DEARQ - Revista de Arquitectura / Journal of Architecture
ISSN: 2011-3188
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Universidad de Los Andes
Colombia

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DEARQ - Revista de Arquitectura / Journal of Architecture, núm. 8, julio-, 2011, pp. 6-17
Universidad de Los Andes
Bogotá, Colombia

Art, design, science, and technology: the necessary melding

Arte, diseño, ciencia y tecnología: una fusión necesaria

Recibido: 22 de febrero de 2011. Aprobado: 1 de junio de 2011.

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Abstract

This paper endeavors to detail the importance of design education and how it helps to prepare students for the challenges that they will face in the design profession. The text is divided into five parts. The three first parts manifest various inherent dilemmas in the area of design: the first deals with the dilemma of the innovation chain, the second studies the conflict between reliability and validity, and the third part tackles the area of creation in design. The fourth topic introduces the necessary path that should be taken to resolve these dilemmas: the educational path. In the fifth section of this paper several examples are presented, which portray design experiences that seek to undertake the dissolution of the schism and emphasize the dialogue between the context and user. This text highlights the need to establish strict correlations between the disciplines of art, design, science, and technology. These areas should not only be contemplated as individual units, but also as a combined organic whole. In contemporary design, cultural transformations are a complex process; with this in mind, the paper reaffirms the belief that responsibility and ethics can help new designers to decide how to and if it is necessary to use constrained social and technical innovations.

Keywords: art, design, science, technology, dilemmas, creation, education

Resumen

Este artículo busca señalar la importancia de los procesos educativos en la enseñanza de diseño, lo cual ayudará a preparar a los estudiantes para los retos que tendrán que enfrentar como diseñadores. El texto se divide en cinco partes. Las tres primeras presentan varios de los dilemas inherentes al área del diseño: la cadena innovativa, el conflicto que se da entre rehabilitación y validez y el ámbito de creación en el diseño. La cuarta parte presenta el camino que resulta necesario recorrer como solución de los anteriores dilemas: la educación. La quinta sección del artículo contiene varias experiencias de diseño que buscan ejemplarizar la disolución del cisma y enfatizar en el diálogo entre contexto y usuario. Este texto hace énfasis en la necesidad de establecer estrictas correlaciones entre ciertas disciplinas artísticas, de diseño, ciencia y tecnología; entendiendo que son disciplinas que no deben comprenderse, únicamente, como unidades individuales, sino como unidades que hacen parte de una composición orgánica en su todo. En diseño contemporáneo, los procesos de transformación cultural son complejos, con lo cual, y teniendo esto en mente, este artículo reafirma el hecho de que la responsabilidad y la ética pueden ayudar a los nuevos diseñadores a decidir cómo, y si es necesario, el uso coercitivo de innovaciones sociales y técnicas.

Palabras clave: arte, diseño, ciencia, tecnología, dilemas creación educación.

The first dilemma: the innovation chain

Little time has passed since those responsible for policy-making in the fields of science and technology have recognized that, as Bonsiepi[1] claims, science, technology, and design constitute a system. It is the author's belief that science, technology, and design form distinct and autonomous fields. Each one of these fields has its own particular approach.

1 Bonsiepi, "A cadeia da inovação", 34-35.

To highlight the differences between these fields, Bonsiepi[2] used a five-category matrix involving: innovation objectives, dominant discourse, standard practices, social context, and satisfaction criteria. He then applied these items to the three forms of innovation: scientific, technological, and design (as shown in Table 1).

2 *Ibid.*, 35-36.

On considering innovation in science,[3] Bonsiepi[4] declares that: a) the objective of innovation has a direct relationship with the generation of new knowledge; b) the typical language of scientific discourse consists of sentences that take the form of verifiable assertions; c) the standard practice used is the generation of evidence that can be proved by other observers. Basically, scientific methodology seeks to express itself through true sentences and not false ones; d) the micro-social context of scientific work is the institute, which can be perceived as a factory for new knowledge; e) success can be measured by recognition from other members of the scientific community, especially from one's peers. In this case, a satisfactory result is proving the truth, which is in turn approved by authorities.

3 In Table 1, see the resulting cells from the cross between the first column and the first row.

4 Bonsiepi, "A cadeia da inovação", 36.

Regarding innovation in technology,[5] Bonsiepi[6] asserts that: a) the objective of technological innovation (or more accurately the product of the various engineering disciplines) is a result of know-how (in other words, how something is made, what materials are utilized, the tole-

5 In Table 1, see the resulting cells from the cross between the second column and the second row.

6 Bonsiepi, "A cadeia da inovação", 36-37.

Table 1: Innovation typology in science, technology, and design

	Science (1)	**Technology (2)**	**Design (3)**
a) Innovation objectives	Cognitive innovation	Operational innovation	Social and cultural innovation
b) Dominant discourse	Statements	Instructions	Assessment
c) Standard practices	Proof	Trial and error	Coherence between objective and user
d) Social context	Institute	Company	Market
e) Satisfaction criteria	Approval of authorities	Technical feasibility	Customer satisfaction

Source: Bonsiepi, "A cadeia da inovação", 35.

rances, how it is finished, etc); b) the language of technology is the language of instructions and commands, similar to a cookbook; c) technology makes use of the trial and error method as a standard practice; d) the institutional context of technology is the company; e) technological feasibilities are the criteria for technological success.

Finally, on design innovation,[7] Bonsiepi[8] affirms that: a) the goal of project activity is the articulation of interface between the user and artifact (not the production of new knowledge or know-how, as it was in the past); in this context, design innovation manifests itself in the domain of social practices in everyday life; b) the language of design is the language of assessments (these assessments are related to practical and functional characteristics, as well as aesthetic and formal ones): it is not a language of assertions or a language of instructions; c) the design methodology emphasizes the coherence between objective and user; d) the micro-social contexts in which design takes place are chiefly, the company, market, and competition; e) satisfaction in design is achieved when there is a direct link between the correspondence of the user's needs and the offer, in the form of a product or service: in this case, the criteria for success are not the verification of a truth, or the empirical verification of a technical viability, but the quest for customer satisfaction.

7 In Table 1, see the resulting cells from the cross between the third column and the five rows.

8 Bonsiepi, "A cadeia da inovação", 37.

Bonsiepi[9] claims that when one element in the science, technology or design chain is not present, innovation ends up not having social and economic resonance. He also states that the situation becomes merely theoretical when the science is separated from the two other elements; it becomes merely technocratic when the technology is separated from the other two elements; it becomes a matter of external esthetics when the design is isolated from the other components.

9 *Ibid.*, 38.

According to Bonsiepi's argument,[10] it is through design that scientific and technological innovations are practically introduced to everyday life. In this way, design is an important factor: becoming part of the process in scientific and technological research institutions.

10 *Ibid.*, 38.

The second dilemma: the conflict between reliability and validity

The dilemma that emerges between the reliability orientation of businessmen and the validity orientation of designers in project development will now be addressed.

In an article entitled "Design & Business: Why Can't We Be Friends"? Martin[11] states that these two different orientations create a fundamental schism. He asserts that when designers and executives understand the sources and nature of the divide, they are able to overcome their tension. With regards to the author's claims, the fundamental tension he refers to is the result of five paradoxes, shown in Table 2.

11 Martin, "Design and business", 2.

Table 2: The fundamental tension: Reliability vs. Validity

Reliability	Validity
- Production of consistent, replicable outcomes - Substantiation based on past data - Use of limited number of objective variables - Minimization of judgment - Avoidance of the possibility of bias	- Production of outcome that meets objective - Substantiation based on future events - Use of broad number of diverse variables - Integration of judgment - Acknowledgement of the reality of bias

Source: Martin, "Design and business", 3.

Martin's[12] analysis of the first paradox is that, *"[r]eliability results from a process that produces a dependable, consistent, and replicable outcome. Validity, by contrast, results from a process that produces the desired outcome"*. The second paradox is that reliability is demonstrated by past events, whilst validity can only be demonstrated by future events that take place over time. The third conflict is that businessmen make use of a limited number of objective variables, while designers seek a deep understanding of the user and the context, examining many variables. In the fourth paradox more reliability requires fewer variables, while more validity requires more consideration. In other words, more reliability requires quantitative judgment, and more validity requires qualitative judgment.

12 *Ibid.*, 2-3.

Martin[13] complements his argument by stating that in reliability, the avoidance of the possibility of the bias prevails, and that in validity the acknowledgement of the reality of bias is predominant. This discussion demonstrates the dialectics that design engages in when it works on one of the most fundamental parts of company life: the development of a project. Hence, reliability and validity subsist in a fundamental-structural conflict.

13 *Ibid.*, 3.

Moreover, for Martin,[14] the tension between reliability and validity can be maintained by the dialectical relationship between business executives and designers.

14 *Ibid.*, 4.

To explain how business and design influence each other, the aforementioned author explains that, at a conceptual level the world of businessmen and the world of designers can be visualized by the two curves showed in figure 1. The business curve emphasizes reliability, while the designer curve emphasizes validity.

According to Martin,[15] while the business curve represents an environment in which meeting with budgetary requirements, hitting earnings targets, and "proving" in advance, results in rewards, the design curve possess an inherent bias toward validity. He says: *"They* [the designers] *don't limit considerations to aspects that can be thoroughly quantified"*.

15 *Ibid.*, 4.

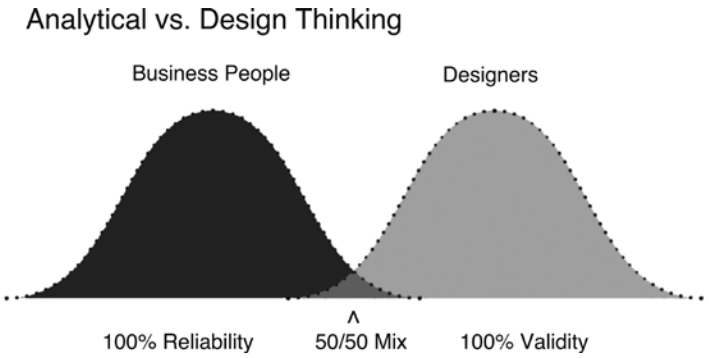

Figure 1: A Fundamental Predilection Gap. Source: Martin[13], "Design and business", 4.

Even with this conflict, we can see in Figure 1 that there is a small gray overlapping area – a small segment – that seems to be contradictory, or paradoxical in the confluence of the two mainstream tendencies. Therefore, in order to overcome the fundamental tension, it is understood, as shall be argued in Part Four of this paper, that the possibilities of change can really become viable: but if only the realm of creation in design can be reviewed (perhaps changed) by means of education.

The third dilemma: the realm of creation in design

16 Fallman, "Design-oriented Human – Computer Interaction", 226.

Based on Fallman's[16] ideas, three accounts that provide *"different but equally important attempts to seize and conceptualize what the vibrant discourse of design really 'is' and what it is designers really 'do' when they design"* will be presented.

These accounts are entitled the following: The Conservative Account, the Romantic Account, and the Pragmatic Account.

17 *Ibid.*, 227.

To highlight the specificities of these accounts, Fallman[17] used a matrix involving six elements: the designer, problem, product, process, knowledge, and role model. He applied these items to the three different accounts, as it is manifested in Table 3.

18 *Ibid.*, 226-227.

With regards to the *Designer*,[18] in the Conservative Account, the designer works as an information processor, like "a glass box". The author asserts that a series of well described, discrete, rational, and structured methodological steps help to achieve progress in the project. Methodology and structure are keywords in design practice. The designer is viewed as an engineer or a natural scientist. In the Romantic Account, the designer works as a creative, imaginative genius, like an artist: a "black box". The designers are regarded as masters equipped with magical creative abilities. The idea of "creative geniuses" is presented in this account, as a reaction against rationalism. In the Pragmatic Account, design is seen as a hermeneutic process of interpretation and creation of meaning. In this theory the designer is related to Levi-Strauss' concept of the "bricoleur". The designers are engaged in a

specific project, in a particular situation, in which constructive and reflective skills are necessities. Design can be thought of as a "self-organizing system".

With regards to the *Problem*,[19] in The Conservative Account, the problem will be defined by the designer (or the design team). This group of professionals will find solutions taking into consideration various constraints for example, cost, time, and performance issues. At first, the problem is ill defined and unstructured, but step-by-step the problem has to be solved. The product is predominantly a result of the process. In The Romantic Account, the problem is subordinated to

19 *Ibid.*, 226-227.

Table 3: Three accounts in the realm of design

	Conservative Account	Pragmatic Account	Romantic Account
Designer	An information processor; 'a glass box'	A reflexive, know-how bricoleur; a 'self-organizing system'	A creative, imaginative genius; an artist; a 'black box'
Problem	Ill defined and unstructured; to be defined	Unique to the situation; to be set by the designer	Subordinate to the final product
Product	A result of the process	An outcome of the dialogue; integrated in the world	A functional piece of art
Process	A rational search process; fully transparent	A reflexive conversation; a dialogue	Largely opaque; mystical
Knowlegd	Guidelines; design methods; scientific laws	How each problem should be tackled; compound seeing; experience	Creativity; imagination; craft; drawing
Role Mode	Natural sciences; engineering; optimization theory	Bricolage; human sciences; sociology	Art; music; poetry; drama

Source: Fallman, "Design-oriented Human", 227.

the final product, which is a functional piece of art. In The Pragmatic Account, the problem is unique to each circumstance and will be set forth by the designer. The product is nothing more than an outcome of the dialogue, bringing to light the interweaving of roles, practices, and technologies involved in each stage of the project.

With regards to the *Process*,[20] The Conservative Account states that it is a rational search process: fully transparent. In The Romantic Account, it is largely opaque and mystical. In The Pragmatic Account the process is a reflective conversation: a dialogue between people, artifacts, and practices, each with their own histories, identities, goals, and plans, much like Schön's[21] notion of reflective conversation.

With regards to the *Knowledge*,[22] The Conservative Account states that the design solution follows the principles of logical deduction and mathematical optimization techniques. In the Romantic Account, creativity and individuality predominate over methodology and control, and aesthetics and individual judgment over transparency and logical reasoning. In the Pragmatic Account, it is important to know how each problem should be tackled. The tacit and pre-reflective knowledge of everyday life and work directs the task. This account considers the experience itself, or the intuitive performance of actions in everyday life.

With regards to the *Role of the Model*,[23] the Conservative Account states that the role of the model is a product of the natural sciences, engineering, and the optimization theory. The Romantic Account claims it is a product of art, music, poetry, and drama. Finally, in the Pragmatic Account, the role of the model is a product of bricolage, human sciences, and sociology.

When endeavoring to synthesize these three types of approach, it is important to remember that in the conservative account the construction process is dominant, in the romantic account the experimentation process is prevalent, and in the pragmatic account a meta-creation process predominates.

As Fallman[24] asserts, in the last case the designer operates like a "bricoleur" (Levi-Strauss) and designs as a "reflective conversation" with the situation (Donald Schön). This professional works with the means available, but treats them abstractly. In each situation, the roles of the concrete tools and materials used are constantly determined and redefined.

The three accounts of design, previously discussed, constitute different ways of characterizing the nature of design. For Fallman,[25] if one or more of these accounts are completely abandoned, or if one of these accounts is given priority over another, design-orientation cannot be achieved. "It is more accurate to say that if one of the accounts is much emphasized, it tends to influence how we think of and explain what it is we do when we design, but that alone does not influence what design 'is".

20 *Ibid.*, 226-227.

21 See Schön's book, The Reflective Practitioner: How Professionals Think in Action.

22 Fallman, "Design-oriented Human – Computer Interaction", 226-227.

23 *Ibid.*, 226-227.

24 *Ibid.*, 227.

25 *Ibid.*, 231.

The three approaches that have been detailed seek to account for the specifics of creation in design. Fallman's,[26] consideration of these previously mentioned topics is that, the role of design (he refers specifically to the design in HCI) is not simply a question of problem solving, or solely an art-form or a struggle with reality, but indeed much more. It explores the tension between details and the search for a coherent, well-balanced whole. It is a reflexive conversation and "[t]he design dialogue thus unfolds".

26 *Ibid.*, 230-232.

The realm of design, therefore, seeks to harmonize the construction, experimentation, and importantly, meta-creation biases that are generated by reflexive positioning and conversation from the players and factors within the design project.

The solution: education

To think of design education as more than the series of mechanical decisions – as a reflexive practice – is a viable way to deal with the dilemmas of innovation and creativity. As Bournett[27] asserts, in order that design students enjoy a successful experience, their course should focused on communication, language, and the quality of interaction: in other words, how to create a relational environment that may or may not have objects as its focus. In this case, the process of production requires a combination of self-reflection and self-appraisal, as well as external evaluation.

27 Burnett, "The difference between Making and Learning", 12.

It is important to move towards this direction, paying specific attention to the educational process in order to provide an opportunity for students to explore new kinds of experiences and interventions.

Therefore, the challenge for both students and teachers is how to expand upon an increasingly narrow set of assumptions about the results of the learning process (Bournett).[28]

28 *Ibid.*, 12.

It is presumed that this situation could be achieved by, as Margolin[29] states, learning from the dialectic of past and present; it is from these situations that the possibilities for the future will be determined. It can be understood, according this thinker's ideas, that *"to plan effectively in the present requires a vision of what the future could and should be"*. His use of the conditional "could" suggests that the future is always based on the contingency of human choices. The conditional "should" indicates that these choices need to be driven by a consideration of what ought to be done.

29 Margolin, "Design, the Future and the Human Spirit", 5.

On reiterating this dialectic, Margolin[30] distinguishes between predictive and prescriptive scenarios. A predictive scenario is based on what could happen, and in juxtaposition the prescriptive scenarios embody visions of what should happen. For the author, predictive scenarios tend to be pragmatic, while prescriptive ones are idealistic.

30 *Ibid.*, 5-6.

Thus, it can be said that considering the discussion in the three first parts of this paper it can be affirmed that design students have to be aware of employing both (predictive and prescriptive) scenarios. It is necessary to show students that each design circumstance requires a balance between these two poles.

It is a given that the world is changing at a dizzying rate. Thus, in response to the increased level of complexity that is, nowadays, involved in cultural transformations, we must try to reaffirm the belief that the educational path can help new designers to make decisions: even if it is necessary to use constrained social and technical innovations. As Thackara[31] proposes: it can be said that, "Understanding why things change – and reflecting on how they should change – are not separate issues".

31 Thackara, *In the Bubble: Designing in a Complex World*. 4.

Hence, in Margolin's words,[32] the big question is: "How does a designer formulate a role as an agent of change and determine a course of action"?

32 Margolin, Design, the Future and the Human Spirit. 5.

Therefore, as Thackara[33] advocated in his book *In the Bubble: Designing in a Complex World*, it is important to reiterate the belief that ethics and responsibility can impact on design decisions without constraining the social and technical innovation it is necessary to engage in.

33 Thackara, *In the Bubble: Designing in a Complex World*. 7.

It is my presumption therefore, that by using the ideas presented Thackara[34] answers to the question posted before can be found. Thus, it is our opinion that the design education emphasis focuses on the complexity of the differences that come from each discipline involved in the design process. As is Thackara's opinion of the design process, we think that it is necessary to introduce a *design literacy* (if it can be named thus), which involves the determination to: a) primarily, think about the consequences of design actions, paying attention to context; b) consider material and energy flows in design systems; c) give priority to human agency; d) not deliver people to systems; on the contrary, it is urged to deliver value to people; e) treat "content" not as if it is something that will be sold; f) treat place, time, and cultural difference not as obstacles, but principally as positive values; g) refrain from producing pointless devices, and focus not on things but services.

34 *Ibid.*, 8.

This is a very difficult task; however it is important that the paths and directions indicated are followed.

Some experiences that undertake the dissolution of the schism

In this final part of this paper, we will present various experiences, showing works of design that seek to undertake the dissolution of the schism and emphasize dialogue between the context and user. These works encourage relationships between the people who make things and the people who use them. These works require the designer to become aware of how each design process requires a balance between what could be done and what should be done.

In Project H Design's context,[35] which can be visited at http://www.projecthdesign.org/index.html, there is a collection of projects that try to improve different people's quality of life, who are living in distinct countries throughout the world. The various works include "Furniture For Rural Schools": a modular and adaptable desk system for rural schools in Mexico; "Whirlwind Wheelchair": a low-cost peripheral function system enabling improved mobility for the disabled in the developing world; "Hippo Roller Re-design": a revised version of a previously existing water transport device that has been redesigned to increase shipping efficiency and broader distribution; "The Design Revolution Road Show": a mobile traveling exhibition and lecture series bringing "product design that empowers" to new generation across the U.S.A in the Spring of 2010. These are some examples of projects that manifest how the new design generation has a big responsibility to change the future and world.

In the last example, the exhibition is housed in an old Airstream trailer. Whilst traveling, it aims to give presentations to different high schools and university design programs regarding thirty-six products that have been showcased in the book *Design Revolution: 100 Products that Empower People*: author Emily Pilloton. In this book more than 100 contemporary design objects are featured. Through the use of appropriate technologies, the development of lifestyle improvements for consumers is demonstrated.

In South America, another example of this kind of product is the project PedalUSP,[36] which is still in the implementation phase in the City University of São Paulo. It is a bike-sharing project inspired by the model that exists some international cities. It consists of a network of automatic bicycle storage stations. The user can hire a bicycle at a station, use it as a method of transportation for a desired period of time, and return it to any station participating in the system. Its intention is to increase mobility on campus, encourage physical activity, and contribute to a greener air policy.

In summary, the different initiatives that are examined in the paper endeavor to change the designer's method of thinking and creating. As Pilloton states, a sentiment that is reiterated by Savio,[37] it is increasingly important for the development of the world to try to "change our cultural understanding of design from the act of forming things to that of changing conditions". In doing so, the designer's energy, knowledge, and talent will be concentrated on enriching people's lives.

Final considerations

It has been the intention of this paper to indicate the importance of contemplating the narrow correlation between art, design, science, and technology. In this paper, art, science, and technology (and even the business) have been treated as an organic system that circumscribes and enfolds the design process. At the same time, the specificities

35 "Project H Design" was founded by Emily Pilloton and is consists of a design team that tries to use "the power of the design process to catalyze communities and public education from within". They believe that design actions belong in the hands of the next generation. In their words: "We don't just deliver design solutions FOR education, we hope to instill design thinking in the minds of young citizens, so that they may be better equipped to take on the next generation of global issues". Available at: http://projecthdesign.org/about.html. Accessed: 7th Feb. 2011.

36 See information at http://www.usp.br/imprensa/?p=9166 /. Accessed: 20th Jun. 2011.

37 Savio. Solving the World's Problems through Design. 54.

and differences of these areas were considered, which in turn draw attention to the dilemmas involved with the constraints of the design profession. The text also tried to show the significance of education, through which designers can become more competent in dealing with restrictions, and also gain a deeper insight into what must be done and what can actually be done.

The dilemma of the innovation chain was dealt with in the first part of this paper. It was realized that science, technology, and design all add certain factors that contribute to the product innovation process. It was stated that, when there is a lack of one of these elements in the chain – science, technology, and design – the innovation does not work properly, and the social and economic resonance cannot be achieved. When the scientific element is given privilege, the theoretical solutions become dominant; when technological element is emphasized, the technocratic solutions become prioritized; and when emphasis is placed upon design, formalistic solutions become prominent. To assure that the scientific and technological innovations can be used in everyday life situations, it is necessary to think about the innovation process as the intrinsic relationships between these three elements.

The second part dealt with the innovation's dilemma, which emerges between the reliability orientation of businessmen and the validity orientation of designers during the project development process. The paradox between the executives' and designers' interests was manifested, as well as the fact that if these poles can both try to overcome the tension, the possibilities for change could become viable.

The third part dealt with the realm of creation in design. We intended to show what the real discourse of the design process is, presenting different ways of characterizing the nature of design: the conservative, romantic, and pragmatic accounts. In the first approach, in which the model is taken from natural sciences and engineering, the construction process is dominant; in the second account, in which the model comes from art, the experimentation process is prevalent; and in the third, in which the model comes from bricolage and human sciences, a meta-creation process predominates. It is necessary to think about the activity of design in harmony with the construction, experimentation, and meta-creation biases, generated by reflexive positioning and conversation undertaken by the players and factors present in the design project.

The fourth topic proposed an educational solution as a way to really solve those three dilemmas. It is important to move towards this direction. It is understood that design students need to be able to employ any kind of scenario, and be able to deal with the predictive and prescriptive constraints. It is necessary to demonstrate to students that each design circumstance requires a balance between ethics and responsibility, and that it is important to focus on the complexity of the differences that each discipline involved in the design process bring.

In the final part, various experiences were presented. They portrayed design works that seek to undertake the dissolution of the schisms dealt with in this paper. The examples given emphasize the required and essential dialogue between the context and users.

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