 2005). The complexity of the design challenges for supporting interactions between operators and control systems reflects the complexity of any controlled system itself: events, pacing and multiple perspectives of operators and automated systems during interventions are all subject to dynamic change and changes

are coupled across several layers of functional relationships in the affected system. Initial change can affect multiple relationships in a system in parallel. Interruptions can lead to cascading events and changes—both fast and slow—that are difficult to control (Woods and Hollnagel, 2006). On the other hand, very slow changes that affect the overall system significantly might be difficult to detect and/or control. They might form unnoticed, if the data change over time is progressing too slowly to be detected, or if changes that unfold are located outside the frame of view defined by the perspectives of operators and automation.

Control rooms align representation properties with systems properties and confront both with the challenges of mediated control at a distance. Control room information displays represent the status and trends of the remote processes that are being monitored. Operations in control rooms are the product of both human reasoning and machine support. To design effective representations of operations, we need to understand how operators form explanations based on the display of data. To do this, we need to fully consider the situation into which data is presented.

Well-documented cases of design error illustrate the role of context—environments, individual views, shared understanding and critical situations during failure; they form a knowledge base of control systems breakdown. Examples are the reports of the National Transportation Safety Board (www.ntsb.gov) on aviation accidents or the case of the Therac-25 accidents with a malfunctioning radiotherapy device that led to several fatalities during cancer treatment resulting from radiation overdoses due to software failure (Leveson and Turner, 1993). Murray and Cox (1989) and Mindell (2008) capture several instances of information display and automation failures in their history of mission control during the Apollo space missions. As a short list of interaction design failures in high-stakes environments that might particularly appeal to designers, these case studies illustrate the limits of technology-centric development and demonstrate the need for bringing more design expertise into human-computer interaction development teams to elicit the views of operators on the envisioned systems before the systems are realized—providing opportunities for developing the right systems the right way—which will result in artifacts and representation design systems that support the cognitive work of practitioners and help them cope with complexity.

Lessons from design error mark turning points in the design of automated control systems and have led to revised views about the roles of designers, human operators and computerized systems in process control. The popular attribution of 'human error' oftentimes is nothing more than an oversimplified account of cause and responsibilities—it provides little insight to improve the designs that lured operators into making wrong assessments. The conception of 'human error' contradicts the reality of the complexities and stakes of operations where expert practitioners work with technology-intense systems. When encountering error, these operators try the best they can to get the situation back under control. They are at the sharp end of the process, and they will be exposed to its consequences first and held responsible for operations gone wrong later (Woods et. al., 1994).

Designers on the other hand, are stakeholders from a distance. Any designed artifact that supports practitioners in making decisions is a stand-in for the designers of the system. The designers are responsible for their systems, even if they are not on site to guide operators through bottlenecks and challenges. Problems with the designed system, however, can be expected. Things that can go wrong will go wrong, and any artificial system can eventually be involved in a situation that is outside the terrain for which it was designed.

Therefore we must both anticipate error and design for error. Design for resilience supports operators in coping with errors by moving the likelihood of errors into protected territories in the design rather that making critical aspects of the design prone to error. This is especially important where outcomes of errors might be difficult to steer (Hollnagel and Woods, 2006). A good control room interface should provide operators with a 'big picture' of the situation the system is in. It should provide information of current status and trends, and it should indicate how the current status relates to expected outcomes, stable operations and the safe boundaries of operations. A good control room interface should not allow operators to steer a process into a catastrophe—in the worst case it might allow them to severely damage the plant. From this perspective, the Three Mile Island control room performed as designed. It reflected design and engineering knowledge at the time and its failure has laid the foundation for new contributions to knowledge in the aftermath of the Three Mile Island accident in 1979.

Newly designed systems will no doubt introduce new errors. Response strategies to cope with these errors may be as novel as the design that produced them, therefore, strategies for coping with error have to be part of the design.

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PAPER PROTOTYPES AND BEYOND

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ABSTRACT
Although approaches to user centered software development have existed for almost twenty years a rift still exists between theory and practice. In practice, many software projects are designed at the code level to the detriment of the endusers. Good Usability Engineering combines complex back-end functionalities with attractive, effective and efficient user interfaces. Successful interfaces minimize cognitive load and help users to achieve their goals. Goals can be defined in terms of intended outcomes which act as benchmarks for developing and testing functionality through prototypes. Paper-based prototyping bypasses the time and effort required to create a working, coded user interface. Instead, it relies on very simple tools like paper, scissors and stickers. However, to be a reliable guide, paper mock-ups need to model accurately the site's functionality and convey the right information.

This paper describes the challenges presented by a complex online information design project, an online research resource of over 45,000 records based on the catalogs of Exhibitions of the Royal Photographic Society 1870-1915. It describes how paper prototyping (used successfully previously) was used to address these challenges and reflects

on the problems that came close to derailing the project this time and their impact on the design and the design process. It concludes by considering a digital alternative to paper prototyping that offers similar ease of use and low cost, combined with the ability to quickly generate interactive mock-ups that overcome some of the limitations of paper prototypes.

INTRODUCTION

This paper is about usability engineering and rapid prototyping in Communication Design. Although approaches to user-centered software development have existed for about twenty years a rift still exists between theory and practice (Holzinger, 2005). Many software projects are designed at code level, to the detriment of end users. "Generally the last thing you want to do when beginning to design an interactive system is write code" (Buxton, 2007, 240). Good usability engineering combines complex back-office functionality with attractive, effective and efficient user interfaces. Successful interfaces clearly signal the affordances they offer (Norman, 2002, 87-104; Krippendorff, 2006, 111-114). Affordances are the perceived and actual properties of something that determine how it could possibly be used (Gibson, 1979, 127-135). Interfaces with clear explicit affordances minimize cognitive load and help users to achieve their goals (Krug, 2000, 11ff; Holzinger et al, 2008). Goals can be defined in terms of intended outcomes, and can be used as benchmarks or baselines (Brown, 2003) against which functionality of the design can be tested. If the intended outcomes of the design are clearly articulated, then the performance of the design can be tested to ascertain how well it supports those outcomes. In effect, all designs are tested after the sales launch. Sometimes they fail in use. An old but dramatic example was the Comet passenger jet aircraft. Launched in 1952 as the world's first jet airliner, the aircraft was withdrawn from service in 1953 because of serious structural cracks caused by metal fatigue (Dempster, 1960). Four years later when the redesigned aircraft was re-launched, the Boeing 707 had reached the market and went on to dominate domestic passenger jet aircraft sales. Less well-known but more recent examples are the circular mouse for the original iMac and the Power Mac G4 Cube (Buxton, 2007, 44). These examples show that performance failures don't have to be as dramatic as air crashes to matter. Norman (2002) describes a catalog of products including doorways, telephones, projectors, washing machines, refrigerators, radios, cookers, taps and hi-fi systems that frustrate their users. Also, designs don't have to fail in use to be unsuccessful. Well-known examples from the history of design and advertising are the Ford Edsel (Bonsall, 1992) and Strand cigarettes (Hackley, 2003). Both failed dramatically in the marketplace because of lack of understanding of the consumer psyche. The affordances they offered were not what the buying public wanted. The famous "You're never alone with a Strand" advertising slogan of Strand cigarettes was rejected by people who did not want others to think of them as lonely, inadequate and needing to seek company in a cigarette, even

though many smokers may have used a cigarette as a prop to boost their confidence in unfamiliar social situations.

Waiting to see how a design performs in the market is a high-risk strategy. By the time of the sales launch there has usually been considerable investment in design, production and promotion (Buxton, 2007, 75). A less risky approach is to test the design before significant investment has been made. Rapid prototyping is a well-established software engineering technique that attempts to address this issue by developing modules of code that can be tested early on in the design-development cycle (Leach, 1999). The advantage of rapid prototyping is that it enables real functionality to be tested objectively. It can help us to answer questions like "does the code work?" "Does it do what was expected or intended?" It can also be used to test user reactions to the design, i.e., "Does it do what users expect and want?" "Do they understand how to get data into and out of the model?" However code development, even rapid prototyping, can only be done when design ideas are relatively advanced, i.e., when what the design is intended to do is already agreed and the question is how best to achieve it. Thus while rapid prototyping is good at addressing "Comet"-like failures where the goal is agreed (a reliable, safe passenger jet aircraft), it is less helpful for "Strand"-like situations when what is required is not fully understood.

User-centered design helps us to deal with the latter kind of situation because it focuses on the needs, expectations and capabilities of the user and uses these to guide the design specification and solution (Katz-Haas, 1998; Vergo et al, 2001). The importance of user-centered design is amply demonstrated in the context of Web site design where people cannot find the information they seek about sixty percent of the time (User Interface Engineering, 2001) and badly designed sites lose repeat visits from forty percent of the users (Manning et al., 1998). This can result in wasted time, reduced productivity, increased frustration on the part of users and loss of repeat visits and revenue, increased training and increased support costs for site owners. Sites which have a clear purpose, are easy to navigate and search and which provide tools that help users to achieve their goals efficiently are more likely to encourage and facilitate access and use than poorly designed sites.

Paper prototypes are a valuable tool that can be used much earlier than rapid prototyping in the design-build-test cycle to explore ideas with users with very little financial outlay (Rettig, 1994; Henry and Martinson, 2003). Figure 1 illustrates how paper prototypes, when used in an iterative process of design and evaluation, can be used at the very start of the project, leading on to more advanced coded versions later. At its most basic all that are required for paper prototypes is some paper, pens, scissors, glue and some sample users willing to try the design and give their feedback. Design concepts can be quickly mocked up, tested, modified on the fly and retested. Since production costs and development times are so small, many alternative designs can be tested simultaneously and because the means of production (paper, pens, etc.) are so simple to use, users themselves can join in to suggest modifications and new ideas.

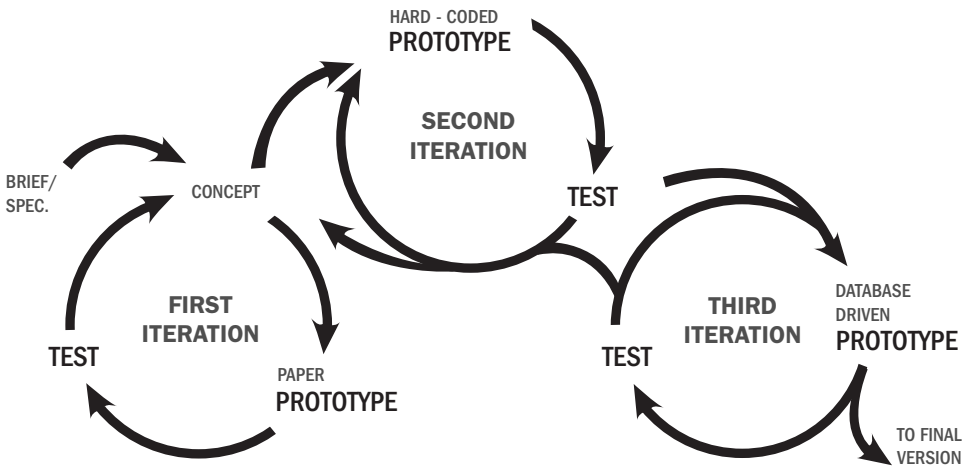


Figure 1
The role of paper prototypes in iterative design and test cycles

The emphasis in each test is on "usability." The International Organisation of Standardisation (ISO) (ISO 9241-11, 1994) identifies three key factors associated with the usability of an interface: effectiveness, or the extent to which the intended goals of use of the overall system are achieved; efficiency, or the effort required to achieve the intended goals; and satisfaction, or the extent to which the user finds the overall system acceptable (John and Marks, 1997). Nielsen (1993) offers a more nuanced list as follows:

- Learnability: ease of learning to use the system so that the user can get started rapidly.
- Efficiency: once the system has been learned, a high level of productivity should be possible.
- Memorability: casual users should be able to return to the system after some period of not having used it without having to relearn everything.
- Errors: it should be easy to recover from errors. Also catastrophic errors should never occur.
- Satisfaction: the system should be satisfying to use.

Buxton (2007, 139ff) draws a distinction between prototype testing in the sense of evaluating ideas and what he calls "sketching the user experience" which is about involving users in the process of originating and developing ideas. This is a useful conceptual difference, even though in practice the two may be closely intertwined such that evaluating the designers' concepts, modifying those in response to user feedback and eliciting user ideas alternate rapidly within even a single user trial session. Buxton also observes that sketching the user experience may involve more than just simple paper-based prototypes. He describes experiments where the proposed design has been mocked up using cameras, televisions, tablet PCs, string, cardboard and people to simulate certain functions. Such "sketches" share the low-cost and flexibility advantages of paper prototypes.

So, to summarize, testing concepts early and often to elicit user feedback and ideas is a sound design strategy that minimizes risk of failure in the finished design. Rapid prototyping, the development of working code, is a step towards this approach, but it tends to focus on the function of the code rather than the requirements of the user. Paper prototypes are a vehicle for deploying early, rapid and frequent user trials and can be used to elicit user ideas as well as test designers' concepts. But what are the limitations of using paper prototypes? Do they model design concepts adequately? In what circumstances might it be necessary to supplement paper-based prototypes with more

advanced, computer-based code and are there any alternatives to the relatively high cost solution of bespoke rapid prototyping? The rest of this paper examines these questions in the context of a recent communication design project that employed paper-based prototyping to test ideas and elicit user suggestions. The design group had previously used paper-based prototyping successfully, but on this occasion found that it produced misleading results. Design decisions based on paper prototype testing feedback were found to be sub-optimal when more advanced coded prototypes were tested. This paper discusses possible reasons for this failure and proposes an alternative to both paper prototypes and conventional rapid prototyping.

EXHIBITIONS OF THE ROYAL PHOTOGRAPHIC SOCIETY

Exhibitions of the Royal Photographic Society 1870-1915 (ERPS) is an online database of photographic exhibition catalogs (http://erps.dmu.ac.uk). ERPS is the latest in a series of photographic history primary resources made available online by Knowledge Media Design at De Montfort University, UK (see http://kmd.dmu.ac.uk/kmd_photohistory_page/ for a full listing). Since we had used paper prototypes to help produce successful designs in the past it seemed reasonable to use the same approach in the design of ERPS; making extensive use of paper prototypes to develop and test ideas.

Exhibition catalogs are a valuable source of information in a field that is hampered by the limited availability of primary resources. Early photographic artifacts were often unique (e.g., Daguerrotypes) and made from ephemeral materials, so survival was precarious. While many major figures are well documented thanks to their prominence at the time (e.g., Hill and Adamson) and the survival of archives (e.g., The correspondence of William Henry Fox Talbot), much less is known about large numbers of other participants. Although various photographic societies flourished in Britain and held their own annual exhibitions, catalogs from most societies have not survived in any significant number. In contrast, the surviving catalogs, from what is now the Royal Photographic Society's annual exhibitions from 1870 onwards, contain detailed entries on photographers, photographs and commercial companies. Collectively, these exhibition records offer a unique insight into the evolution of aesthetic trends, the application of photographic processes and the response of a burgeoning group of photographic manufacturers, as well as the fortunes of the Society itself. The Society's exhibitions attracted a wide constituency of photographers, from Britain, Europe and America. Many individuals

launched their photographic career by exhibiting at the Royal Photographic Society and a significant number went on to become leading practitioners of their day. The exhibition catalogs were published in full in the journal of the Society *The Photographic Journal*, copies of which are available in many research and public libraries. However, even major UK libraries such as the National Science Museum and the British Library do not hold complete runs and loan policies are restrictive, making it difficult for most researchers to access and compare data such as exhibition sections, processes and exhibitors across different years. Our intention therefore was to provide online access to and facilitate the use of these catalogs by researchers, primarily those working in the field of photographic history, but also with a view to wider research audiences concerned with technological and scientific developments, art, culture and social trends. Our objectives were to build an information resource that combined browse-able rich visual information (page scans and photographic exhibits) with highly structured searchable data (exhibition catalog entries). The focus of our work was from 1870 when the first catalog was published to 1915, after which the annual exhibitions became smaller in scale and national in character as the First World War began to affect the progress of photographic culture throughout Britain and Europe.

The catalogs themselves contain three broad types of information: details of the exhibitions (e.g., dates, venue, title, sections, judges); the exhibits (e.g., exhibit number, title, exhibitor name, photographic process, award status, price and sources; and exhibitors (e.g., name, title, address, RPS membership, qualifications and affiliations). However, the exhibitions were discrete annual events. While there was some continuity from year to year, inevitably over the forty-six year period in question there were changes in exhibition content, structure and presentation, which are reflected in the catalogs. As time went by, the exhibitions became more complicated, trade entered the picture, the photographic press and industry became more complex, there were more products to choose from, more participants and ideas and technologies changed. The catalogs themselves also evolved. Thus in 1876 the first advertisment appeared in the catalog, in 1880 for the first time the judges were listed and by 1895 pictures began to appear to illustrate some of the exhibits. In 1870 the catalog ran to 8 pages only, but this rose to over 100 pages in the early 1900s. Figure 2 illustrates some of the different types of data and information presentation styles used.

CATALOGUE.

PHOTOGRAPHS.

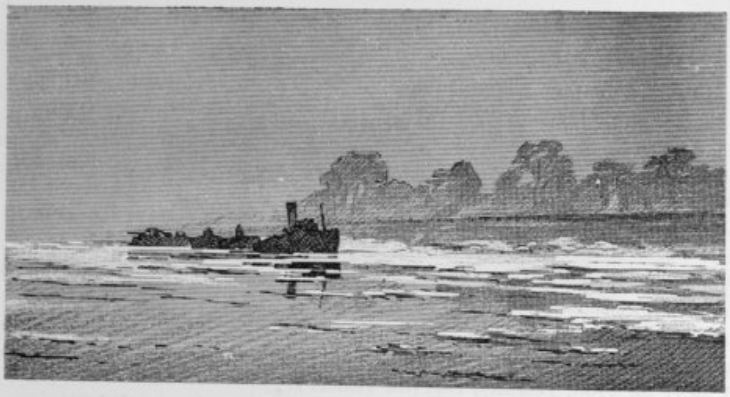
N.B.—Where a price is mentioned, the exhibit is for sale, unless already marked sold. The price in all cases is for the exhibit itself, not for a duplicate, and includes the frame.

1.	Greek Study. (*Carbon*)	3	3	0	PERCY S. LANKESTER.
2.	Simplicity. (*Photogravure*)	0	10	6	WALTER L. COLLS.
3.	Morning on Tyse Fjord, Norway. (*Photogravure*) ...	0	15	0	HERBERT DENISON.
4.	"Emotions." Produced for Sir J. Crichton Brown, F.R.S., from an untrained model. (*Carbon*) ...		—		ANDREW PRINGLE.
5.	Beaulieu. (*Platinum*)		—		GEO. SCAMELL.
6.	The Haven under the Hill. (*Platinum*)		—		W. D. BOOKER.
7.	A marée basse. (*Photogravure*)		—		A. CHARREL.
8.	King Harry's Ferry, Cornwall. (*Photogravure*) ...	0	15	0	HERBERT DENISON.
9.	In the Winter of Life. (*Carbon*)	1	10	0	HALL EDWARDS.
10.	Janet		—		RALPH W. ROBINSON.
11.	As the Shades of Evening Descend. (*Carbon*) ..	1	1	0	W. DAWES.
12.	Along the Road. (*Platinum*)		—		OTTO NIEPORT.
13.	"Eileen Asthore," Light of my heart. (*Silver*) ...	3	15	0	OSCAR BLYFIELD.
14.	Une Bayadere. (*Platinum*)		—		J. S. BERGHEIM.
15.	Photogravure		—		HAROLD BAKER.
16.	A Foreshore Study. (*Cold Bath Platinum, Untoned*)	1	5	0	JOHN A. HODGES.
17.	A Country Lane: Denmark. (*Photogravure*) ...		—		HORACE WILMER.
18.	Portrait study in sepia, from negative by B. Collenette. (*Carbon*)		—		THE AUTOTYPE COMPANY.
19.	Cordelia. (*Platinum, not retouched*) ...		—		J. S. BERGHEIM.
20.	Coquette. (*Ditto ditto*)		—		DITTO.
21.	Whitby Harbour. (*Ditto*)	2	2	0	REV. F. C. LAMBERT.
22.	Horsey Dyke, Norfolk. (*Photogravure*)	0	12	6	HERBERT DENISON.
23.	Evening on the North Sea. (*Ditto*)		—		HORACE WILMER.
24.	The Old Smithy. (*Gelatino-chloride*)		—		TOM BRIGHT.
25.	Clifford's Chantry, Bolton Abbey. (*Photogravure*) ...	0	12	6	HERBERT DENISON.
26.	A Sussex Team. (*Gelatino-chloride*)		—		TOM BRIGHT.
27.	Example of Carbon Process without Transfer ...		—		VALENTINE BLANCHARD.
28.	Sorrow. (*Platinum, not retouched*)		—		J. S. BERGHEIM.
29.	After Rain. (*Platinum*)	1	5	0	JOHN A. HODGES.
30.	Clifford's Chantry, Bolton Abbey. (*Photogravure*) ...		—		HORACE WILMER.
31.	The End of the Day. (*Platinum*)		—		FREDERICK A. CREW.
32.	Across the Moor. (*Gelatino-chloride*)		—		DITTO.
33.	Helluo Librorum. (*Carbon*)	1	10	0	HALL EDWARDS.
34.	Joyce		—		RALPH W. ROBINSON.
35.	Moorings off the Tower. (*Platinum*)	0	12	6	E. EVELYN BARRON.

Figure 2
1895 listing of photographs with illustrations and prices

No. 23. EVENING ON THE NORTH SEA.—HORACE WILMER. 11 × 6.

No. 69. PARTING DAY.—RODERICK J. FRY. 14 × 6.



No. 79. THE BREAK OF THE FROST.—W. MARTIN, JUN. 11 × 6

Different, named sections within the exhibition were only introduced for the first time in 1877 and their names changed frequently thereafter. In the three years 1905 to 1907 the number of sections in the exhibition stabilized at eight, yet as the following extracts show, the names and subject matter of the sections evolved quite noticeably even in this short space of time.

View exhibit records by section: 1905

- Lantern Lectures
- Pictorial
- Scientific and Technical Photography and its Application to Processes of Reproduction
- Lantern Slides in the Scientific and Technical Section
- Loan Collection of British Technical and Scientific Photographs from the St. Louis International Exhibition of 1904
- General Professional

View exhibit records by section: 1906

- Lantern Lectures
- Pictorial
- Scientific and Technical Photography and its Application to Processes of Reproduction
- Scientific and Technical Photography and its Application to Processes of Reproduction. By Invitation from the Council
- Lantern Slides in the Scientific and Technical Section
- Transparencies in the Scientific and Technical Section. By Invitation from the Council
- General Professional Photographs
- Photographic Apparatus and Material

View exhibit records by section: 1907

- Lantern Lectures
- Pictorial
- Scientific and Technical Photography and its Application to Processes of Reproduction
- Scientific and Technical Photography and its Application to Process of Reproduction
- Scientific and Technical Photographs, &c.
- The Autochrome. Collected and Arranged by R. Child Bayley and Thos. K. Grant, By Invitation form the Council.
- General Professional Photographs
- Photographic Apparatus and Material ·

The way in which an exhibit might be classified thus varies considerably over time. A "transparency" might at different times have been exhibited under any of the following section headings:

1. Autochromes,
2. Autochromes and Other Colour Transparencies,
3. II. Colour Photography. Autochromes and Other Colour Transparencies.,
4. II. Colour Transparencies,
5. III. Colour Photography, Including Autochromes and Other Direct Screen-Colour Transparencies,
6. II. General Photography, including Lantern Slides and Stereographs, Lantern Lectures,
7. II. Scientific, Natural History, Colour, and General Photographs - Lantern Slides
8. II. Scientific, Natural History, Colour, and General Photographs - Stereoscopic Slides
9. II. Scientific, Natural History, Colour, and General Photographs -Transparencies,
10. Lantern Slides in the Scientific and Technical Section,
11. Stereographs and Transparencies in Sections II., III. and V.,
12. Stereoscopic Photographs,
13. Lantern Slides,
14. Lantern Slides and Transparencies,
15. Stereoscopic and Lantern Transparencies,
16. Stereoscopic and Lantern Transparencies and Prints,
17. Stereoscopic Slides, Stereoscopic Transparencies,
18. Transparencies,
19. Transparencies in Sections II. and III. Colour and Monochrome,
20. Transparencies in Sections II. and III. Stereographic Transparencies,
21. Transparencies in the Scientific and Technical Section. By Invitation from the Council,
22. III. Scientific and Technical Exhibits, Natural History, Colour Prints, Lantern and Stereoscopic Slides.

It seems likely that researchers interested in one type of transparency such as 'Autochromes,' may be interested in some other types, such as 'Color Transparencies' and even possibly 'Lantern Slides.' So some grouping of categories might be useful for researchers because it would reduce the length and complexity of the searches required to identify all the items relevant to a query concerning transparencies. On the other hand, in the interests of preserving the accuracy of the original data, all these different sections should be listed individually, even in items like drop down search menus, even though this could make the menus impossibly long and confusing for most users.

Across the period in question the kind of information associated with exhibits changed. As previously noted, prior to 1877 the exhibition was not divided into different sections so not all exhibit records contain a section entry. Not all exhibits had multiple exhibitors, or sub components, or were part of a larger group, not all included information about prices and so on. So, although an exhibit record could potentially include up to fourteen different items of information, not all fields are required for every exhibit.

Furthermore different kinds of catalog entries were listed in different ways. For example "Lantern Lectures" and "Stall holders" were not given exhibit numbers for obvious reasons and fields such as "process" and "prices" did not apply to the latter. To show all possible fields for every exhibit would result in long tables of largely empty cells, making them difficult to read and tedious to page through. Omission of empty cells on the other hand hides from the user the hint that some records contain more or different information than others.

Our intention was to convert the catalogs to a digital database to facilitate searches and collations that would be tedious and time consuming if they had to be done manually, working from the original paper catalogs. For instance, it is a very simple matter to list all the records for a particular exhibitor in a single table so that their complete pattern of activity across the years can be seen. The difficulty lies in knowing for sure that exhibitors with similar names in different years are indeed the same person. Table 1 shows a listing of all the exhibitor records for the surname "Abney."

Records for Abney

Year	Name	Title	Address
1905	Abney, W. de W.	Sir	Rathmore Lodge, Bolton Gardens South, S.W.
1906	Abney, W. de W.	Sir	[Not Listed]
1870	Abney, W. de W.	Lieut.	Chatham
1871	Abney, W. de W.	Lieut.	Chatham
1872	Abney, W. de W.	Lieut.	Chatham
1873	Abney, W. de W.	Captain	St. Margaret's, Rochester
1875	Abney	Capt.	St. Margaret's, Rochester
1876	Abney, W. de W.	Capt.	Rochester
1878	Abney, W. de W.		3, St. Alban's Road, Kensington
1879	Abney		3, St. Alban's Road, Kensington
1879	Abney, C. E.		[Not Listed]
1880	Abney, C. E.		Derby
1881	Abney	Captain	3, St. Alban's Road, Kensington
1881	Abney, Charles E.		Derby
1882	Abney, W. de W.	Captain	3, St. Alban's Road, Kensington
1883	Abney, W. de W.	Captain	Willeslie House, Wetherby Road, South Kensington, S.W.
1883	Abney, C. E.		St James Street, Derby
1884	Abney, C. E.		6, St James Street, Derby
1884	Abney	Captain	Willeslie House, Wetherby Road, South Kensington, S.W.
1887	Abney, W. de W.	Captain	
1888	Abney, W. de W.	Captain	Willeslie House, Wetherby Place, South Kensington, S.W.
1889	Abney	Captain	Willeslie House, Wetherby Road, S.W.
1892	Abney	Capt.	[Not Listed]
1893	Abney, W. de W.	Capt.	Willeslie House, Wetherby Place, South Kensington, S.W.

Table 1
Entries for exhibitor "Abney"

From this list it is clear to a human observer that "Abney, C.E." is not the same person as "Abney W. de W." but that the various W. de W. Abneys and Captain Abney (1875 and 1889) are the same person. So should a search for "Capt. Abney" return results for "Captain Abney," "Lieut. Abney" and "Sir W. de W. Abney" as well? Or all entries for "Abney" just to be on the safe side? While it is easy enough to associate variations on a name in the database so that a search for that name returns all the associated hits, the difficulty lies in deciding which names to associate with each other. While it is highly probable that Captain Abney (1892) is the same person as the other W.de W. Abneys, it is not certain from the information available here. In other cases, for example where a woman changed her name and address on marriage, the degree of interpretation required is even greater. The problem here is how to deal with ambiguity and uncertainty and it is compounded by errors as well as variations in the data. For example, exhibitor "Marjory T. Hardcastle" appears with alternative spellings of "Marjory" and "Margery." While a search for "Hardcastle" would return both variations, an exact word search for one of them would not include the other. It would make searching for specific items easier if obvious errors like this were corrected. However errors are not always so easy to spot and there may be differences of opinion as to which is the correct version. So error correction raises the possibility of introducing more substantive errors of fact and poses a dilemma as to how far should one interpret the data in order to improve usability?

The communication design challenge we faced was to find a way of presenting such heterogeneous and ambiguous information in a consistent and usable way, that communicated the richness of the data available without overwhelming the user with a mass of information, while simultaneously representing that information faithfully and allowing users to see connections and patterns among small details.

APPROACH

While the database tables were determined to a large extent by the catalog data itself, the data views and the interface design issues were tackled using a user-centered design approach to ensure they were as fit for purpose as possible for the primary and secondary target audiences. This entailed gathering feedback responses from sample users to mock-ups of the site that exhibited increasing complexity and verisimilitude as the project advanced. According to Neilsen (1993), prototypes should vary according to the stage of the process and the purpose of the trial. Usually the choice is between three types:

"vertical" which offer in-depth functionality of a few selected features, "horizontal" which offer full interface features but no underlying functionality and "scenario" which offer functionality for specific pathways or task scenarios. In this project we began with paper-based "horizontal" prototypes and proceeded via paper and then screen-based "scenario" types to a fully functioning screen based system connected to a prototype database. Paper-based mock-ups were used in the earlier stages because they are quick and cheap to produce, can be modified easily and make users feel more relaxed about offering criticisms (Rettig, 1994).

The user trials were planned as four rounds with relatively small numbers (three to six subjects per trial), selecting a fresh sample each time to ensure that results were not cross-contaminated by previous exposure to the design. Sample sizes of three to five users are sufficient to obtain valid results in this kind of test (Krug, 2000; Neilsen, 1994), even though larger samples are usually required for scientific studies (Bevan et al., 2003). The first iteration entailed showing users simple hand drawn pages asking them what they thought the site was about, what it did and how they might use it to find certain types of information on the site.

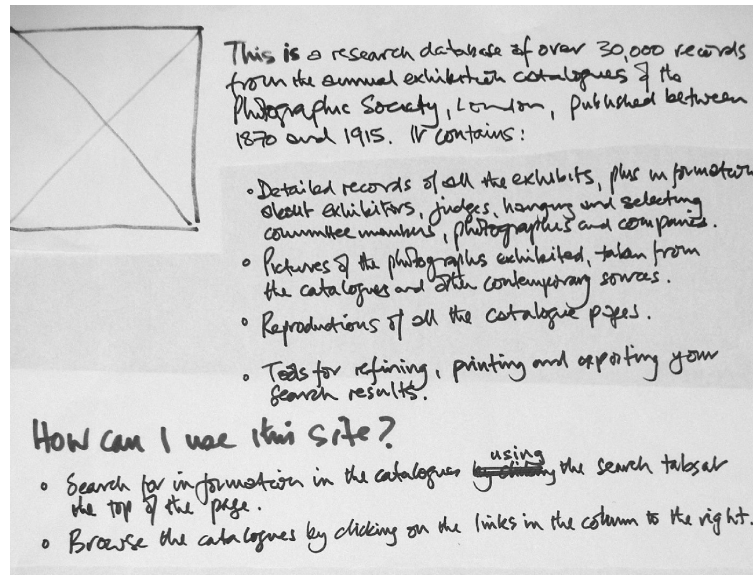


Figure 3
Early concept mock-up used to test intelligibility of the site

Subsequent trials were more focused and objective, requiring users to actually perform certain tasks in response to a series of questions, still using paper prototypes. Table 2 shows some specimen questions used in the trials and Figure 4 shows a specimen page used to simulate an information search task.

Table 2 Some of the search scenarios used in the user trials

1 You are researching Alvin Langdon Coburn and want to use the ERPS site to find any references to his work and his involvement with the RPS.
2a You now want to start a new search looking for all individuals who were associated with both the Royal Society and the RPS between 1870 and 1900.
2b From these results you now want to find anyone who took photographs in South Hertfordshire at the turn of the century, so you need to find exhibitors based in Watford between 1890 and 1900.

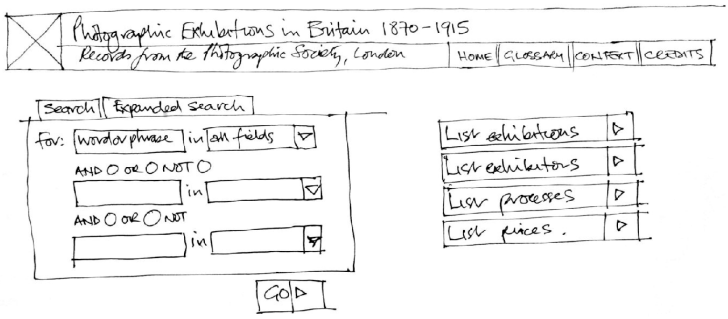


Figure 4
A simulated search page

To answer these queries requires searching for particular items across different years and in different categories. Coburn was both an exhibitor and a judge. In some cases his work was shown by other exhibitors. For example a photograph shown in the 1914 exhibition by David Octavius Hill was printed from a paper negative by Coburn. So Coburn is listed under several categories.

Since the trials were task based, screen mock-ups had to include features such as drop down menus and search result pages *(figures 5 and 6 show examples)*. It should be noted that in the case of search results the experimenters did not laboriously represent the possible results to every search query tested. Instead they wrote out just a few specimen hits for each query, to show the users what kinds of results they would get from such queries.

After two rounds of paper based trials the design moved on to simple hard coded "wireframes" that mocked-up the functionality with greater precision than the paper sketches and then in a fourth round to trials involving real (albeit incomplete) data drawn from a prototype database *(see figure 7)*. In these rounds the emphasis was still on functional layout and navigation rather than visual appearance. The wireframes represented the design using simple blocks of text and was monochrome. The final visual treatment was added only after the designers were satisfied that the layout worked satisfactorily.

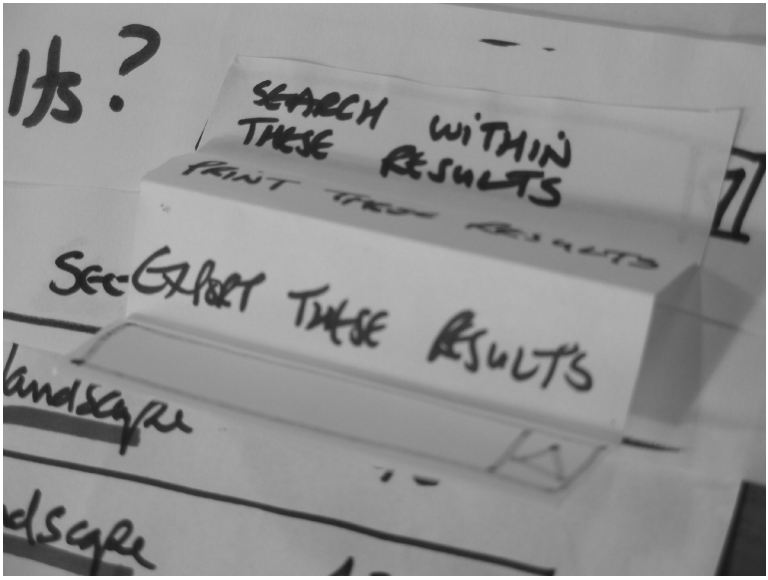


Figure 5
Drop down menu

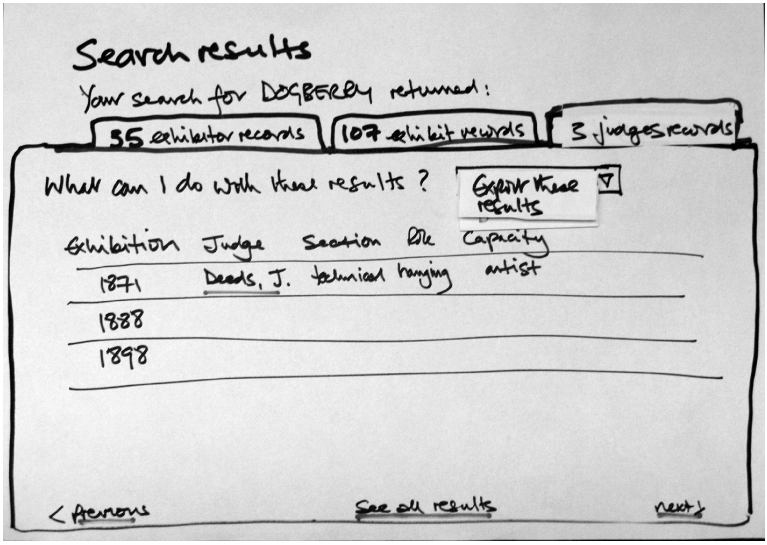


Figure 6
Example search results

RESULTS

The results of the first round of trials indicated that subjects easily understood what the site was about and what it could be used for, but there was some confusion about how the site worked, in particular they were confused by the Boolean search options offered. Most said they would either just search by browsing or, enter one or two words in the simple search box and then click on "go." This is consistent with findings elsewhere (Brown et al., 2006) that Arts and Humanities researchers generally employ relatively unsophisticated digital resource search strategies (single or two word phrase searches in popular search engines are common) and generally they are largely unaware of the possibilities for data analysis and multimedia data presentation that digitization offers.

A major change resulting from this was the introduction of an additional, form-based, "guided" search that was intended to indicate to users the full range of fields that could be searched including lists with drop down menus of all exhibitor titles, RPS membership status, qualifications and affiliations; judges roles, capacities and exhibition sections; exhibit types, processes, prices, medal status, sources and exhibition sections, as well as drop downs for exhibition dates and free text entry boxes for exhibitor names, addresses, etc.

In the second and third round of trials most subjects preferred to use this guided search rather than the Boolean version as it provided more information on what kinds of data were available, but they were so overwhelmed by the complexity of the interface that they did not notice many of the information categories on offer and found it difficult to select the most appropriate ones. Many resorted to selecting the "search all fields" option to be on the safe side and explained that if they were using the real database they would expect to be able to visually scan the results to pick out the relevant hits for themselves. They also said that they preferred to see their search results presented as a single scrollable list rather than as "Google style" pages with a "next" button.

In response to these findings it was decided to simplify the interface by summarizing the information types. For example, the drop down menu of exhibition sections was reduced to the summary list shown in figure 9.

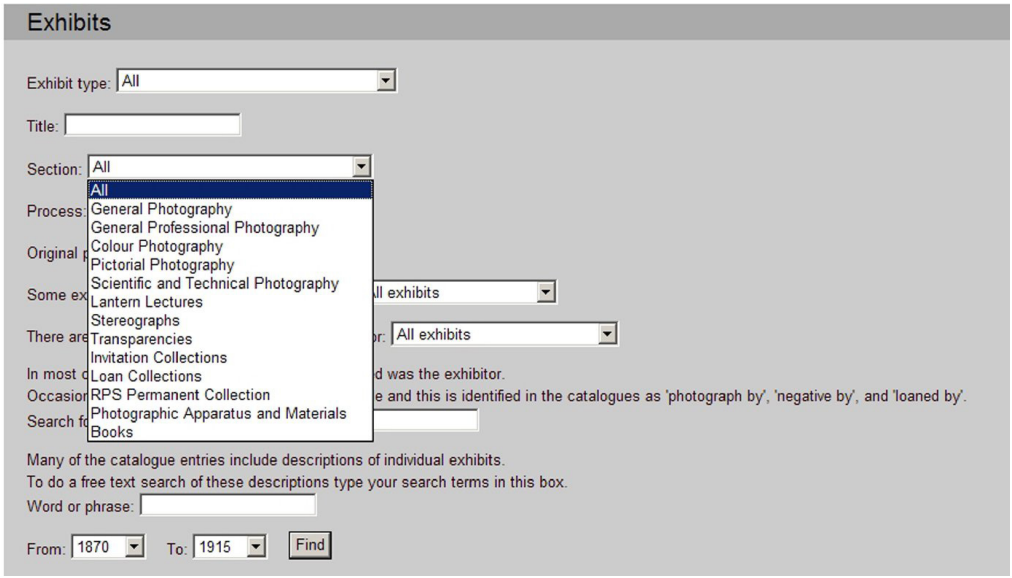


Figure 7
Simplified drop down menu for exhibition sections linked to a prototype database

The fourth round of trials was significant in that it was the first time that the prototype was linked to a working database. A consequence of this was that searches returned complete listings of actual results rather than just representative examples mocked up by hand. Disappointingly, the trial results revealed that although subjects were able to use the search interface satisfactorily, they were confused by the results pages, because searches were returning more information than they expected. In some cases the results included information they had not realized they had requested (due to poor framing of the search query) and there were so many hits in some cases that it was not easy to scroll though them and visually select the relevant ones. It seems that the transition from scenario-based paper mock-ups to prototypes connected to a trial database turned out to be more significant than anticipated. The simpler paper-based and on-screen wireframe mock-ups did not give subjects an adequate impression of the volume and complexity of information available and this compromised some of their responses to the design, leading them to believe that they would be able to search effectively by asking for hits in all fields which they could then simply scroll through to select the relevant results. As a consequence, design decisions taken after the second and third trials concerning which search interface was most effective and whether to employ scrolling as opposed to paged results were contradicted by responses in the fourth trial.

DISCUSSION

Prototypes and sketch designs are types of models. That is to say they represent certain, relevant, features of the object in question and ignore or deliberately distort other features for the purposes of simplification and clarification. "As a general rule, models should be kept as simple as possible" (Jenkins, 1972, 94). A familiar example is Harry Beck's iconic London Underground map that aligns the sprawling tunnels with a geometric grid and manipulates the positions of stations on the grid to convey a clearer picture of the network (Garland, 1994). The paper prototypes developed for ERPS were deliberate simplifications. For example, they were not given a visual treatment expressly because it was believed that this would distract users from their underlying functionality and result in unhelpful comments about color schemes, button shapes, etc. at the expense of valuable insights into the way the navigation was perceived. While this approach served well in previous projects, in retrospect it seems to have failed in ERPS because crucial features were oversimplified, distorting users' perception of how they could use the site. If users had understood properly the complexity and richness of the data and the sheer volume of information in the database, it seems likely that they would have not reported a preference for simple search strategies such as "search all fields" and they would not have relied on scrolling through a set of results to pick out the relevant hits themselves. The paper prototypes used in rounds 1 and 2 and the wireframes used in round 3 relied on the researchers to adequately represent these characteristics, but because of the laborious nature of the task: identifying and writing out in some cases hundreds of search results, we unwittingly chose to oversimplify the task by writing out just a few sample results for each query. As a result, earlier design decisions had to be revised and a further round of trials conducted to ensure that the design was back on track to meet the needs of its intended users.

Some of the user feedback received since the launch of the final version (http://erps.dmu.ac.uk) indicates the extent to which these difficulties were finally resolved:

- "I found *[Exhibitions of the Royal Photographic Society 1870-1915]* easy to navigate, fast and efficient, what I found less easy was the multiple forms under which some names appeared but I got used it."

- "The alphabetical drop-down listing of exhibitors' names is good, simple and goes some way towards getting around the fact that in many cases there [are] several permutations of names for the same person."

- "Ability to refine the search within results was very useful and worked well."

- "A fantastic, comprehensive rendering of all the information on RPS exhibitions which is contained in the RPS journals, with the huge advantage of being searchable and making links across journals. The search functions were good—I liked the combination of the ability to browse on several different fields with the more general search. It's possible to approach the database in a [sic] many different ways, depending on whether you are researching a specific photographer, exhibition etc."

While these results are reassuring they do not detract from the fact that the project encountered significant difficulties due to the way paper prototypes were implemented. So what can we learn from this experience? It would be easy to dismiss the application of paper prototypes in this case as incompetent, but that would not help us to avoid making similar mistakes in future. Paper prototypes were used in this instance because we wished to involve users in the design decisions. A prototype interface linked to a test database could have been set up earlier but we wanted to keep the informality and fluidity of paper prototypes until the design stabilized, "sketching the user experiences" in Buxton's terms, while working prototypes were reserved for testing, i.e., validating the designs that emerged from the paper "sketches." So the question is, is there a compromise between flexible, low cost, quick to produce and easy to modify paper prototypes and the relatively more expensive and inaccessible (by the user) rapid prototype?

One possible solution may be wikis. Wikis are "A series of web pages which users can add to or edit via any internet browser." (JISC, 2009, 53). They do not require programming or even html scripting knowledge, but can be used by anyone with basic word processing skills. Their visual treatment or "skin" is very basic (although modifiable via style sheets). They thus have many of the characteristics of paper prototypes:

- Low cost: wiki server applications such as MediaWiki are freely downloadable and free wiki hosting solutions such as PBwiki are widely available.
- Easy to use: only word processing skills required. A small repertory of formatting buttons facilitates insertion of hyperlinks, headings, pictures, tables, etc.
- Flexible: can produce html pages quickly that can be easily modified on the fly.
- Basic appearance: visual appearance is clearly not a polished Web page.

However wikis have a number of advantages over paper prototypes:

- Tracking: who made what changes and when is automatically recorded and easily checked.
- Roll back: earlier versions are automatically saved and can be easily restored.
- Neutrality: the visual appearance of basic wiki skins is even more bland than hand drawn pages. This is useful when one is trying to get users to see past the visual treatment and concentrate on functionality.
- Interaction: wikis allow embedding of a variety of interactive features such as hyperlinks to other wiki pages or to external Web sites, navigation bars, picture thumbnails, alt-tags, etc. that can be used to model Website functions much more convincingly than paper prototypes can.

This last feature is particularly useful if, as in the case of ERPS, one wishes to link the prototype to a database via a search engine. The search function can be presented on the wiki page as a hyperlink that takes the user to a data query screen belonging to the database, outside the wiki. While this is not elegant it has the merit of modelling the behavior of the proposed design much more accurately than a paper prototype allows but more easily and flexibly than conventional rapid prototyping allows. To test this idea we have recently been using a wiki to simulate a proposed Website for encouraging appreciation of electro-acoustic music, as part of an extension to a previous project (Landy, 2007). Figure 8 shows a test screen developed in PBwiki Media Wiki. While trials have yet to be conducted using these screens, learning how to use PBwiki *Media Wiki* was very easy for the designer (a PhD student without a computing background).

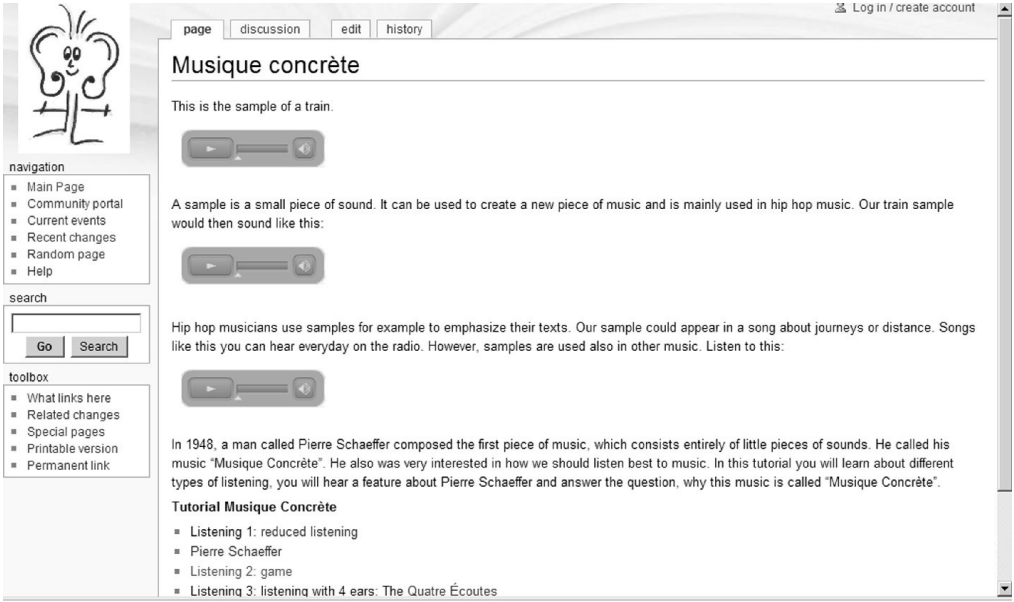


Figure 8
Wiki test screens showing embedded sound files

CONCLUSIONS AND SUGGESTIONS FOR FURTHER RESEARCH

This paper has argued that users frequently cannot find the information they seek on websites generally and even researchers are reluctant to invest time in order to better understand and use resources more effectively. The result of badly designed sites is lost repeat visits, wasted time, reduced productivity, increased frustration and loss of repeat visits and revenue, increased training and increased support costs. One way of overcoming such problems is to develop designs that maximize the usability of the resources by promoting their affordances and by making it easier for users to achieve their goals. Historical, event-based, data such as exhibition catalogs present particular problems because the relationships between entities across different events are relatively weak and the number and type of data categories are likely to change considerably. This creates complexity, ambiguity and uncertainty that can be dispelled to some extent by data interpretation and simplification. However, doing so can result in oversimplification of the information and confusion on the part of the user. Managing the relationship between usability, functionality and data integrity is not a formulaic process, because different resources are targeted at different user groups that have different needs,

expectations and abilities. Resources should, therefore, be tailored to the requirements of their target users. This study has reported how paper prototypes were used as part of a user-centered design approach to identify user needs and preferences in relation to these issues and to elicit design ideas from sample users. However the transition from scenario-based paper mock-ups to prototypes connected to a trial database turned out to be more of a step change than anticipated. Critical characteristics of the proposed design were not adequately modelled in the paper prototype. While this shortcoming could have been overcome by using rapid prototypes earlier in the design process, rapid prototypes have a number of characteristics that make them less suitable for modelling designs where user needs are still unclear and there is a wish to encourage users to contribute ideas. They are more suitable for testing code than exploring user needs and expectations.

What is needed therefore is a low cost flexible rapid prototyping tool. It has been suggested that wikis may offer a solution because, while they possess many characteristics similar to paper prototypes, being computer-based enables them to be used to create a more realistic simulation without the disadvantages of conventional rapid prototyping. Trials currently underway at De Montfort University using a simple, free, hosted wiki to model ideas for a learning resource website will test this suggestion. It will be particularly important to ascertain how easily users can modify the proposed designs and contribute their own ideas using the wiki interface; how easy it is to link the wiki pages to other non-wiki computing elements such as sound synthesizers, flash movies, etc.; and the effect on users of seeing the design on a computer screen as opposed to rough drawings on paper.

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RECOGNIZING RISK-OF-FAILURE IN COMMUNICATION DESIGN PROJECTS

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ABSTRACT

The pace of commercial graphic design practice presents very few opportunities to conduct user research after a project's launch. This makes the design team's ability to anticipate and address risks during the design development phase even more important, recognized in the astute observation from Tim Brown, CEO of leading international design group IDEO, that sometimes you must "fail early to succeed early."

This paper presents the methods and strategies used by the Centre for Design Research's (CfDR) creative team to mitigate risk during three communication design case-study projects. Elements of failure are identified in each of the three cases and presented, with discussion of where and why they occurred, and the possible approaches for reducing the risk of such problems re-occurring. To provide structure to the discussion, the paper frames each contributory issue as either a usability, communication or technical failing.

The analysis demonstrates that the factors contributing to design process failures are often complex and multi-layered. To avoid a poor design project outcome, it is evident that consistent risk monitoring is present in all stages of a design project, but might be improved by better understanding how issues change their degree of importance and potential negative impact during the course of the project. Developing a mechanism to enable teams to objectively identify and manage these fluctuating project risks, will contribute to a more coherent and effective strategy for recognizing and managing future design projects.

INTRODUCTION

Few practicing designers are so psychologically secure and so confident in their own abilities that they have a healthy appetite for post-mortems when projects go awry. The majority would likely move swiftly on, particularly as designing is a creative and therefore quite personal endeavor. But perhaps this anxiety prevents the designer from considering factors that are really systemic rather than personal failings and therefore miss the opportunities for design process improvement they imply.

This paper has provided the authors with an opportunity to reflect on past projects and identify the strategies used to manage risk and prevent project failure. It focuses on those failures that occur during a design process and have the potential to threaten the satisfactory completion of a project—rather than failures of a product on reaching market. If design process failures are preventable, or at least possible to mitigate, the likelihood of a design failing in the market will be considerably reduced. Case studies present reflection on what the team understood to have happened during the course of the project and, as a result, their tone is personal and reflective. Three design projects were selected by the authors, all delivered within the commercial constraints typical of graphic design practice. The reflective review of those projects provides a glimpse into the complex nature of problems arising in this setting.

WHAT CONSTITUTES A DESIGN PROCESS FAILURE?

Design process failures are not the same as creative failures—they are not about evaluating which design solutions might have been more successful, but rather identifying a failure to meet the various expectations of user, client and design team. For the user, a piece of visual communication should be functional and avoid misinformation. For the client, it should fulfil its communication purpose, and be delivered within the agreed time and cost. For the design team, it should answer the brief, be delivered on time and within budget and, most importantly, provide a design solution that meets (if not surpasses) user and client expectations. To provide structure to the discussion, the paper frames each contributory issue as either a usability, communication or technical failure.

Usability failure

Usability failures are those attributed to functionality problems that result in misuse of a product, or the user's failure to perform an intended task due to a fault of the design. Usability in this context can also encompass the miscommunication of a visual or textual message. Usability failures tend to be more critical for projects at the functional spectrum of communication design, such as interactive and web-based projects.

Communication failure

Communication failures are those attributed to a breakdown in communication between the designer and either their stakeholders (external) or their team members (internal). Communication failures can occur in any type of visual communication project and are not bound by its design purpose. Communication failures are probably more commonly discussed in Design Management or Organizational Learning literatures. However, as many of the problems that arise in design projects are communication-related it would be remiss to omit these issues from our discussion of ways to minimize design process failures.

Technical failure

The authors identified three types of technical failures: production-related, skills-related and context-related. Examples of production-related failures include errors in print production, software platform compatibility or inappropriate file formats, and these types of failures are equally distributed across different forms of media. Skills-related technical issues can be attributed to the available expertise of the design team. Context-related issues can be harder to identify but include changing external project conditions such as budget and timescales, which are often beyond the apparent control of the design team.

METHODOLOGY

The case studies for this paper are past projects carried out in the Centre for Design Research (CfDR) at Northumbria University. CfDR is a multidisciplinary design group that offers design services ranging from product design and engineering, to graphic design activities such as print, web and interface design to design research. This paper will focus on graphic design projects.

The case studies selected were chosen to highlight good examples of design process failures and strategies in the three areas of usability, communication and technical issues. The case studies were reviewed and analyzed by means of a hindsight review using a three stage process:

Stage 1: A review of project documentation including original brief, meeting notes, client correspondence, planning documents, research materials, sketches, concept boards, user feedback, system architecture and design iterations. This stage provides an 'aide memoir' to enable an accurate description of events.

Stage 2: To conduct what Greenwood (1993) describes as a 'cognitive postmortem' based on Schön's (1987) reflection-on-action process. Reflection-on-action is described by Schön as thinking back to what we have done in order to discover how our knowing-in-action may have contributed to an unexpected outcome. Each member of the project team produced a reflective report, responding to four key prompts in order to elicit reflection on the key decisions taken during the project. These prompts asked the respondent to:

- Describe the project in detail
- Describe the problems anticipated at the start of the project
- Describe the actual problems that emerged during the project
- Reflect on what was learned from these problems, and the strategies taken to ensure they would not re-occur in future projects

Stage 3: Validation of the analysis result by the project team, supported by peer feedback from team members on report conclusions.

Any methodology that uses hindsight review will always be susceptible to unintended bias. When we reflect in hindsight, it is difficult not to be influenced by our knowledge of the outcome. Fishchhoff (1975, cited by Jones, 1995) describes this as 'creeping determinism.' To address this, we have cross-referenced our personal recollections with project records such as meeting documentation, reflective notes and externally validated papers wherever possible. Stage 3 provides an additional level of validation by the project team members, reducing personal bias on the final project outcomes. Due to the nature of design practice, which rarely allows for reflection-on-action due to time constraints, this method was deemed most suitable for the purpose of this study.

The format of the case studies presented consists of a project description, discussion of anticipated threats at the start of the project, an analysis of why some threats were well-managed and the lessons learned from failures that occurred during the project. In evaluating each project we considered the number of anticipated issues and challenges in relation to the actual problems that arose. This list of problems (or 'threats') can be divided into three categories:

- High risk—issues with high levels of uncertainty and the potential to be 'show-stoppers' to the successful delivery of the project.
- Medium risk—issues of minor concern and with some uncertainties present, which we were reasonably confident of managing successfully.
- Low risk—issues of no real concern, where the challenges and work required may be significant, but which we were confident was comfortably within our capabilities and experience and did not therefore pose a significant threat to the success of the project.

CASE STUDY 1

Project background and context

A newly formed healthcare company was developing an innovative service offering aimed at elderly patients and their carers. CfDR were commissioned to work on interface design as well as corporate branding, exhibition graphics and a promotional website.

Anticipated threats to the success of the project

We understood this to be a project with multiple deliverables, all of which our two-member team would need to work on simultaneously and complete to a tight deadline, created by the company's impending launch at a national conference.

At the early formative stages, the potential 'show-stoppers' to the project's success were perceived to be:

1. Limited availability of development time in relation to the number of required design outputs
2. Definition of the company aims, objectives and service users
3. External development partner's responsiveness to, and ability to implement within their development timescale, our interface design proposals—as initial email contact suggested our influence on this project component could be limited

We had some minor concerns about:

1. The possibility of 'feature creep,' where a client wishes to extend design work beyond the agreed project brief and budget
2. Website development as additional work outside of the original project scope

We had no real concerns about:

1. Outsourcing work—as the addition of website development to our project brief initially seemed unlikely, due to the client's reluctance to commission it as an additional project component

How the threats were managed and where failures occurred

Table 1 tracks anticipated risk levels at the start of the project against actual impact upon the project. The issues are color-coded into high, medium and low-level risks. Identified failures are also classified as technical, usability or communication failures.

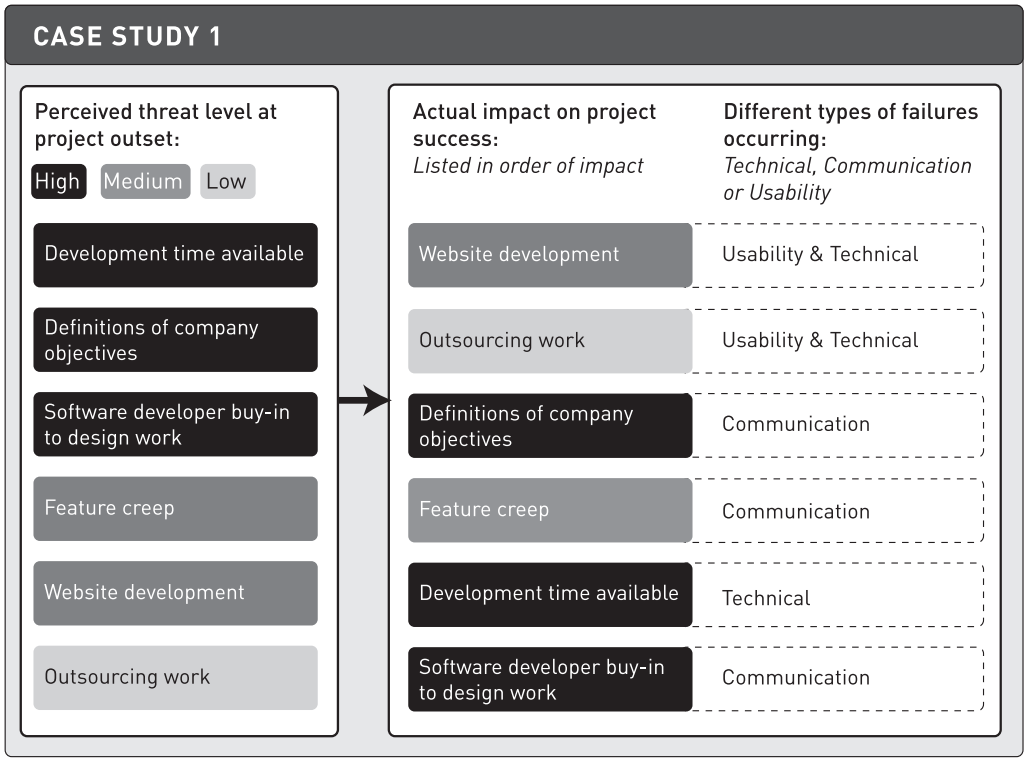

Table 1
Anticipated problems compared with actual problems arising during the project.

The risk analysis table indicates that, while we managed the anticipated 'high risk' issues well, we were less successful in ensuring that other issues did not evolve into higher threats. This was probably because we focused too much on managing the higher-level threats at the beginning of the project, and did not track how other identified threats were progressing.

Website development

We originally thought it unlikely we would be working on the website as the client seemed reluctant to commission the additional work. However, eventually they did decide to commission a website and content management system (CMS); this became a large part of our overall work and caused several major problems. Because of the client's limited budget, we chose to utilize a free open-source blogging platform to produce the website. Two main issues arose from the use of this platform: server compatibility and usability. Due to an oversight on our part we failed to confirm the type of web hosting platform currently used by the client, resulting in the production of a website that was incompatible with their web hosting package; we were forced to engage in an extended research and discussion process to come up with a cost-effective solution that would meet the client's current and future needs. In addition to this compatibility issue, the client found the website's CMS system difficult to use, despite our provision of training sessions and technical support and eventually chose to remove the website from the public domain and identify their own alternative solution.

Outsourcing work

The outsourcing of website development to an external company meant that we were at arms' length from their development process, and some problems with the implementation of our design work were not revealed until the developer's work was nearly complete. We spent a considerable amount of time 'bug checking' the website and sending lists of errors for the developers to resolve; this continued beyond the launch of the website as the client identified more problems with usability and functionality.

Definition of company objectives
At the start of the project we conducted a service mapping exercise to assist the client in identifying the company's full range of services. We assumed that this exercise would help to bring shape and focus to the client's objectives for the company's offering. However, the client's thinking about the structure of their service and products continued to evolve throughout our work for the company—meaning that requirements across all of our project components were also subject to ongoing change.

Feature creep
As anticipated, we received several requests for design work outside the agreed project scope. Given the overall size and financial value of the project we chose to undertake some of these tasks as 'gestures of goodwill.' However, this created difficulty on occasions when we couldn't reasonably accommodate minor tasks and had to assign them an additional development cost.

Development time available
Careful scheduling of development of the various project components was undertaken, to ensure all work was delivered when it was needed. While some slippage inevitably occurred in places, the existence of key event-based deadlines like the company launch helped to keep development moving at a brisk pace.

Software developer buy-in
Despite our initial reservations, the external development partners were enthusiastic about our design suggestions and commented favorably on our contribution to their work.

Lessons learned from 'failures'
Match budgets to appropriate solutions (and do not force one to fit the other).
The failure of the website stemmed from the fact that there was a mismatch between available budget and the required functionality of the website. We believed that the cost saving in using a free open-source CMS would give the client better value for their money. However, in the end they felt that the system provided was not fit for use. We concluded that we should have recommended our preferred option of a higher-quality bespoke system. Even though this would have cost more, the client would have understood how that cost related to the quality of the end product.

Ensure clarity on project scope and deliverables

A sign-off should be a sign-off. Make the client understand that this draws a line under a stage of work, and signifies the delivery of a finished component. Within reason, any work beyond that should be re-negotiated.

Prioritize project components

If the client is reluctant to prioritize project components, do it for them. Make clear how delays, or the introduction of additional tasks, will influence the outcome or delivery of key project components.

CASE STUDY 2

Project background and context

CfDR was commissioned by a research and development center for renewable energy to develop a Solar Thermal 'Trolley' demonstrator unit with an accompanying teaching pack. The purpose of the project was to raise awareness of renewable energy among secondary school pupils, with a view to encouraging them to consider careers in science and technology. There were three main components to the project: the Trolley demonstrator unit, interactive teaching materials and a project website.

For the purpose of this paper, we will concentrate on the visual communication aspects of the project, which were the teaching materials and the project website.

Anticipated threats to the success of the project

At this formative stage in the project, the potential 'show-stoppers' to the project's success were perceived to be:

1. Motivating teachers to incorporate the use of the trolley and curriculum materials into their lesson plans and ensuring that the trolley did not end up gathering dust in a cupboard
2. Gaining access to teachers and students in order to understand the environment of use and develop appropriate levels of content

We had some minor concerns about:

1. Content team: people responsible for writing and editing the content for the curriculum CD-ROM
2. The ability of the proposed website to create a 'learning community' enabling schools to share their collected data
3. The technical challenge of streaming live data from a fixed solar collector to the project website

We had no real concerns about:

1. The technical challenge of producing the curriculum material and developing the project website

How the threats were managed and where failures occurred

Table 2 (see below) tracks anticipated risk levels at the start of the project against actual impact upon the project using the same format as in case study 1.

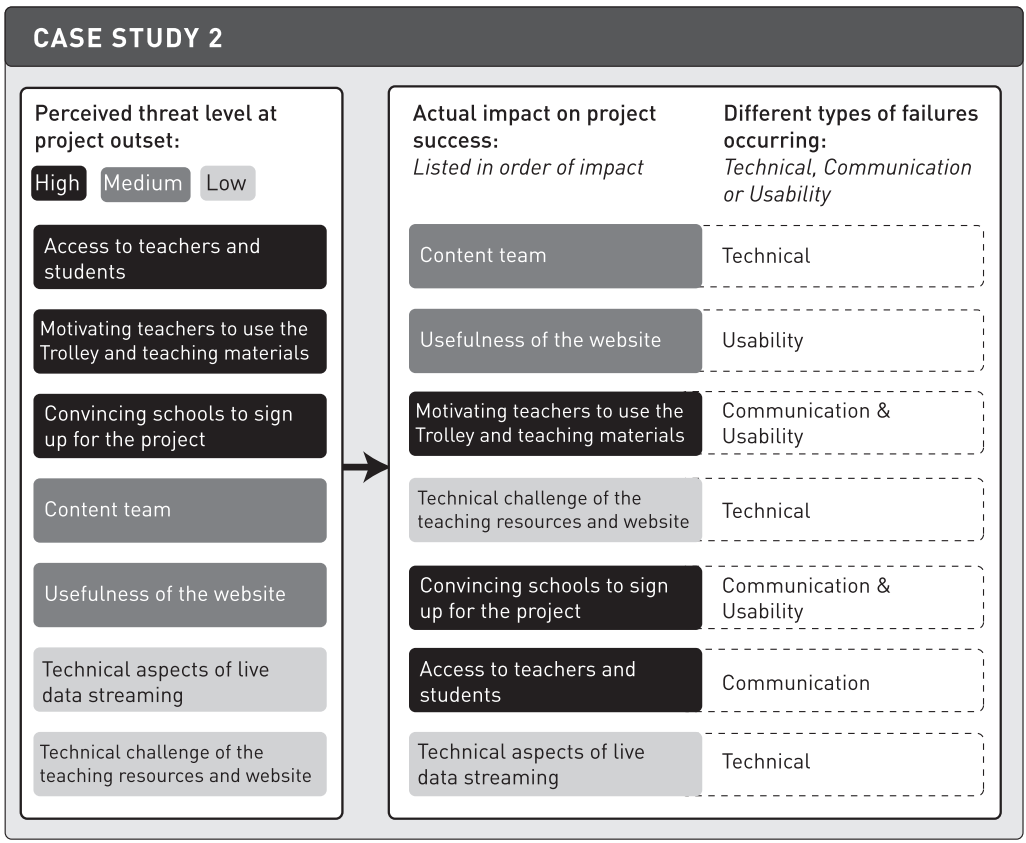

Table 2
Anticipated problems compared with actual problems arising during the project.

The risk analysis table affirms that our early and determined effort at gaining access to teachers was key to managing this risk well. However, we were perhaps too late in recognizing the importance of securing additional budget for a content writer after our initial meeting with the teachers. Other issues such as convincing schools to participate were resolved more through external factors than our own direct action (see section below).

Content team

We stated from the outset that our original budget did not account for the provision of content authoring by our team, making clear that it would be the responsibility of a Content Team (which we believed should be comprised mainly of teachers) to write and organize the teaching materials to which we, the Design Team, would respond. Although the client did offer an additional budget to pay for access to teachers, we realized after our first initial meeting with those teachers that it would be difficult for them to dedicate any time to content authoring. We also did not have enough budget to pay for a professional writer to take on this role. As a result we had little choice but to take on the responsibility of content creation ourselves; we used our additional budget to pay for content review meetings with a small group of teachers from different subject areas, who provided us with feedback on our design work at key points during the design development.

Content authoring proved to be a huge undertaking, which on occasion drew our focus away from the more creative aspects of the project. This probably limited what was achievable on the project budget, because we effectively reduced time spent on design, particularly production time, to accommodate the writing process.

Usefulness of the community-based website

The client was keen for a website to form part of the teaching resource, believing it could offer a platform for datasets gathered from the Solar Trolley to be archived and shared. We were unsure of how useful it would be for teachers and students to have access to archived data, or how practical it was to expect teachers to spend time uploading the data onto the website. We felt that the budget would have been better spent elsewhere, such as on consulting more with the teachers on the likely benefit of the proposed functionality. Although this issue was not a major threat to the overall success of the project, we did not manage to convince the client of a better alternative.

Motivating teachers to use the Trolley and the teaching materials
Convincing schools to sign up for the Solar Trolley was only half the battle. Once the school had signed on and received the trolley and materials, it was equally important to consider what would motivate teachers to incorporate the resource into their scheme of work. We carefully considered the relevance of the Solar Trolley to the current UK teaching curriculum, the way a lesson is structured and delivered, technology available within a typical classroom, the type of learning activities currently employed and the resources that teachers find most useful. As a result of our research and classroom observations, we produced twenty-four teaching activities with printable worksheets, animations, interactive exercises and guidance on differentiation for higher and lower-ability students.

Technical challenge of the curriculum material and project website
We had no real concerns over the technical challenge of producing either the curriculum material or the project website. However, we did encounter a problem with the print production of a polypropylene folder used to contain the teaching materials. The project logo printed onto the spine of the folder proved illegible on the final printed goods and we believe there were two reasons for this error: our difficulty in visualizing a mock-up that could replicate the translucent nature of the intended folder material, and the fact that the project logo (which we did not design) consisted of gradients that did not translate well when screen-printed. As a result of this error, we had to send the folders back to the printer for a reprint over the affected area—for which we had to bear the additional cost.

Convincing schools to participate in the project
Creating demand for this project was an important issue, which was recognized early on by the client. Even though the Solar Trolley and its teaching materials were to be provided to schools free of charge, the project team was unsure how schools would react to the project. Resources which are given away free of charge often have very little perceived value and are easy to neglect or ignore, so we knew that if the client did not have a marketing plan in place our efforts may not get noticed at all. However, we were fortunate that the client recognized the importance of promotion and engaged their marketing manager to work with us on project promotional activity, targeting the appropriate people within schools to help champion the project.

Access to teachers and students

Having worked with teachers before, we predicted that their heavy workload might make it difficult for us to gain significant access to the people we needed. From the beginning of the project we stressed to the client how important it was to speak to teachers before making any major design decisions. Luckily, the client was able to recommend a school that would be keen to participate in the project due to their interest in the renewable energy agenda and we were able to arrange four twilight meetings and a day of classroom observation. Overall we managed this perceived threat well due to our constant reinforcement of the importance of the issue to the client.

Technical aspects to live-data streaming

At the start of the project there were a lot of unknowns related to the technical requirements of streaming live data onto a website, as we did not have the technical expertise in-house to evaluate the complexity of this task, and also our client was unable to specify the type of technology they would be using to capture the data. This issue was only resolved in the latter half of the project when we were able to bring in appropriate technical expertise to complete the task. We managed this risk by managing the expectations of the client in terms of what would be feasible within the agreed budget, and by ensuring that the web developer we hired to develop the website database was made aware of this requirement at the outset.

Lessons learned from these 'failures'

Get clarity on content creators

We underestimated the time and money required to write the content, and did not push the client for more money to fill this gap, instead taking it upon ourselves to create the content in order to avoid jeopardizing the project. For future projects relying heavily on learning and teaching content, we must ensure that a content team has been appointed or else get assurances from the client that they will take responsibility for delivering content during early project negotiations.

Re-evaluate the original brief to ensure relevance

The project team should always re-evaluate the business case for project components during development, in order to ensure that decisions made early in the project are still valid.

User access challenges

Gaining access to users is a challenge in every project. It is useful to start the conversation about accessing users with the client as soon as possible and if necessary, as in this project, allocating a budget to offer an added incentive to potential participants. Incorporate these consultations into the overall project time plan and allocate plenty of contingencies, either in terms of time or identifying alternate sources of user feedback.

CASE STUDY 3

Project background and context

The design brief was to create a web-enabled tool to improve existing recruitment procedures for a design school in a UK university. Central university systems, which were adequate for the majority of academic subjects, were not always appropriate for design. In the case of overseas student recruitment, online application forms existed but this did not accommodate the visual, portfolio-based selection process that the art and design schools used to identify applicants with the most potential. Existing practice therefore involved the posting back and forth of physical CDs, with the imagery they contained remaining fairly meaningless without the presence of the designer to explain the thinking processes behind the work. A suggestion at an internal university conference was that this could surely be developed as an online solution.

Based on initial research with users, the CfDR team tabled a proposal for a pilot project that would result in a reduction of decision-making turnaround time from an average of six-weeks to seven working days. The proposal for a pilot project was accepted and a developmental budget secured for this work. As well as the delivery of a usable, fully functioning web tool, the project's ambition was to achieve important elements of policy reconfiguration and behavior-change through the adoption of a service-level promise.

Anticipated threats to the success of the project

CfDR understood this to be a service design project, rather than simply a web-development project from very early on. A service design project involves the planning and organization of components that make up a service (such as communication, people, infrastructure and material) in order to deliver value to the users of the service. As such, we expected the toughest challenges to be 'behavior change' issues, along with the policy dimensions of the proposed new service.

At this formative stage in the project, the potential 'show-stoppers' in terms of the challenges to the project's success were perceived to be:

1. Getting student recruitment agents based overseas on-board with the new process
2. Trusting design school staff with recruitment decisions that would affect the performance of several courses that were jointly owned with other schools
3. Offering an effective alternative to the current selection practice, usually based on face-to-face contact and discussion and which we expected to vary substantially across the wide range of disciplines taught in the school

We had some minor concerns about:

1. Course leaders failing to prioritize decision-making for overseas applicants, so that a consistent level of service could not be promised
2. Points of contact between the new service and existing Management Information Systems

We had no real concerns about:

1. The appetite of potential overseas applicants to remodel their project portfolio in order to submit their application
2. Getting buy-in from the School's Management Team (SMT), which was funding the work
3. The technical challenge (although we recognized it as such) of delivering a working pilot. On the basis of other successful projects we were reasonably confident we could conceive and deliver an appropriate solution

How the threats were managed and where failures occurred

Table 3 (next page) tracks anticipated risk levels at the start of the project against actual impact upon the project using the same format as in the previous case studies.

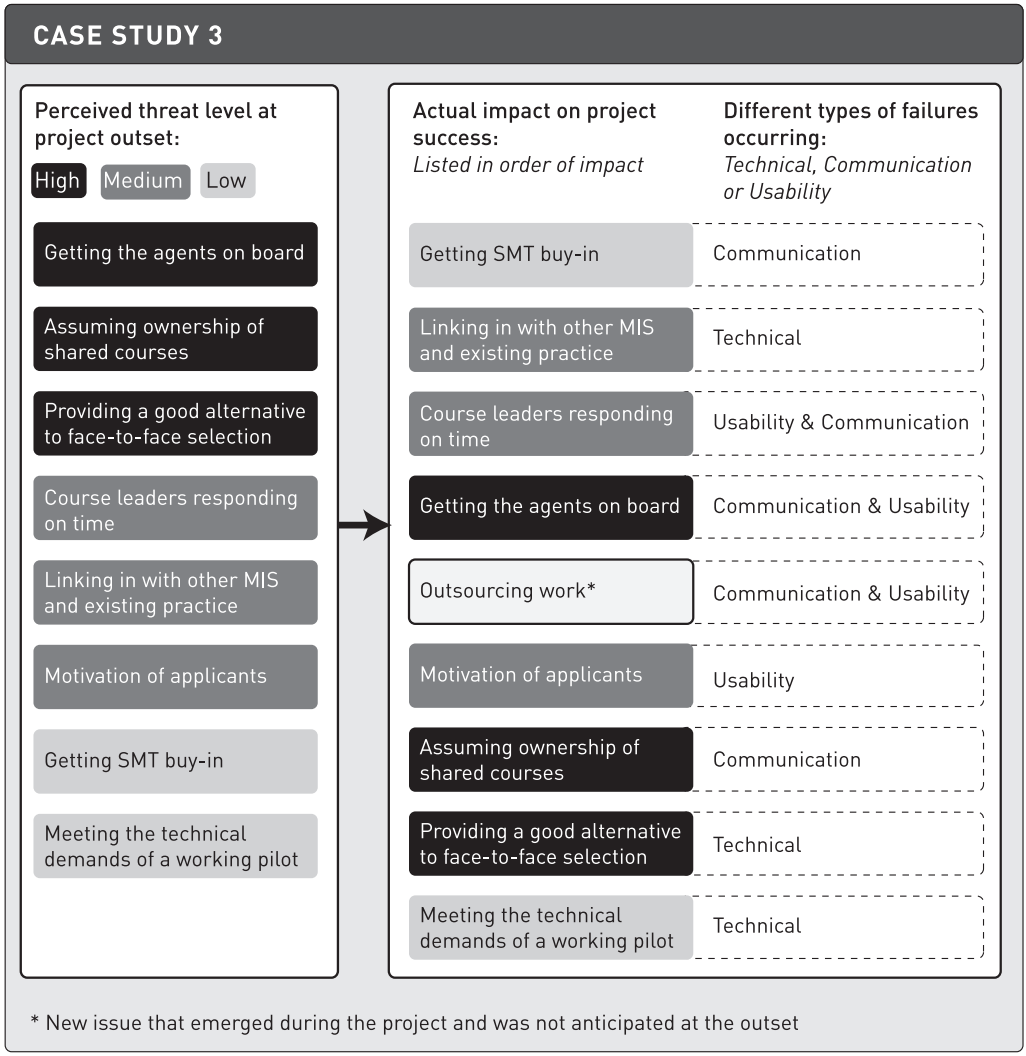

Table 3
Anticipated problems compared with actual problems arising during the project.

The risk analysis table highlights that while we managed the higher level threats well, we did not anticipate, or deal well with, the lack of ownership of the project, which resulted in the main project failure. A lack of political will within the SMT to enact systemic change also resulted in poor integration of the current system with existing Management Information Systems.

Getting the buy-in of the School's Management Team (SMT)
The failure to secure long-term buy-in from the School's Management Team ultimately resulted in the website being taken offline. Two years after its launch, the website was shutdown after the SMT decided not to continue supporting the cost of web hosting. Although we had minor usability problems relating to the user interface for site administrators, the system was working well and had over fifty applicants on its database. The website shut-down was very disappointing considering the fact that no formal evaluation was undertaken to identify how successful the system had been in fulfilling its initial project aim. The design team was also confused as to why the shutdown decision was taken, given that the SMT was very enthusiastic throughout the project's development.

Linking with other Management Information Systems (MIS) and existing practices
The university had a number of Management Information Systems and processes in place to deal with overseas applications. The new system had to account for their information requirements, data transferability and integration. In the end it proved impossible to change the way the university handles information and we were forced to adapt our system to the existing MIS, even though this meant that at certain points in the process data had to be manually duplicated.

Course leaders responding on time
We had assumed that if we built a usable and functional system that was demonstrably better than current practices, convincing users to adopt it would be effortless. However a combination of 'technology-phobia' and an unwillingness to embrace change meant that some course leaders were not fully committed to the new process.

Getting the agents on-board

We initially thought it might be difficult to convince overseas recruitment agents to use the new system, as it could be perceived as an additional barrier for students wanting to apply. However, through a combination of communicating the right message and demonstrating the functionality of the system, this issue become less of a risk. Early conversations with agents informed us of the key characteristics and functionalities that they would require from the system. We also stressed to them that, instead of a decision time of around two weeks, the new system could guarantee a response in seven working days.

Outsourcing work

This was an unexpected issue that emerged during the project due to the technical requirements of the new system. We hired a freelance web developer to work with us to meet these requirements, however halfway through the project this individual moved to another country. The main problems this caused us were in communication and management: it was difficult to contact him about arising issues, which ended up being discussed and negotiated through emails and online chats. This unexpected change in the working relationship between the main designer and the web developer meant that problems took longer to resolve, which subsequently caused delay to the overall project timeline.

Motivation of the applicants

The risk of applicants being unwilling to use the system was managed through the careful consideration of usability issues and consistent testing of the system during development. Although we did not manage to get actual users to test the system during development due to the practicality of recruitment, we did manage to test the system with current overseas students. We were also careful to test the system with users who were unfamiliar with the project, to ensure there was no bias in their evaluation. The step-by-step structure of the system meant that the user was effectively 'chaperoned' through each step, minimizing the chance of errors or confusion.

Assuming ownership of 'shared' courses

This risk was managed by inviting the participation of the administrators of the shared courses from the start of the project. Contrary to what we feared might be an unwillingness to let the design school assume ownership of shared courses, the other schools had no objection to this once they saw how the system could help speed up the application process for their students.

Good alternative to face-to-face selection
We initially assumed that there would be too much variation in the evaluation criteria of a potential student, making it difficult to synthesize these requirements into the proposed new system. However after a series of consultations with different admission tutors, we concluded that the evaluation criteria for all subjects were fairly similar, and were able to synthesize these criteria into a set of general requirements.

Lessons learned through these 'failures'

Get clarity on project ownership
It felt great to be acting as both client and contractor on this project, however this led to a poor level of buy-in from the (notional) project owner and when it was time to push on the implementation the will and urgency was not there to 'make it happen.' Have a single project owner (usually a client of course), but be sure they are accountable, for example, to a stakeholder group with authority, otherwise they may act whimsically.

Nurture the project champions for when you will need them most
Don't adopt the attitude that good work will speak for itself. You will require different types of project champion at different stages of the project. Repeatedly make the case as to why the project is important, keep it high on their agenda by acting with a sense of urgency. Also make sure there is a governance/ownership framework laid out from the start, and that the right stakeholders play a part in order to avoid subjectivity.

Are you sure we all want the same thing?
In this case, the project owner and users (course leaders) had a natural conflict of interest, as the project owner needed to 'sell places' whereas the course leader prefers to have tight quality control in order to avoid recruiting potential underachievers.

Work with the key stakeholders and then work with them some more
Build in some contingency budget, specifically to provide directed support to key stakeholders whose opinions you need to change—especially if they might be resistant. One key stakeholder in this project lacked confidence with IT, and would normally be acting alone in a remote setting, where you would expect them to be even more risk-averse than usual.

Have a legacy plan
Plan for a post-project champion to support the system (financially and politically) in order to ensure the project's long-term future. It may help to include a section on how the system should be supported after the project has ended in the initial proposal.

CONCLUSIONS

No one category of failure was more likely to prove catastrophic
When analyzing the case studies in detail, we found that that it was helpful to categorize the failures encountered rather than treat them all as general design process failures. However, we weren't able to draw any conclusions from these cases on which category was the most likely to lead towards a whole-project failure.

Each team member had different perceptions of the project's failings
Perhaps due to their different responsibilities in each project, in comparing each team member's reflections it is evident that, while each person highlighted similar issues, their perception of which issues posed the main threat to the project were very different. We found the process of reflecting on how the threat-level of each issue had changed over the course of the project enlightening. It seemed a useful means of encouraging constructive critique within the design team, and we believe this experience will help us to better identify and address potential threats to future projects.

Usability issues did not significantly contribute to project failures in the cases reviewed
In our analysis of these three case studies, we did not uncover any major usability failings, perhaps because we already observe a strongly user-centered philosophy in our team. We routinely spend a considerable proportion of the budgeted hours planning, recruiting and consulting with users at different stages of each project to mitigate risks in this area.

Even a strong design solution won't speak for itself so keep communicating

It is not enough to produce an exceptional solution in terms of usability and technical achievement if communication and particularly ownership issues are not addressed. For example, in Case Study 3 the lack of buy-in from some members of the School's Management Team took us completely by surprise and emerged very late on in the project. As we were not prepared for this problem, we probably did not put as much effort into 'selling' the new system internally as was required. Championing new developments might seem best focused on those areas where resistance is anticipated, but this must not lead to complacency with other key stakeholders.

Implications for Design Practitioners

1. *A visual risk management tool*

   While we were successful at managing high-risk issues across all three case studies, we failed to anticipate the impact of other issues. Visualizing how key risks change throughout a project (tables 1-3) as we have for this paper could form the basis of a useful real-time project-tracking tool for design practitioners, reducing the possibility of low risk issues becoming a major concern. It could be used to consolidate end-of-stage thinking into concise risk-trend information for the whole team to discuss and take account of.

2. *Scheduling reflection into the project timeline*

   It would have been useful to begin all the case study projects by making project risks explicit to each team member and referring back to those identified risks during key decision stages. We now believe that using the risk-tracking tool developed to analyze the case studies for this paper will help us to track and manage the risks better as a team.

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AUTHOR NOTES

Joyce S.R. Yee is a practising designer, researcher and lecturer in visual communication at Northumbria University in the UK, where she completed a doctoral degree that focused on reframing how we understand typography in a digital environment. Earlier, she received an MA in Visual Communication at Central Saint Martins College of Art and Design. Her research is bound by a common theme of understanding how designers develop and improve their practice. She is interested in the areas of developing design-specific research methods, particularly human-centered research methods for design process and developing a knowledge-based approach to graphic design education in view of emergent media.

Matthew Lievesley is an Industrial Designer with an MBA from Northumbria University. His research is set in the context of commercial design practice, the complex world of competition, compromise, risk and pragmatics. His work has achieved international recognition in both industry and academia. In 2007, Matthew was selected by the UK's Design Council, the national strategic body for design, to support their flagship business engagement programme. This role complements his main work as Reader and Design Manager in the School of Design at Northumbria University. His portfolio includes national and international patents, journal and conference papers and designs for Boots, BT, McDonald's, Marks and Spencer, etc.

Louise Taylor studied Multimedia Design and completed an MA in Design Practice at Northumbria University and has been working as a designer in new media for the past eight years. She was previously a founding director of a design company specializing in the development of web solutions for business. Now based at The Centre for Design Research at Northumbria University, Louise's role encompasses branding, graphic communication, web and interface design with a strong focus on engaging end-users in the creation of innovative and enjoyable product and service offerings.

FAILURE? ISN'T IT TIME TO SLAY THE DESIGN-DRAGON?

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Winkler, 254-271

ABSTRACT

There is a closed cycle of design education that replicates the most common design practice—and feeds into that practice that seeks awards based on incremental change supported by professional organizations and trade journals—that feeds back to education forms for imitation. This is the educational failure this paper cites. It takes to task the stagnant, homeostatic educational institutions that fail to transcend the traditional guild system and sustains an anti-intellectual view of design and its future. Exposing historical roots of the situation, the author calls for design education to embrace preparation of students for the "knowledge society" and take a leadership position in design's future.

Warden,
Road Prison 36:

What we got here is . . .
failure to communicate.

You run one time,
you got yourself a set of chains.

You run twice,
you got yourself two sets.

You ain't
gonna need no third set,
'cause you gonna get
your mind right.

Some men
you just can't reach.

So you get
what we had here last week,
which is the way he wants it. . .
well, he gets it.

I don't like it any more
than you men.

You gonna get used to
wearin' them chains
af'er a while, Luke.

Don't you never
stop listenin' to them
clinking.

'Cause they
gonna remind you
of what I been saying:
"For your own good."

Luke:

Wish you'd stop
bein' so good to me, Cap'n.

Text from "Cool Hand Luke"
(Pearce, 1967).

DESIGN'S DEADLY INSOUCIANCE

A group of graphic designers, all winners of a prestigious national award, claimed the following:

> *Graphic designers are intimately engaged in the construction of language, both visual and verbal. And while our work often dissects, rearranges, rethinks, questions and plays with language, it is our fundamental belief, and a central tenet of good design, that words and images must be used responsibly, especially when the matters articulated are of vital importance to the life of our nation. (From a 2006 letter to the White House, signed by Michael Rock, Susan Sellers, Georgie Stout, Paula Scher and Stefan Sagmeister.)*

Does this mean that these designers are really qualified, steeped in and familiar with the work of linguistic relativists like Franz Boas, Edward Sapir or Benjamin Lee Whorf, whose research was challenged but not negated by formal linguists like Noam Chomsky, moving the discourse from anthropological filters to psychology, and back again to Steven Pinker's *The Language Instinct*? Did they have a deep or just a cursory look at the volume of expert research? On what portions of their own language research do they depend for supporting their claims: aesthetic, experimental, logical or philosophical linguistics, because any of these are necessary to claim responsible experimentation with logic, philosophy or language? How deep is the disciplinary knowledge-reservoir of the design profession to allow any designer so confidently to dissect, rearrange, rethink, question and "play" with language? How can they seriously live up to the tenet of design? If these five can, can the rest of the 299,995 estimated members of the American design profession (US Department of Labor, 2008)?

> *I seem to be, to my surprise, a member of a large profession. There are some "300,000 designers" in this country alone, nearly all of them have emerged in my adult lifetime. They are all prosperous. Most of them seem to be busily applying "design" to problems of life and personality. Many of them seem to feel that all we need to do is consolidate our scientific gains. Their self-confidence astonishes me. For these gains seem to me puny, and "design intelligence" seems to me ill-founded. (Paraphrased from the psychologist J.J. Gibson critiquing his own discipline (Reed and Jones, 1982).)*

Carr, prison floorwalker, to Luke:

Them clothes
got laundry numbers on them.
You remember your number
and always wear the ones that
has your number.

Any man forgets his number
spends a night in the box.

DESIGN IN TIMES OF DISCONTINUITY

Designers, whether they like it or not, live in the mixed metaphor for a time-warped niche in the Gutenberg galaxy, namely at the edge of an unexplored and not verified problem universe. Their world appears sometimes greatly separated by dangerously deep waters and sometimes connected by safely linked lands, even if the ideal conditions could be thoughtfully established through a thorough investment in research. Problem resolutions are still according to individual whim, sentiment and feeling, rather than based on logical and critical communication analyses. Individual sentiment still guides designers' surrealist ways, in which they try to intuitively move away from any solid center of critical knowledge and continue to fish in an unexplored and unreasoned void. They have not yet accepted the tenant of responsibility for moving towards the gravitational core of a problem, for what Christopher Alexander already advocated fifty years ago, namely a "correct fit" between object/message, contents and context. He advocated trust in the carefully assembled and researched information to reveal a "fitting solution," rejecting reliance on predictable repetition of the prevailing conventional methods of matching conditions with preconceived and formerly successful solutions (Alexander, 1964).

Design has failed or if that is perceived as too tough a statement, it has definitely stagnated. The great promise, after having moved from the Bauhaus, a technical school facilitating guild and craft attitudes, into the American academy, that it would evolve from an unself-conscious (intuitive) to self-conscious (critically and intellectually meditated) design methodologies, did not materialize. The possible growth has been severely stunted due to the poor examples set by homeostatic universities and notable but apathetic design schools, naïve professional organizations, a more than ridiculous accreditation system for design education, and a vast majority of practitioners holding nineteenth century craft-guild skills scrambling now to match them with digital technologies.

The true failure of design, not living up to responsibilities of engaging audiences in vital communication, lies in not recognizing the clear functional delineations that separate divisions of communication labors. Living in the new problem universe of a "knowledge society" requires a commitment to accelerated intellectual competence; in order to function as "professionals," designers must step beyond the now insignificant traditions of intuition-fed visual entertainment. The public deserves, especially during dangerous times like these, to be empowered by useful and reliable information that is easily observed, compared and synthesized for reaching critical survival decisions.

Their needs should not be distorted or filtered through somebody's individual sense of expression. Design has to become more educated, informed, intelligent and above all smarter than the typical four-year education of citizens.

Christopher Alexander, comparing unself-conscious and self-conscious cultures, uses the Eskimo as analogous to the traditional intuitive designer, and the critically thinking designer as analogous to the contemporary designer. For an example of the latter, a highly educated designer of artificial limbs must combine knowledge of various disciplines to evolve maximal operational prostheses by being intellectually engaged with social and behavioral psychology, anatomy as translated into mechanical, electrical and computer engineering along with material and medical sciences, pharmacology, etc.

The Eskimo (traditional designer), to cool the temperature and stop water dripping from the igloo ceiling, pushes through the snow or ice wall to let the frigid air in with the aim to hasten the refreezing of water, and then when the right temperature has been reached, takes several handfuls of snow slush to close the opening again. In contrast is the well-educated architect who must anticipate all possible operational failures encountered by modern high-rise dwellers, which are far removed from understanding the problem logistics and will call the building superintendent to fix the leak and adjust the temperature. If the superintendent can't cope, a specialist is summoned.

Design homeostasis is mirrored by all traditional cultures. The perception of need for change is slow. There is little acceleration over generations. With indigenous people, design reality is tied to the moment, framed by issues of immediacy, copied and duplicated procedures and methodologies provide the common perception that most failures have been reduced to a minimum over epochs. New impositions are not foreshadowed. Things grow gradually. Individuals solve problems directly by existing example: "in our tradition" or "how things are done here." There are improvements, but they are small. The individual defines a problem for himself in relationship to personal education, experience and tradition, totally outside of the aggressively dynamic multi-disciplinary world.

In the self-conscious society, which measures its benchmarked success abstractly against rules of efficiency, time and money, the citizen has been forced to give up solving problems to the hands of the supposedly well-educated specialists, namely the design practitioners. The self-conscious culture tries to externalize and streamline methods, processes and procedures but increases the intellectual distance between end-user and so-called expert. Even when great progress has been made in recognizing diversity and needs for customization, unless great care is invested, the majority of solutions become less individual and more general for users because of the corporate aim

These here spoons . . . you keep with you.

Any man loses his spoon spends a night in the box.

at an intended larger aggregated consumer mass. Objects, messages and methods become generic and frequently are illsuited for a large portion of users.

The rather young design culture, not snatching failure from the jaws of success, must first recognize that times have changed. Their expertise has shifted from unself-conscious forms of visual expression to those needed in coping with the dynamic issues of a fast growing, self-conscious "knowledge society." If design continues to rely primarily on approaches fostered by guild traditions, then it will reach but a fraction of the total populace, namely those who have innate abilities to adjust easily to any twist and turn in the road. The communication needs of the much larger group, including the language handicapped group of immigrants and especially the between 8.7% and 18.1% at the extreme end of the spectrum, a group of about 55 million Americans diagnosed with phobias of all kinds; they will not be served well at all, because designers are short-changed by their narrow education (Lenzenweger et al, 2007).

One would think that design understands that a society that considers "knowledge" as its primary currency and product requires investment in intelligence, innovation and invention from all its segments. But communication design continues to vacillate between two worlds, one that still rejects cognitive, cerebral and systemic communication research, and the other, which still is enamored by art and adores self-expression.

DISORIENTATION AND FEELINGS OF LOSS

The conventional view is that learning works best by applying well-used methodologies that reinforce the paths that have a success-history of secure footsteps and promise. When applied to new problems, they are perceived to step-up to solutions with greater probability of success. However, they do not eliminate emerging obstructions and chances for failure. In the evolution from the unself-conscious stage (individual approaches, few conventions) to self-conscious stage beyond the craft-guilds, which pride themselves in establishing and reinforcing conventions, the next evolutionary stage will require intellectual agility beyond the present-day conventions.

Presently, design lives in an environment of very rigid conventions, mirrored in a bottom-line barter system, in which budgets are translated into and measured against concepts of adequacy, time efficiency and expediency and expectations of what the market will bear, not maximal fidelity. This does not encourage additional search for highest

standards or potentials. It can be argued that reinforcement of conventions easily satisfies and can lead to intellectual rigidity, making it more difficult to adjust to more dynamic situations and times. Also one forgets that the environment of rigid conventions creates serious dependencies. In the case of the design profession, if design practice does not demand greater sophistication and intelligence from the institutions that train and supply the major design workforce, then design can't grow; and vice versa, if design educators cannot model the benefits of intellect over craft, then design practice will be delegated to a support and not a leadership position.

There's no playing grab-ass or fighting in the building. You got a grudge against another man, you fight him Saturday afternoon.

Any man playing grab-ass or fighting in the building spends a night in the box.

Marvin Minsky (2006) probing the new and unprecedented, suggests that entering an unfamiliar terrain or attempt to understand new paradigms and difficult subjects, will lead most likely to discomfort and stress, confusion and disorientation, because most of everyday learning involves only minor adjustments to skills that are already known and tested by trial and error, allowing for small changes. This seems to bear out the professional design organizations' approach, which, by awarding minor improved performance will elevate and enshrine minor changes. However, Minsky believes that this strategy won't work well in unfamiliar cases that may require older techniques to be totally abandoned even though they may have previously served well. When substantially new methodologies need to be learned, new strenuous work is created with new forms of stress and less frequent rewards.

HOLDING ON FOR DEAR LIFE

A critical look at communication design, education and practice, its beginnings and traditions, requires getting away from the substantial innovation levels and potentials of digital technologies and the concern for the variety of graphic expressive visual formatting and typographic styling. Instead, it should specifically review the rate of growth of intellectual and conceptual components that relate to understanding communication in social, cultural and economic contexts; one has to realize the nearly stagnant or at least homeostatic condition of the field, with little change over a century. Appropriate contents and solutions can only evolve from an intense inquiry into human factors that facilitate or hinder communication.

The "professional" rhetoric, touted by journals, organizations and schools, suggests having moved three feet forward. But the reality looks more like having moved backward by two feet with the result of a gain of one foot only, just ahead of stagnation. That one measly foot of progress is not driven by significant intelligence or innovation, but

First bell's
at five minutes of eight
when you will get in your bunk.
Last bell is at eight.

Any man
not in his bunk at eight
spends the night in the box.

by adaptation, namely the process that pedagogues and practitioners use when perceiving an advantage in the knowledge and skills held by a competitor and then copying it. This is an ingrained design tradition. It dates back to the *Buchdruck Zunft* (German printers guild) related to goldsmith skills for letter production, paper-making and printing and other Central-European guild systems (Hobsbawm, 1965; Braudel, 1982), from which many conventions of graphic design originate. This is exemplified by the rapid spread of printing techniques throughout Europe, starting 1452 in Mainz, spreading from there through Germany to Vienna in 1462, then to Basel by 1464, to Venice by 1469 and Spain and England by 1473. Those who aspired to become masters in their field were required to leave their countries for a number of *"Wanderjahre"* (years of journeymen travel) and then, as quasi-industrial spies, to bring back the accumulated knowledge of processes, methods and materials directly experienced in other cultures. That may be the reason why craft skills when transferred from one culture to another rarely retain the original culture's philosophical framework. What transfers, is mostly style and rudimentary methods, not contents or context.

Lissitzky's suprematism, John Heartfield's approach to photographic political comment, Jan Tschichold's constructivist arrangements in typography were all adapted and are now part of the design canon as any design exhibition will verify; so was the Müller-Brockmann and Karl Gerstner launched "Swiss Design." It was adapted, for example, by Container Corporation of America to its operations, then promoted through Unimark across the world, and it finally infiltrated most of American industry, educational institutions, commerce and federal agencies. For a while the use of Armin Hofmann's Basel-approach to styling and Wolfgang Weingart's "new" typography became pedagogical credos, adapted by most American academic design institutions. Adaptation is never an innovative process, even if what is adapted seems to be new and unknown to those hankering to adapt to it.

THE HOMEOSTATIC CHARACTERISTICS OF THE DESIGN DISCIPLINE

In all disciplines, for example, the physical and biological sciences, it is the level of intellectual achievement, honed by research and critical discourse, that establishes the professional hierarchy; not so in communication design, where opinionated, self-appointed and self-selected ideologues dominate a homeostatic design institution and its field of practice. They establish a fictitious but authoritative hierarchy, sanctioned later by academic certification, highly ranked academic

pedigrees and middle management and middle-class social standing. They, as figureheads become gatekeepers involved in protecting their territories. With significant public prestige, PR notoriety and money at stake, they have little use for refining or updating their information reservoirs. They disseminate only selected portions, or withhold vital information all together. Then the homeostatic superstructures they select to represent, create hierarchical class structures in which some participants are more equal than others: insider/outsider; tenure/tenure-lined/untenured; part-time/full-time and other separations.

There is no smoking
in the prone position in bed.
To smoke
you must have both legs
over the side of your bunk.

Any man caught smoking
in the prone position in bed . . .
spends a night in the box.

There is a great reliance on bureaucratic authority and control (authority embedded in frozen policies and procedures; personnel and "how-to-do" manuals; deviance of opinion and behavior is seen as threat to homeostasis). Interactions with outside experts exist only with those that do not threaten the existing ideology. (In education, it is the process of bringing alumni in as authoritative lecturers or experts to reaffirm the institutional success and to legitimize the educational process to new generations.) Homeostatic organizations always try to obscure the level of their competence. There is an avoidance and outright rejection of any critique coming from the outside, and the resident critic or whistle-blower is soon eliminated. Failure is not allowed but obscured and serious experimentation is restricted. Experimentation is reserved only to acceptable areas of the canon.

In homeostatic systems, there is usually little future planning, after all the singular approach, concept or ideology has been found and refined. Instead there is a keen pursuit of minutia and a multitude of insignificant short-range goals. Critical discussions are often postponed on the grounds that the dialogue is too important and must be tabled for more "appropriate times." But there are never appropriate times; therefore the discussion never takes place. The use of tried, self-grown, even misunderstood methods adopted from others, is encouraged for the continuation of systems that have run their course with few alterations or critical analyses. Members of homeostatic organizations use old, authoritative rhetoric (better, best, first, only, unique, oldest, etc.), relying on reputation, which may have been legitimately earned decades earlier, but is out of proportion with present-day reality. Standing a head above a crowd of intellectual mediocrity is still just a little ahead of mediocrity. Design schools will, like the auto-industry, not change through their own incentives, but only when the markets demand it. The questions are, can homeostatic entities survive during times of uncertainty? Can they continue to maintain their stability for the next decade based on mythology when the real public needs lie somewhere else? It is fact right now, nearly all design education programs are preparing students without

You get two sheets.
Every Saturday, you put
the clean sheet on the top . . .
the top sheet on the bottom . . .
and the bottom sheet
you turn in to the laundry boy.

Any man turns in
the wrong sheet
spends a night in the box.

responding to the reality of public and global need. Design for print has evaporated all together and graduates are saddled with skills for times, long gone. When information shifts, changes and accumulates at high speeds and volumes, the traditional skills are too cumbersome, slow and inefficient for life in dynamic change environments.

THE NEEDS FOR REAL CHANGE

Gerald J. Skibbins (1974) described the characteristics of "real change" as those resembling biological metamorphosis, when caterpillars change into chrysalises and then to butterflies, or eggs into tadpoles and later into frogs, in which each progressive evolutionary stage does not look at all like the stage left behind. Real change is not just looking for how to move from A to B, but how to move beyond B and plan for future stages. That takes knowledge, contemplation and imagination. He also claimed that there is too little "planned metamorphosis" and decries the great abundance of "inadvertent change," because institutions do react to adversity in fire drills only. When the emerging dynamics demand answers for society and culture, homeostatic institutions have to be dragged to the table.

Adaptation creates some liberation from homeostasis, but it is limited because when institutions and corporations take their adaptation from others, they usually select things out of context. They rarely understand the full extent of context within which these methods and processes became successful. They commit themselves only to the most immediate organizational demands without investing extra energy, time and effort.

A metamorphic change system, most likely, would want to replace itself, not just reshape the exterior shell. Nomenclature changes from graphic design to "communication design," "new media design," "digital imaging" and other quite meaningless titles, in fact, they just cover up that the technology has changed, but not the contents or ideology. "Emotional design" covers the same territory that "design based on human factors" (physical, psychological, social and cultural) did, but one-generational minds perceive the same activities as new. Does the new nomenclature expand the territory? After Venturi's *Learning from Las Vegas* (1977) schools proudly proclaimed "they 'do' vernacular design." Outside temporary PR sound-bytes, what did that really mean? What was contributed to better communication?

In a metamorphic change system, a lot of independent thinking is required to fully develop brand new goals; aims that are not short-lived but are to endure to reach other future stages through trial and error. A metamorphic change system would require administrative

mechanisms to recognize innovation, provide incentives for formal/informal self-education, insist on advice, critique and input of all adjacent disciplines to broaden the understanding of the complexities and potentials of visual and verbal communication, and also help participants to overcome their fear of crossing borders in open-ended search and intercollegiate dialogue. Most of all, it must encourage the homeostatic staff to see intellectual innovation not as a "gamble," but as the only life-blood leading to all kinds of possible futures.

No one'll sit in the bunks with dirty pants on.

Any man with dirty pants on sitting on the bunks spends a night in the box.

DESIGNERS OF EPHEMERA ARE NOT FUTURISTS

Communication design is not thought of or taught as an intellectual adventure, comprised of risky, dangerous uncertainties, but as the directly opposite, namely through definitive power-examples of success, which define fidelity as universal, safe, efficient and expedient, with the intent to reduce the potential for failure to a minimum. In the field of practice, the succession of problem-resolution approaches resembles more the cautious linkage to and repetition of earlier successes than aggressive steps towards continuous change. It is design practice according to the passive traditional Yankee motto: "if it isn't broke' don't fix it" or "don't worry about something until it happens."

Most communication designers are developers of short-lived ephemera. That is why their major contributions lie in aesthetic styling and formatting; not in content-development or strategies for better communication or decision-making. Their contributions become only valuable and permanent when attached to the intelligence of other disciplines.

Seen from a critical angle, designers seem to deliberately build obsolescence into each project-solution, because visual styles rarely last longer than a moment. Since most professional design journals refrain from serious forensic post-mortem design critiques, the debugging of defects are left up to the individual who is usually too close to process the full array of interactions between faulty project irritants. There is a good reason why authors turn their material over to content experts with significant subject matter knowledge, and only then to skilled wordsmiths and proofreaders. Designers could learn from that process. In addition, whether it is to their liking or not, authors have to submit their work to an unpredictable and unlimited reservoir of critical journalistic and academic reviews. Designers do not.

Although schools teach through successful case studies, the examples seem to encourage duplication and plagiarism. One actually learns little from the success of another designer. In moving success

Any man don't bring back his empty pop bottle spends a night in the box.

methodologies over to another problem, one finds that conditions, circumstances or contexts usually don't match, and what is good somewhere, becomes mediocre somewhere else. Because the relationships between components of the amalgam that are facilitating success are so complex, it is never clear to what proportional extent positive or negative dynamic forces were summoned to interact. The same successful plan applied to another project has a great chance of providing a mediocre solution or becoming a complete failure.

Failure teaches much more aggressively through retrospection. Failure could be part of a single malfunctioning component, lack of fidelity in concept development or of faulty fabrication/implementation. It could be due to one or several of the dynamically interactive ecological or environmental conditions that either facilitate or interfere with the succession of project steps (because of intellectual, cultural, social and political conditions or well or ill chosen metaphors and semantics. The environment behaves like the weather in which everything impacts, like proper translation into media, awareness of signals, timing, place, season, overload and competition and much more.

THE GUILD'S CRAFT-SEEDS FALLING ON STONY GROUND

Walter Gropius made (Wingler, 1978), if one is concerned with the source of intellectual dearth in the design discipline, a historically fateful decision in 1914. Having been asked to combine the Weimar Academy of Fine Art and the School of Arts and Crafts by the Grand Duke of Weimar, he preferred to abandon the academy and its philosophical and intellectual research in favor of hand-skills and aesthetic studio investigations gleaned from the arts and crafts and the traditions of the guild system. This was not just a minor turn of events. In fact it has hindered the maturing of design practice into a professional discipline. It has seriously waylaid the intellectual preparation for the field. Frederick II, 1712-1786, King of Prussia, had restructured the Prussian academy as a seat of free search and independent thought, believing that Protestant intellectualism was able to compete and challenge the French Academy, which he considered dogmatic, subservient to and controlled by Vatican dogma. Frederick II also set up clear status divisions, hierarchical authority and specific territories between the intellectual academy and the technical schools. The academy was independent. The arts and crafts were groomed to support trade.

Any man loud talking spends a night in the box.

Gropius moved design into the arena of vocational technical schools, away from the academy. In an historical paradox, after the nineteen-thirties, the Bauhaus ironically finds a new home at American ivy-league campuses; Harvard, Princeton and Yale. A better fit would have been with MIT or IIT, two science and technology-focused institutions (IIT appointed Moholy-Nagy and Mies van der Rohe). For the first time ivy-league schools supported programs not built on philosophical discernment, but on the anti-intellectual traditions of guilds, which, as Gropius expressed it, perceived members of the academy as dilettantes (those that profess, namely those with vast intellectual resources; theorists that don't do but speak). This view still prevails today at most design schools, especially on undergraduate levels, where "doing" by example is still more important than "critical thinking." Both Mies van der Rohe and Laszlo Moholy-Nagy were not academy educated. For example, van der Rohe attended the Aachener Domschule attached to the bishop's domain, a catholic parochial school intended to prepare pupils for entry into the guilds, where he received his formal education for the last two years before he left at fifteen years of age, to enter a four-year apprenticeship as a draftsman of ornamental stucco. Moholy-Nagy's education was also very mottled and self-directed. The negative end result is a baccalaureate degree in design initially geared to prepare fifteen-year-old apprentices, not the independent thinkers that are needed today. The baccalaureate in design very much mirrors the four-year apprenticeship that used to lead to the level of *"Geselle"* (journeyman) along with adaptation of the knowledge developed by others. There were never any intentions to grow mature master and doctoral programs. Unfortunately there still aren't in the US, beyond doctoral programs at the Institute of Design at the Illinois Institute of Technology, Chicago, or North Carolina State University, Raleigh.

This anti-intellectual view was already challenged two decades earlier, by Peter Drucker's ideological framing (1994) of the "knowledge society," in which he perceived access can only be gained through deep, formal and continuous intellectual education. Drucker makes clear distinctions between those skills that one can accrue through apprenticeship and through on-the-job-coaching (traditional hand-skills and physical procedures, software programming knowledge and use of digital technologies, etc.) and those that can be acquired only through formal university education, through research and testing. Manual and technological skills alone, no matter how advanced, will not propel anyone to leadership in their discipline in a "knowledge society" driven by intellect. The only measure will be the intellectual levels that the design discipline reaches, how its intellectual integrity is perceived by other vital disciplines and how it translates intelligence into public good.

IS THERE LIFE OUTSIDE OF THE "DESIGN BOX" . . . NOT YET . . . NOT EVER . . . NEVER?

The historian Thomas S. Kuhn (1962) claims that in science, progress cannot be measured via a linear accumulation of new knowledge, because the discipline goes through major revolutionary shifts that abruptly transform the nature of scientific inquiry within a particular field. If the intellectual community he represents has accepted this insight, then why does the same possibility not exist for communication design? New design paradigms lack common characteristics and qualities necessary for comparison. Although not impossible, it is most difficult to understand a revolutionary paradigm through the homeostatic conceptual framework of a paradigm that is beginning to wane. But it is clear that the traditional design paradigm now shows many anomalies from the norm, which should signal a time for change. Design can't afford waiting for the crisis to get even worse. It must act now.

If not, designers will continue to play in a very confining box, even if they seek credit for playing outside of it. A perfect analogy for describing communication design is provided by the game of chess. Scholars believe it is very unlikely that "creativity" can be attributed to any single person (designer) or single culture (school) for the invention of the structure, rules and physical configuration (dogma, methodology, mythology and hierarchy) of the game of chess. Chess (communication) is an organic historical fusion of commonly experienced human factors, psychological, social and cultural. This definition eliminates "creativity" and "invention." The players (designers) can only contribute to the elegance of the game by translating the rules into productive strategies and tactics. They can explore numerous possibilities among the finite patterns. There is some room for intellectual bravura and conceptual surprise, but the aesthetics lie in the development of operational strategies or tactics. Efforts of aesthetically styling or changing the form of any of the game-pieces will not make the game more intelligent. In chess as in communication design, useful intuition emerges only after a significant investment in intellectual trial and error, imagining and applying strategies and tactics, winning and losing. True creativity would mean changing the game, not just moving the figures around according to existing rules. There are millions of chess players, but there are very few chess geniuses. Still designers should try to emulate Archimedes who reserved the claim that if given the lever of a far-reaching enough concept or idea and a solid foundation for a pointed intellectual position on which to stand, he would lift the earth off its foundations. And just possibly, designers could try to do the same thing. They should at least consider such efforts.

But to begin to do that, they have to escape the intellectual and behavioral imprinting of design education institutions and design practice. Pavlov's learning theory of conditioning designers must be challenged—to not associate concepts of excellence and competence with myths of award and adulation, to not begin salivating immediately at each announcement of a new award competition.

You got questions,
you come to me.
I'm Carr, the floorwalker.
I'm responsible for
order in here.

Any man don't keep order
spends a night in . . .

. . . the box.

FIGHTING THE DESIGN-DRAGON

Projects begin with a client's incomplete project brief that describes usually the tip of the problem-iceberg only, and unless designers ferret out the hidden information of the true context of the problem to understand to what extent their solutions create the right fit between content, context and satisfaction of use, they potentially and with great probability will snatch failure from success, because it is impossible to design for unlimited or poorly understood dynamic conditions. The more substantial the problem and corporate financial investment are, the more convoluted, longer and jittery the decision-making processes becomes. In dynamic times, even though businessmen understand the constant dynamic shifts in the world of stock, they are unaware that delays in decisions begin to offset the otherwise right and intended fit.

The various "you-are-so-marvelous" design confabulations make up the professional slight of mind in which the true reason for a continuously growing black hole in designers' knowledge to deal with larger important problems is hidden. The steady decline of status is covered up with self-deceiving rhetoric, which in time is believed to be true by the membership, even though lacking scrutiny or analysis, testing or critical evaluation. Small is not always beautiful. Design does not always sell or work. And a picture is not always worth a thousand words. Even Louis Sullivan's "form follows function" has been finally dragged down to "form follows precedent" and applied in subsequent instances.

Texts on animal breeding warn of problems of inbreeding. They point to the lack of resilience in the immune system, all kinds of genetic disorders, reduced fertility and vitality. They even point to early mortality rates. So why do schools and design studios behave like owners of puppy-mills, continuously graduating closely related pedigrees; creating an intellectual monoculture, instead of becoming astute stockbreeders?

In design, "tar baby schools" are trying to hold things together by shielding constituents from being thrown into the thorny intellectual briar patch, afraid of sticky situations that require serious investment of intelligence. In the quiet of their conscience, recognizing that their businesses have been in drastic decline, they honestly must admit that this is not due to any economic recession, but more to intellectual apathy. They must also realize, the longer they wait with redress, the worse it will get, especially if they continue to protect the status quo.

Since the development of graduate programs half a century ago, graduates from a handful of institutions dominate the majority of faculty at US institutions. Someone has to give an answer to the critique that present day design education across this country is incapable of supporting the needs of a contemporary "knowledge society." Without a serious critique, the self-defeating, crippling cycle will continue, the design-dragon biting its own tale in perpetuity, supplying the next rung of educators and practitioners. Why is the hiring process used to minimize conflicts between disparate ideologies instead of stimulating vigorous debates? The tenure, contract renewal and employment processes make clear that it is safer to avoid ideological confrontations; to not arouse anger in the homogenous beliefs of a group. Cognitive diversity requires that persons from different educational and occupational backgrounds be brought to the table to help break design's major mind-jam.

Conformity has bred complacency and created a serious loss of cognitive diversity, which has not been addressed by heads of design departments and especially not by the academic leadership of deans and presidents. Any alert university administrator should recognize that design has the slowest upward moving knowledge-curve compared to all other disciplines. In fact, they should wonder, why the subject of design should be taught today at a university all together. It seems to fit much more into the vocational environment. General education distribution requirements continue to be the only glue to the promised university experience. This bare minimum of intellectual stimuli is incapable of supporting design as a professional discipline. Maybe, it has escaped the academic mind that it is supposed to lead, not be lead.

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INDEX FOR VISIBLE LANGUAGE VOLUME 43

By Author

By Title

COMING SOON...

The next issue of Visible Language (44.1) continues the exploration of Communication Design Failures. Authors continue to critically examine failures of interest or even their own. The following papers round out the investigation.

Designers often ignore, or at the very least find theory suspect. Semiotics has received attention in various ways in design education, sometimes in a cursory way and in rare cases in depth. Following an historical look at the competing structures of semiotics and semiology, Storkerson examines their use in graphic design education and their operationalization in technical communication and human factors. This is necessarily a critical paper that attempts to understand the gap between philosophical terminology and theory construction and its application as an analytical and generative strategy in design.

Not accepting the traditional, legal-based structures for communicating pharmaceutical information for the use of medications, van der Waarde finds them inadequate for the end user, and seeks to reveal the false assumptions on which they are based. He uses rhetorical theory in a careful step-by-step analysis to ferret out the issues. The results are surprising as they underscore the bureaucratic initiative driving the information design to the detriment of people needing accessible, safe, complete and understandable information. The investigation is in the context of European Union constraints, but his systematic approach demonstrates a useful tactic. The ideas about the presentation of medicine information go beyond the EU.

Context change is the focus of this paper that explores the problems of signage as a dynamic rather than static situation in which customized one-off designs were the norm. Now open source and do-it-yourself production methods require a reframing of the designer's engagement. Signage failures are evident through the workarounds one sees. This signals a systems failure in which the designer conceived information as static rather than responsive to contingency and occasion. Response to the extensive media-rich, changeable information environment in which we live is seen as a missing aspect of design education.

Dubai, a city within the United Arab Emirates, is reinventing itself in an advanced modern mode. Its real estate developments and financial service sectors make a legitimate claim for Dubai as a world-class city. It is home to the Ibn Battuta Mall that purports to celebrate Ibn Battuta, a 14th century Muslim explorer. Using an edutainment strategy, the mall has distorted historical fact and authenticity and failed in its educational goals. It is easier to educate or entertain in isolation than it is to perform and integrate both strategies simultaneously; one, the other or both suffer.

FAILURES IN CROSS-CULTURAL DESIGN

Susanna Barreto

Thrust into a global economy, living with images and narratives from around the world via media, designers need to ask: Is global design possible? Is there such a person as a world-citizen? Taking a case study approach, this paper examines the relationship between the global and local and how local values and context can derail global approaches to design communication. Barreto cites two important, often overlooked and uncontrollable aspects of the current situation: global exposure and global memory. Designers cannot afford to be culturally naïve or ignore the far-reaching media access employed worldwide.

The guest editors of this special series reflect on the failures identified in the various papers and interpret what this suggests for design research, practice and education. The context in which design operates is changing rapidly; the failures cited in this series point out the fractures in our understanding and practices from user-centered, digital, process-oriented, cultural, ethical and even safety-oriented perspectives.