AC 2011-1989: DESIGNING IN A SOCIAL CONTEXT: SITUATING DESIGN IN A HUMAN-CENTERED, SOCIAL WORLD

Craig Titus, Purdue University
Carla B. Zoltowski, Purdue University, West Lafayette

CARLA B. ZOLTOWSKI is Education Administrator of the EPICS Program at Purdue University. She received her B.S.and M.S. in Electrical Engineering and Ph.D. in Engineering Education, all from Purdue University. She has served as a lecturer in Purdue's School of Electrical and Computer Engineering.

William C. Oakes, Purdue University, West Lafayette

William Oakes is the Director of the EPICS Program at Purdue University, one of the founding faculty members of the School of Engineering Education and a courtesy faculty member in Mechanical Engineering and Curriculum and Instruction in the College of Education. He is an fellow of the ASEE and NSPE. .He was the first engineer to win the Campus Compact Thomas Ehrlich Faculty Award for Service-Learning. He was a co-recipient of the 2005 National Academy of Engineering's Bernard Gordon Prize for Innovation in Engineering and Technology Education for his work in EPICS.

Designing in a Social Context: Situating Design in a Human-Centered, Social World

Introduction

Since the appearance of the National Academy of Engineering's (NAE) 2004 report, *The Engineer of 2020*[1], several aspects of the future of engineering have been undeniable. The world population is changing in mostly known ways and changing with it are the kinds of stakeholder needs typically addressed by engineers. Government studies project population worldwide to increase from 6 billion currently to 9 or 10 billion within the lifetimes of today's beginning engineers[1] and this massive increase will bring with it more than the challenges of sheer volume. The demographic diversity of the global population is changing just as radically. To give one example, according to a US Census Bureau study, "If current trends continue . . . the percentage of whites will decline from the 2000 value of 75.6 percent to 63.7 percent . . . . [and] by 2050, almost half of the U.S. population will be non-white"[1]. This is a significant change that means engineering as a profession will have to remain socially sensitive and be aware of the ways in which it must adapt if it is to properly address the needs of its stakeholders. The engineers of 2020 and beyond, as envisioned by the NAE's report, must become versed in more than the technical possibilities of problem solving by incorporating a deep and meaningful understanding of the social context in which their design work is situated. In going beyond, engineers should aspire to "expand their vision of design through a solid grounding in the humanities, social sciences, and economics"[1].

The movement in engineering design education in recent years has been toward a more social, more human-centered design. It is our claim that if engineering education is to keep up with the changing social needs of stakeholders, it could hardly do better than to advocate a deeply and socially sensitive human-centered design (HCD) approach. In the book *Educating Engineers: Designing for the future of the field*, Shulman writes:

> Increasingly, design is understood as a collaborative process in which different types of engineers, as well as nonengineers from a variety of backgrounds, become part of the design and implementation teams with which engineers must work collaboratively. Similarly, the process of engineering design increasingly places the human impact of design and its products at the center of the deliberations. "How might it have been designed otherwise?" is a question about the human consequences of human invention, a consideration of engineering design as a social and humanistic field as well as a technical and scientific one[2].

This move is partly due to ABET's accreditation requirements now including language stressing the importance of engineers working within social constraints, such as the environmental, social, political, and ethical situations of their designs. And ABET goes further still, requiring students become capable of communicating effectively, of working on multidisciplinary teams, and of understanding the broad impacts of their work in global, economic, and social contexts. It is our belief that as globalization and technology render the world culturally flatter, bringing more of the world's people together, students must be equipped with not only the technical skills required of their discipline, but with the ability to see their work in its relation to human beings—to all human beings. As engineers are being asked to address needs that are more global in nature the social context cannot be a mere constraint on the technical design, but must inform the entire design process.

In this paper we will discuss the methods we have used within a service-learning program to integrate engineering and technology education with the social concerns such work involves. We believe the EPICS program at Purdue University, with its focus on multi-disciplinary teamwork and interaction with local communities, along with its explicit and radical commitment to human-centered design, offers an example of an educational environment that will allow engineering to develop and maintain the social sensitivity it needs.

This is not to say that we turn away from rigor or sound technical fundamentals. To the contrary, the move toward a more human-centered design approach necessitates a sound grasp of the technical fundamentals *first* in order to be able to apply these tools effectively and efficiently in different contexts. What is needed is not a full reversal from the technical focus that has historically defined engineering. No one is recommending that engineers shift their focus to the social criteria of their user's requirements *in lieu of* the technical criteria. If there are to be changes in engineering and in engineering education, the approach must be to rebalance the perspective of designers to put the user and the user's needs at the center of design rather than centering technology for technology's sake.

We believe all design is design for a user. This starting point implicates any engineering or technological design work as part of a broad and complex social context involving much more than what might be typically associated with engineering as a practice. Design education, then, must be inclusive of this broad understanding. In response, we have developed pedagogical methods, teaching philosophies, and curriculum components to help students better integrate their thinking about the technical aspects of design with the social aspects of design. Specifically, we have expanded our entire introduction-to-design lecture series to provide examples of how engineering and technology affect people's personal lives and how people's lives affect design decisions. We have also created ethics and social context skill sessions—small scale group-oriented workshops to allow students to work on design challenges in a more hands-on, personal way. Our overarching motivation throughout the development of these curriculum materials has been to adopt a human-centered design approach as a way of implementing a closer focus on a design's social context. In many important ways, human-centered design represents a solution to the need for engineering educators to prepare students to address the social needs of their users.

Challenges Faced by the Engineers of the Future

Vincente[3] points out a common double standard in engineering design, one that illustrates the complexity of the engineer's relationship to the user. "When engineers ignore what is known about the physical world and design a technology that fails, we blame them for professional negligence. When they ignore what is known about human nature and design a technology that fails, we typically blame users for being technologically incompetent." Engineers are expected to know the parameters of the physical constraints they are given and to design within them, but they are less-commonly expected to know the constraints of their users. Insofar as this example rings true, we begin to see the problem with the technology and physics-oriented focus of engineering. Users are expected to be able to learn how to use the products they are given and they are expected to play a role in the adoption of new products into everyday use. But what if the products they are given do not mesh with their requirements? What if users, as it turns out, are fully competent agents after all, but are continually being given products that have been designed without their consultation and without a good understanding of what might work best for them? According to the example given by Vincente—and innumerable anecdotal confirmations of its point—we should continue blaming users for their own incompetence. This is a frightening idea when we consider that every day more engineers are introduced to more of the world's people and that if these engineers are to be effective designers and effective problem solvers they will have to engage with the users of their designs in a more meaningful way than the engineers of the past.

The NAE's report on the engineer of 2020 is clear that the engineering profession must find ways of keeping up with the increasing diversity of the world. Engineers must develop global competencies that extend well beyond technical expertise and incorporate, instead, user's social needs as well as their technological needs. This of course dramatically increases the complexity of the job of the engineer, an increase the NAE report illustrates in a complexity model (fig. 1). As the profession changes and new problems fall within the purview of engineers, those engineers must adapt and must come up with new solutions to new problems. The complexity model shown in the figure below suggests that as new solutions are created to address the new problems, confidence in the effectiveness of the solution increases. Likewise, as engineers increase their knowledge of the new problems and the new solutions, they become more likely to design cost-appropriate solutions.

Part of understanding the nature of the new problems faced by engineers is understanding what non-technical issues are relevant. The NAE suggests that instead of the typical narrow technological view of the solution space of engineering problems, the engineers of the future must consider the "legal, market, political, etc. landscape and constraints that will characterize" new problems and new solutions[1]. In other words, engineers will be expected to

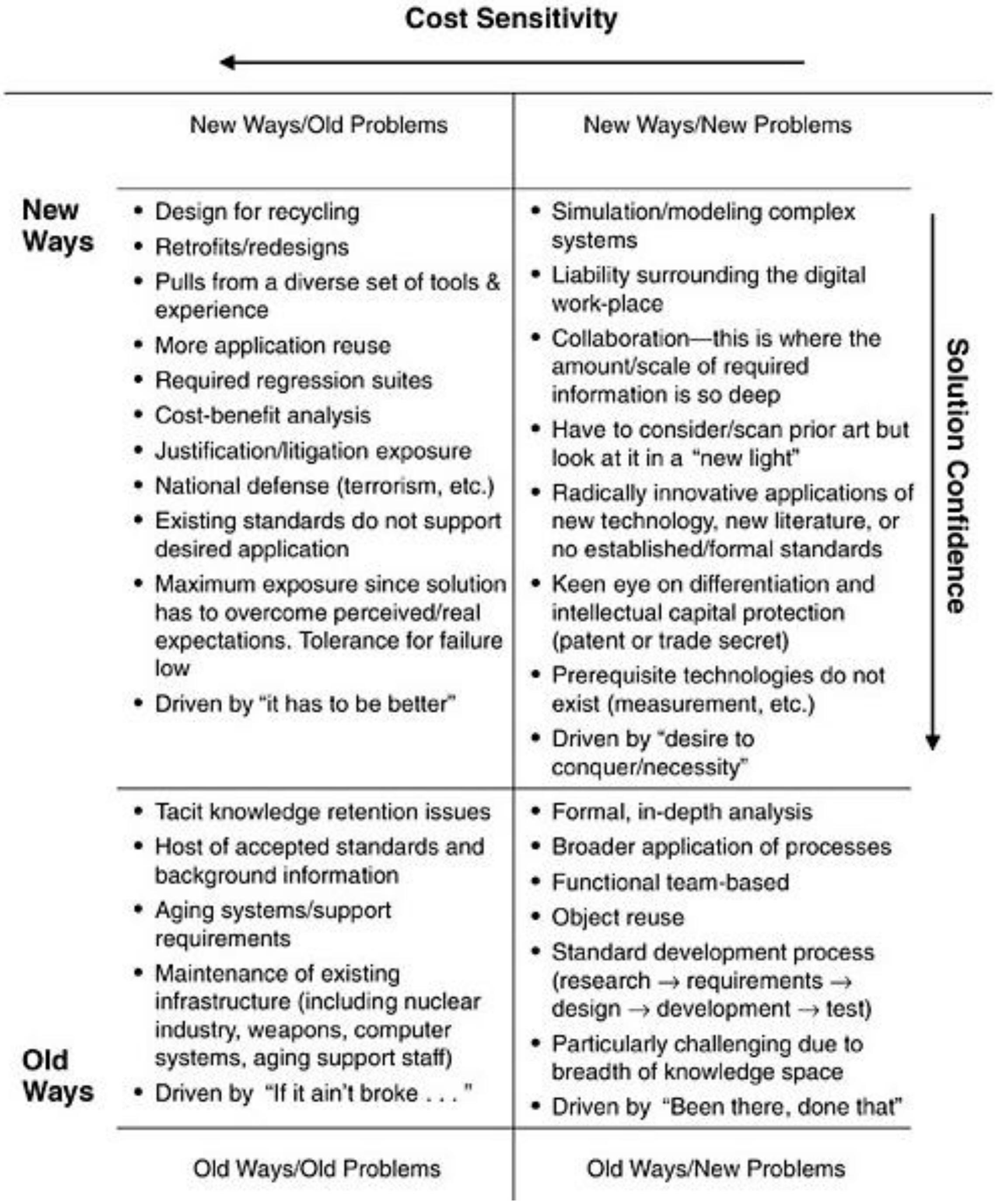

Figure 1

know more than the constraints of the physical world. They will need to become political agents, and become versed in the legal and economic limitations and possibilities of their designs. They will need to incorporate far more information into their designs than ever before. So the question remains, how are engineers expected to do this? Surely they will need a better design process and a better method for acquiring and understanding the increased information necessary for an appropriate design. The solution, we claim, can be found in the use of a human-centered design process.

New Approaches to Engineering Design

Design in general has been defined in a number of different ways. Dym, Agogino, Eris, Fey and Leifer[4] define design as a "systematic, intelligent process in which designers generate, evaluate, and specify concepts for devices, systems, or processes whose form and function achieve clients' objectives or users' needs while satisfying a specified set of constraints." Alternatively, engineering design is the "art of applying scientific theory and principles to the efficient conversion of natural resources for the benefit of humans to satisfy perceived needs and desires"[5]. While both of these definitions mention technological solutions to specifically human problems, they do not specify the degree to which any new technologies should be addressed to the person's complex needs. How many of the user's needs must a design satisfy, for example? If not all of them, which ones, and in which categories? We might also ask who makes these decisions. That is, who decides which needs are more important than others and which requirements have priority in the final design over others?

In a human-centered design process the user makes these decisions, but not alone, in conjunction with the design engineer. The engineer who is engaged in human-centered design must strive to go beyond a mere comprehension of the user's requirements. The engineer must try to see the problem from the perspective of the user, to take on that user's worldview for a moment and internalize the user's understanding of the problem and vision for the solution. Human-centered design in the ideal form is empathic design, where the engineer is able to empathize with the user or take on the user's feelings on the broad range of issues defining both the problem and the solution space.

This conception of design as human-centered is in distinction to the more common notion of technology-centered design. Krippendorff[6] describes technology-centered design as follows:

> Technology-centered design improves the world in the designers' or their clients' terms. Making a machine cheaper to produce, more energy efficient, or more usable by more people may well be intended to and actually does benefit a community of users, but the measures of these benefits are the designers' choice…[and] imposed from above, by experts onto lay people. (p. 31)

A technology-centered approach has also been described as where "devices are designed according to the design-then-train philosophy 'force users to adapt to the system. The user is entangled with the system terminology and jargons that are the designer's view of the world'"[7]. Neither of these descriptions of design is consistent with a human-centered design. Neither is interested in understanding the problem from the perspective of the user. Other human-centered design models serve to illustrate the distinction. Where technology-centered design focuses more on the technical constraints and possibilities available to a design challenge, human-centered approaches begin by trying to understand the stakeholders in broad ways and by including them as much as feasible in the design process. Examples of this latter kind include user-centered design, participatory design, contextual design, inclusive design, activity-centered design, use-centered design, practice-centered design, client-centered design, and empathic design.

Service-Learning

Service-learning is the intentional integration of service experiences into academic courses to enhance the learning of the core content and to give students broader learning opportunities about themselves and society at large. Service-learning has been defined as a type of experiential education in which students participate in service in the community and reflect on their involvement in such a way as to gain further understanding of course content and of the discipline and its relationship to social needs and an enhanced sense of civic responsibility[8]. The pedagogy of service-learning is has four key characteristics: service to underserved communities; academic content; reciprocal partnerships with the community, university and students; and reflection or metacognitive activities that enhance student learning of course content, the community and themselves[9].

When design is taught through service-learning, it moves to a human-centered approach. Students must understand the users, stakeholders and the issues impacting the need and potential solutions to develop an effective design. The reflective components of service-learning function effectively as methods to guide students in their exploration and understanding of the users. The concept of reciprocal partnerships raises the stature of the users in the mind of the designers and can empower the kind of relationship and interaction sought by a human-centered approach. While students are practicing the characteristics of high quality service-learning, they are also developing their skills as human-centered designers.

Curricular Program

The EPICS Program is a nationally recognized model for engineering-centered, service-learning design[10, 11]. In EPICS courses, students learn design by participating in design teams that develop solutions to meet the needs of the local community. In the 2010-2011 academic year, almost 700 students from over 50 majors participated in 90 design projects, addressing needs ranging from data management for human services to creating energy efficient, sustainable home designs for low income families.

Each EPICS project involves a team of eight to twenty undergraduates, a not-for-profit community partner—for example, a community-service agency, a museum, a school, or a government agency—and a faculty, staff or industry advisor. A pool of graduate teaching assistants from seven departments provides technical guidance and administrative assistance.

Each EPICS team is vertically-integrated, consisting of a mix of first-year students, sophomores, juniors, and seniors and is multidisciplinary, drawing from across engineering and from across the entire campus. Teams often operate for several years, from initial project definition through final deployment and support. Once the initial projects are completed and deployed, new projects are identified by the team and its project partner, allowing the team to continue to work with the same community partner for many years.

Engineering Education Curriculum Solutions

The EPICS Program uses a human-centered design foremost because of our belief that it is the most effective way to prepare engineers and designers for the next century. The integration of service-learning and human-centered design has the potential to fulfill several of the broader professional skills required by ABET and the Engineer of 2020. To achieve this potential we have created several curricular components and have integrated human-centered design into our overall pedagogical strategy. We require that students work through a specific design process with a user-centered approach. This process is explicitly human-centered and is comprised of iterative communication, prototyping, and feedback with the stakeholder at each stage of the process. The steps in the design process also guide students through the development and allow the program to support and monitor the progress of the projects as they approach completion and eventual delivery into the community (see fig. 2).

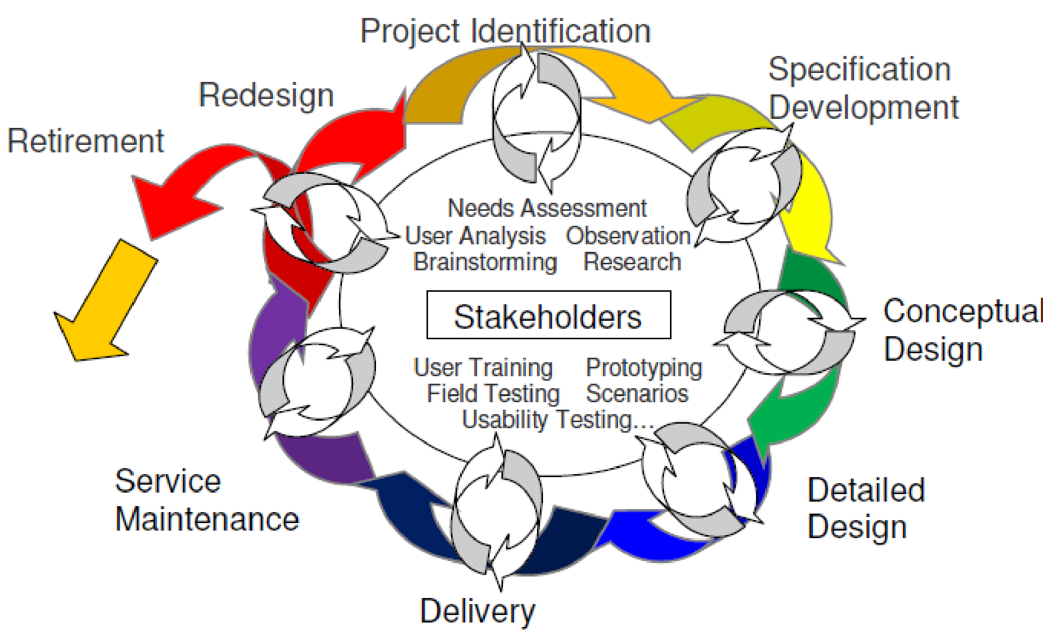

Figure 2

As part of their EPICS design experience, students are required to complete a design document showing the work they have done to satisfy each step of the process, including how they have communicated with the stakeholder(s), discovered their broad needs, and incorporated their feedback in the design. Students are also expected to maintain individual "notebooks" (physical or electronic) that chronicle their interactions and capture their own thinking. By pushing the students to provide evidence of their thinking about the users, the design, their decisions and their impact, we encourage the practices associated with human-centered design. Since their users are all community organizations, it also provides opportunities for students to demonstrate their awareness and understanding of the community issues that are impacting the needs of the users and therefore impacting their designs. This service-learning design experience helps develop professional skills, community awareness and design skills.

The students are given guidelines to help them broaden the focus of their designs beyond the technical requirements. In the example below, part of a companion document to the design process shown in fig 2, students are shown how to investigate the social context of their users (what we call project partners). This perspective is in addition to the need to address the user's technical requirements of the design, although the two perspectives are not mutually exclusive.

Understand the Social Context in which your project partner operates: The social context of your community partner reflects a complex matrix of variables (social, cultural, economic, political, and /or organizational) that influences the operation of your project partner and how your project partner responds to the particular social issue outlined in their stated mission and goals. At all stages of the design of your project these "social facts" (and your perception or understanding of them) constitutes the larger social reality into which your design solution will be embedded. Therefore it is important that you be able to describe and begin to understand the social context of your project partner; this understanding is a critical starting point in being able to assess the implications of any design decisions you make and how these decisions will impact the stakeholders in the project. The following are important questions and factors to consider in writing out your description of the social context of your project partner.

Understanding the social challenges addressed by the project partner and the client served: What is the mission of my project partner? Or more particularly, what is in-depth the larger social challenge your project partner is attempting to address (e.g., drug use; poverty; science, technology, and math education; students with disabilities)? Who are the clients that your project partner serves and the particular challenges these clients face in their situation? Are there stereotypes or prejudices associated with these clients? Are there differences in cultural understanding or behavior that affect the issue your project partner confronts or how the issue is framed? How do the following factors impact the project partner or the people they serve: socio-economic status (especially issues of poverty and lack of resources), gender, race, ethnicity, and physical or cognitive disability?

Understanding the project partner as an organization: How does my project partner's organization interface with other groups or organizations? How is my project partner organized? What body or persons govern the behavior of my project partner? How is my project partner funded? What constraints do funding put on the organization? What institution(s) impact the patterns of behaviors expected of my project partner and how the organization responds to particular social issue (i.e., family, education, economic, political, religious, health-care, social service)? Are there regulations (city, county, state, federal, and/or professional) that dictate the behavior or guide the operation of your project partner?

A broad understanding of the user's social context is required throughout the design process. The way students are able to address this need for understanding is through the human-centered design practiced in service-learning. As students follow the iterative design process referenced above in Figure 2, interaction with the stakeholders is encouraged at each step in the design. Typically this interaction is done through presentations of prototypes or demonstrations of concepts. A major emphasis in this design process is information-seeking strategies. Students are encouraged to find ways of learning information about their users, either through prototypes or observations or discussion. They key activity in human-centered design, and the activity made available to students through the service-learning environment is the interaction with the users and stakeholders, and interaction at a level broader than discussion of only the technical requirements. When students are using a variety of communication methods to gain information from their users, to explain their own interpretations and ideas for solutions, and the ways in which their design ideas address the broad needs of the user, they stand a greater chance of designing a well-suited solution.

In EPICS we engage our students in skill sessions, or small-scale, intimate workshop settings which allow them to engage with a specific activity in a deep and meaningful way. For example, an instructor might present a typical EPICS design task of designing an interactive model to help local elementary school teachers teach our state and national history and geography. The technical criteria are given and are straightforward, but no other information is given. Students are set to work on designing possible solutions to the teacher's stated need, but only if they explicitly ask are they given additional information about the social situation of the school, its teachers, and its student body. When they do ask, they are given the (true) information that the school is located in an economically depressed area and therefore has little if any money to contribute. Members of the student body represent an extremely broad collection of nationalities, native languages, and socioeconomic statuses. The students who ask for and gain this information are then able to do further research to determine what might be appropriate given this setting. They can then alter their designs accordingly. In the end, students discuss the differences in their designs and how the differences in knowledge and understanding of the social context of their user affected their overall design.

We also integrate social context and human-centeredness in our primary required lectures. We require all new students to attend a five-lecture series on design which covers in depth the ways in which a human-centered approach is actually a part of design, rather than an accessory to it. From the beginning, students are shown how good engineering design begins and ends with good communication with the user.

Conclusions

A human-centered approach to design has been shown to add value to the design process and results in more effective designs. The attributes of the engineer of 2020, called for in the NAE report, are the kind of attributes that can be developed through a human-centered design approach. Service-learning offers a relatively easy way to integrate authentic, user-centered design into the curriculum. This approach has the added value of placing the designs into the kind of social and human context that allows additional attributes of the Engineer of 2020 and outcomes from ABET to be achieved without additional course time or infrastructure. The EPICS Program has been used as a model and has been replicated at several other institutions to achieve these goals.

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