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## **Go With The Flo:**

### **A report on a collaborative toilet design project that utilized a transdisciplinary approach**

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#### **1. Introduction**

One of the great challenges facing design education today is how to bridge the gap between research and practice. This paper describes a collaborative project undertaken by two faculty members and two graduate students in the Industrial Design department of a major American university. The primary goal of the project was to use diverse design backgrounds as a catalyst for research that would generate insights that could be utilized during the design process. In addition, this project illustrates how collaborative work between faculty and graduate students can produce both publishable research as well as a new product design concept.

The 'baby boomer' population in America is approaching late life and will certainly have different needs and expectations for their aging experience than previous generations. Representing nearly 30% of the population in the United States, this generation displays marked differences in terms of education, marital status, spending habits, and technological aptitude. Noting that proponents of universal design often cite the need to accommodate elderly populations, and further noting that universal design should strive for a more cradle to grave approach in terms of the user; a team of faculty and graduate students at Arizona State University in Tempe, AZ, USA set out to design a transgenerational toilet that would be usable by toddlers and their grandparents alike. This is the story of a transdisciplinary team of four, their approach to this problem, and how the resulting design shifts paradigms of toilet use and universal design.

#### **2. The Transdisciplinary Team**

The next generation of interdisciplinarity has emerged and it is called transdisciplinarity. Transdisciplinarity is defined as "a new form of learning and problem solving involving cooperation among different parts of society and academia in order to meet complex challenges of society" (Häberli, 2000). What differentiates transdisciplinarity from pluri-, cross-, multi- and inter-disciplinarity is the evolutionary nature of knowledge that expands beyond participants' boundaries to create new forms of knowledge, the sum of which are greater



than the knowledge of any single partner and the totality of which exists beyond the borders of any one discipline. (Allen, 1997; Kleiber, 2000; Nicolescu, 2002; Thompson Klein, 2000; Wilk, 2000).

Recognizing the challenge of designing a toileting experience for users of all ages would require specialists from diverse backgrounds, the following four team members were recruited to participate in the product development process:

An Assistant Professor of Industrial Design who specializes in the humanization of technology with a focus on assistive devices.

A Faculty Associate of Industrial Design who spent many years in professional practice and specializes in brand architecture, design management, and design methodology & theory.

An Industrial Design Graduate Student who brought a background in mechanical engineering to the group and specializes in the integration of human factors and ergonomic studies into the design process.

An Industrial Design Graduate Student who specializes in design theory and socio-cultural and historical design research that can provide actionable insights for the design process.

While each member brought a different specialization to the team, Industrial Design was a unifying interest for all. This point of overlap in education and professional practice became a common “language” that could be easily spoken by all team members, thus allowing them to bridge disciplinary boundaries that often inhibit group productivity. In addition, each member was familiar with the process of design thinking and creating that required the ability to suspend judgment, brainstorm effectively, and delay closure and premature problem resolution. The brainstorming session actually became a foundation for the transdisciplinary process that resulted in the creation of new knowledge and a new patent-pending process.

### **3. The Transdisciplinary Methodology**

The methodological approach created for this project was based upon the need to generate new knowledge about toileting practices, behaviours, and designs based upon the diverse areas of specialization represented in the group. The team did not wish simply to design a more beautiful or easy-to-use toilet; rather they set out to completely reinvent the paradigm of the toileting experience to be more sustainable and more accommodating for users of all ages. This involved great flexibility on the part of the design team and much research into the evolution of the toilet as it is known and recognized today.

The research foundation of this design project focused on three primary areas: the socio-cultural climate surrounding the toilet and its use in Western cultures, the physiological needs of human users during the elimination processes (i.e. human factors analysis), and the environmental impact of current toilet design regarding water usage (including alternative toilet designs) and efficiency. A transgenerational methodology shaped the survey of toileting use beginning with new users (i.e. toilet training toddlers) and concluding with an examination of the aging baby boomer cohort and their particular needs and expectations. This research relied upon literature reviews, case studies, and empirical data. Each member of the transdisciplinary Flo toilet design team acted as participant observer (Robson, 2002) where their observations and insights contribute to the body of knowledge regarding the application of transdisciplinary design collaboration in the form of an autoethnography (Reed-Danahay, 1997 in Spry, 2001).



**Research Focus: Sociocultural**

Social systems theory—borrowed from the social sciences and adapted for this study— informed the analysis of the socio-cultural existence of the toilet. Recognizing that the meaning of any object can be attributed as much to its physical form as to the relationships and experiences that exist around the object, both areas were explored. (Ackoff and Emery 1981; Bertrand 1972, Lidz 1963; Parsons 1971).

An analysis of the socio-cultural atmosphere of toilet use revealed that the process of socializing a child to the toilet is quite challenging for parents who often resort to punishment and reward systems. Additional devices must be used for this activity because current toilet designs do not facilitate small users.

Within the social system, the family is considered the primary social unit that is responsible for the socialization of its members into greater systems (i.e. groups, organizations, institutions, and society). The family is also seen as a system of roles (a collectivity) which is governed by the hierarchical structure it adopts to ensure its survival. “The family is recognized as a biologically required social institution that mediates between the biological and cultural directives of personality formation, and a social system in which the child assimilates the basic instrumentalities, institutions, and role attributions that are essential to his [sic] adaptation and integration. (Lidz 1963, pp. 75-76 in Anderson & Carter 1990, p. 158).

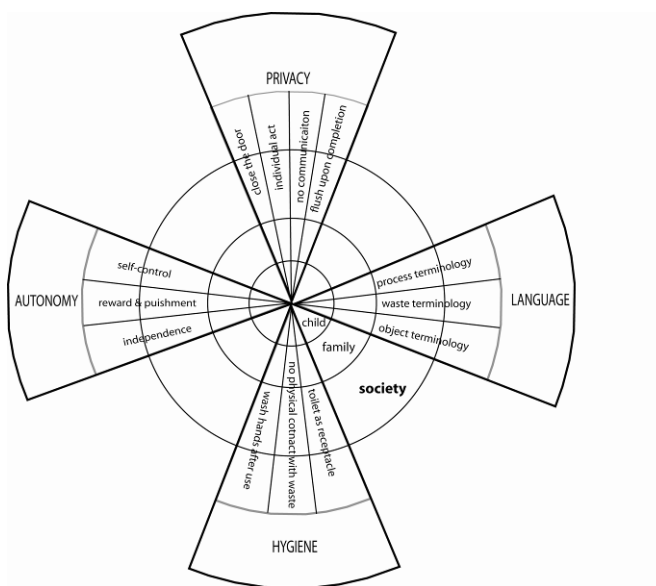


Figure 1. Social System Analysis of Toilet Socialization.

“Social systems are those constituted by states and processes of social interaction among acting units” (Parsons 1971, p. 4). In order to examine the toilet as a vessel for the transfer of norms and roles between the family and society, the elements of this system will be explored individually followed by a holistic analysis that will shed light on the entire system and the relationships within it. Based upon a review of literature and empirical data collected from a survey of parents and care givers, four primary roles involved with the socialization of the child to the toilet have been identified. Privacy, language, hygiene, and autonomy are considered the essential determinants of a child’s successful socialization to the toilet and preparation for membership into the



adult world of appropriate toileting behaviour. Figure 1 is a diagrammatic representation of this analysis of socializing a new user to the toilet and the social norms and practices that are transferred during this process.

In an extensive survey entitled *The bathroom, the kitchen, and the aesthetics of waste*, Ellen Lupton and J. Abbott Miller (1992) catalog the evolution of the context of today's toilet: the bathroom. Developments in technology and aesthetics were shaped by an increasing societal demand for cleanliness and proper hygiene. The heart of this movement dates back to the early twentieth century when medical advancements in "germ theory" linked disease prevention to cleanliness. And so began the war against dirt and the entry of the hospital into the home. The movement has been credited with the popularity of the white porcelain-enamelled toilet bowl which, still common today, reveals any blemish or stain left behind. This standard has been maintained for over half of a century, with minor modifications in appearance allowing for innovations in form and color. Notably, recent legislation and innovation have also resulted in toilet designs that reduce water consumption. (Horan, 1997)

A review of toilet designs from Eastern cultures revealed a sensitivity to the issue of water consumption, illustrated in the Japanese toilet style that includes a faucet: water that is first used to wash the hands is then used to flush away waste. This search also revealed a paradigm for toilet use not readily found in Western culture—that of the squat toilet. Although the squat toilet is present in both Eastern and West European cultures, the Westerners interviewed for this project described it as an initially awkward or disconcerting experience. However, once socialized to the activity, most subjects reported being more comfortable with the process. The physiological benefits of this device will be explored in the following section.

American baby boomers (those born between 1946 and 1964) represent nearly 30% of the U.S. population and have grown to expect great things from the products they purchase (Mature Market Institute, 2003). It has been asserted that current product offerings targeting the elderly will not be satisfactory for the baby boomer cohort; a group of people who are accustomed to aesthetically pleasing, technologically advanced, and environmentally friendly products.

Results of the socio-cultural analysis provided inspiration for a toilet design that would be usable by all family members, from toilet training toddlers to their aging grandparents. Furthermore, the socialization to a new toileting paradigm with young users would decrease the possibilities of physiological challenges in their later years. Aesthetically, the visual transparency of the toilet's inner workings paralleled a desire to increase awareness of the process of elimination as a natural act thereby placing the physical human action within its environmental context.

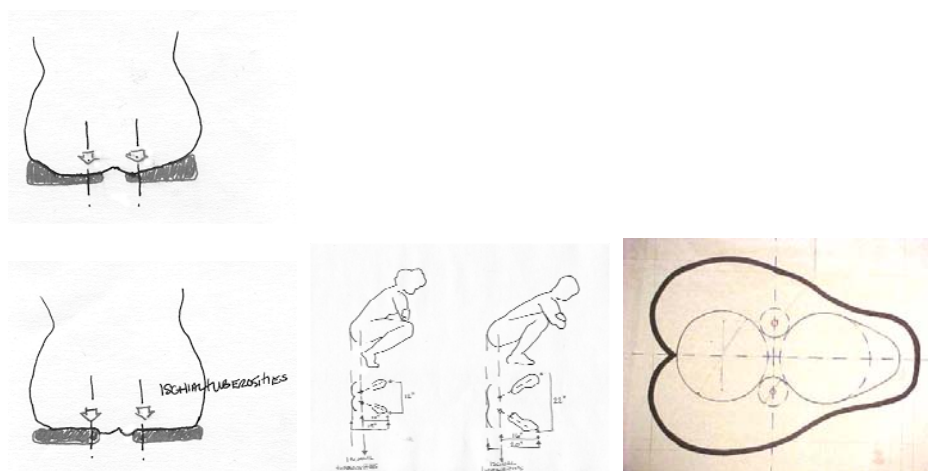
### **Research Focus: Physiology**

Western culture is witnessing a surge in appreciation for the Eastern philosophy of living. This is illustrated in the popularity of feng shui, janimation, Japanese gardening and interactive personal electronics. Perhaps the most obvious recent adopted trends are yoga and mediation— including television programming, books, and the flood of associated products on the market. *Yoga Living*, in fact, has recently published articles encouraging the adoption of the squat posture for elimination (Isbit, 2001). Numerous health problems—including incontinence, hemorrhoids, appendicitis, colon cancer, and prostate cancer—have been linked to the use of the standard sitting toilet (Balukian 2002). These are typically caused by one of two factors: the inability to



completely empty the bowels or nerve damage due to chronic straining. The squat posture, already used by nearly 2/3 of the population, provides proper alignment of the intestines and colon.

The quintessential text, *The Bathroom*, by Alexander Kira (1976) was also consulted and reports the same preferred posture for elimination. Kira even offers specific ergonomic standards for toilet height, hole shape and width, and weight distribution. Most of these specifications are aimed at providing support for the ischial tuberosities (also known as the “sit bones”) as the primary point of contact with the toilet, not the legs and entire posterior which has become the comfort standard for American toilet seat design. Although this book was published nearly 30 years ago, it seems that the message has yet to reach the American public. Figures 2, 3, and 4 are reproductions of Kira’s recommendations.



**Figures 2, 3, 4.** Reproductions of Kira’s recommendations for toilet seat dimensions and shape according to position of ischial tuberosities.

Empirical data was also collected from 42 subjects of varying height, weight, and gender. A measurement wall was devised that indicated height in feet and inches. Subjects were photographed from both front and side views in four positions in front of the wall. The positions included standing, seated upon the toilet, squatting without any assistance, and squatting with the assistance of a bar in front of the body. This process was undertaken to determine how easily people could assume a squat posture at Kira’s recommended height of 8” without assistance. Of the 42 subjects, 13 (or roughly 30%) were able to squat to the 8 inch height without assistance. All participants were able to reach a 12 inch height with the assistive bar. See figures 5,6,7, and 8 for examples of the photo documentation.



Figures 5, 6, 7, and 8. Photo documentation of various toiling postures.

The final toilet dimensions are based upon recommendations by Kira, supporting empirical data, and regard for physiological benefits of the squat posture. The seat height of 10 inches accommodates a posture that is attainable by most users, but the addition of a grab bar (incorporated into the wash basin) provides support for users not yet able to maintain this posture. Repeated use of the toilet, and hence adoption of the posture, promotes improved flexibility and decreased chances of later physical ailments just as daily yoga practice has been proven to do the same.

#### Research Focus: Water Usage & Efficiency

Within the U.S, water regulations exist on both the federal and state levels. Federal legislation is often responsible for water quality regulations that apply to water-resource utilization, water-quality compliance standards, as well as environmental protection (Water Plan: 2000-2050). The Clean Water Act (CWA), responsible for maintaining the integrity of the nation's water supply, and the Safe Drinking Water Act (SDWA), are both examples of federal water regulations that impact water consumption on the state level. In actuality the implementation and enforcement of federal water regulations fall upon state regulations (Water Plan: 2000-2050).

The American Water Works Association reports that the average single family household uses 19.3 gallons of water daily through toilet use alone (AWWA, 2005). That is equivalent to 26% of the overall water consumption in the home. Ultra-low flush 1.6 gallon toilets can save up to 9.3 gallons per day and are now being mandated by the Department of Energy. Unfortunately, in a recent study conducted by two University of Arizona water researchers, 43% of the low-flush toilets they measured had problems—due to aging and decrease in functionality (Harrison, 2000). These statistics demonstrate a need and opportunity for water conservation innovation regarding water efficient appliances such as the Flo toilet.

In pursuit of design innovation and invention the Flo toilet uses a minimal amount of water for waste disposal. Based on a reservoir system, the Flo toilet reuses water from hand washing. The presence of two tanks is also unique; tank one for flushing after urination uses only 0.5 gallons of water, and tank two for flushing after defecation uses 1.0 gallons of water. The core technology of the Flo toilet is based on the electromagnetic/magnetic ball valve (patent pending) which uses electromagnets to release (flush) water from the tanks to the toilet. The electromagnetic ball valves are also used in the control of water flow to each tank from the reservoir tank. The electromagnetic ball valves are powered by a mica capacitor that is charged by microhydro turbines that build electric charge whenever water passes through them. The use of



electromagnetic ball valves powered by microhydro turbines (pinwheels) makes the Flo toilet fully self-sustaining and fully independent from the electric power grid.

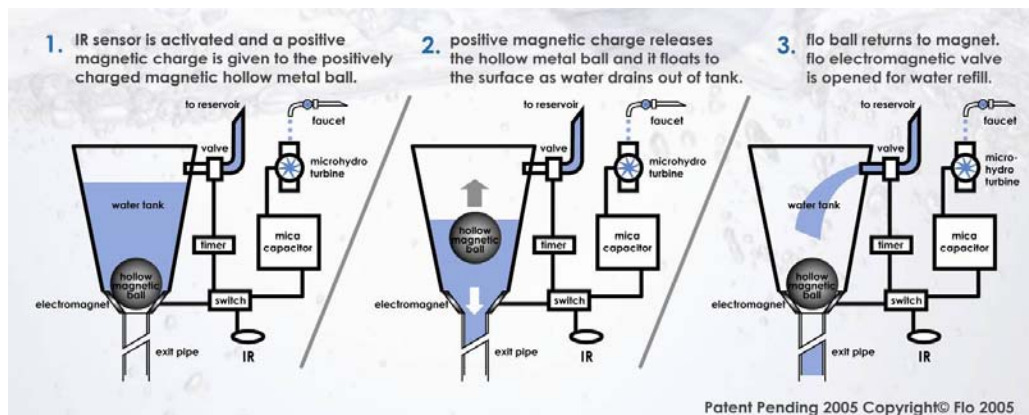


Figure 9. The electromagnetic ball valve system developed for the Flo toilet.

## Design Process

The team set out to use the three previously described research foci as the basis for brainstorming sessions that were held once a week for a period of six weeks. All team members were present at the sessions which provided a chance to analyze and discuss research findings from diverse disciplinary perspectives. Although the primary goals for each session evolved over the course of the project, the following issues were repeatedly addressed: form, mechanical function, technological innovation, materials, social responsibility, ergonomics, sustainability, brand identity, and cultural expectations.

The brainstorming sessions not only generated new ideas, but also new knowledge for the members about toilet practices and design. The most inventive breakthroughs (including the electro-magnetic ball valve) were not the product of a lone engineer, but of a group of individuals working towards an understanding of new possibilities. Following each session the members agreed upon individual tasks (or research) to be completed for the next meeting.

The initial phase consisted of research collection, data analysis, and brainstorming. The following phase was dedicated to application of research findings towards the development of the toilet design. By collaborating completely throughout this phase, the task of engineering the internal mechanisms was never separated from the development of the exterior form. In fact, this transparent process resulted in a visually transparent form that reveals its intention to its users in hopes that they will glean new knowledge from the experience of use.

The goal of the transdisciplinary design process was to create new knowledge that would benefit both designers and users alike. The team was able to transcend disciplinary boundaries that resulted in the invention of a patent-pending flush mechanism. The elegant placement of this unique process within a paradigm-shifting translucent form encourages users to look deeper, quite literally, into the object and the act (see Figure 10).

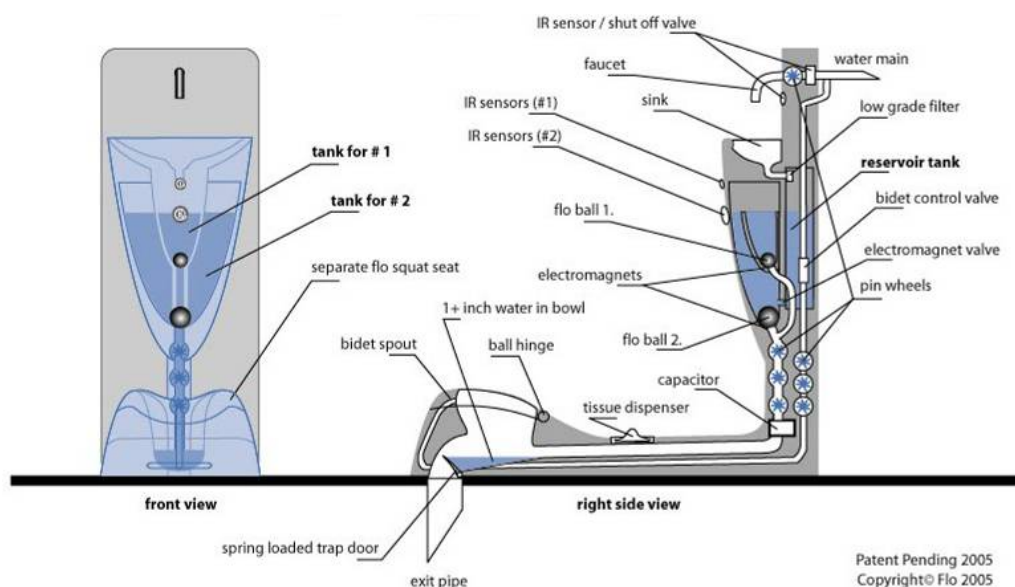


Figure 10. Diagram of the Flo system and its internal mechanical function.

#### 4. Results: Flo Features and Benefits

The result of this transdisciplinary product development experience is Flo, a toilet design that shifts the paradigm of toilet use and includes users of all ages. Flo offers numerous features and benefits:

##### Physiology

Flo is ergonomically designed to provide a healthier posture when using the toilet. It functions similarly to a squat toilet, facilitating a physiological response with its use. The low Flo seat allows users to take a squat-like position when sitting which is better for elimination.

##### Sustainability

Flo is designed to use a minimal amount of water in the disposing of waste. Based on a reservoir system, the Flo reuses water from hand washing. The tanks are also unique because there are two; tank one for flushing after urination which uses only 0.5 gallons of water and tank two for flushing after defecation which uses 1.0 gallons of water.

##### Invention

The core technology of the Flo is based on the electromagnetic ball valve (patent pending) which uses electromagnets to release (flush) water from the tanks to the toilet. The electromagnetic ball valves are also used in the control of water flow to each tank from the reservoir tank. The electro-magnetic ball valves are powered by a mica capacitor that is charged by microhydro turbines (pinwheels) that build electric charge whenever water passes through them. The use of electromagnetic ball valves makes the Flo toilet fully self-sustaining and fully independent from the electric power grid.

##### Health

Flo incorporates a bidet function which is used to maintain hygiene. This feature also reduces the need and usage of toilet paper making it as economically friendly as it is environmentally friendly.





#### Amenities

Flo incorporates a sink for hand washing that is controlled by infrared sensors. The flushing switches are also controlled by infrared sensor so that the user need not make contact with any part of the Flo other than with the ergonomically designed Flo squat seat.

#### Materials

Departing from the cold, hard, white porcelain of the current western toilet the Flo is made from a natural polymer known as 'Tenite' cellulocics produced by the Eastman Chemical Company. The key feature of this material is that specific agents can be encapsulated in the plastics to reduce mold, mildew and calcium build up as well as to provide long lasting antimicrobial protection. In addition, this material is available in countless colors.



Figure 11. The final toilet concept, Flo.

#### 5. Conclusion

The collaboration between specialists in diverse fields facilitated the creation of a transgenerational toilet which offers a new paradigm in toilet use. No one contribution of disciplinary expertise could have resulted in the final design concept. The very nature of Transdisciplinarity is the generation of new knowledge that is greater than the contributions of any single individual and the benefit of which transcends any one discipline. Transdisciplinary teams that are willing to cross boundaries in pursuit of innovation have a better chance of generating both meaningful design and valuable contributions to existing bodies of knowledge.



The team effort initiated by faculty and graduate students also represents a departure from current standard practice in American universities. Although such opportunities may be more prevalent in other academic and professional cultures, this project illustrates new potential for research and practical experience within Master and PhD level design programs. The potential for learning and innovating was broadened because the contributions of each team member were valued separate from their academic standing or level. Additional research is needed to assess the effects and potential benefits of student-faculty collaboration of transdisciplinary teams.

“In order to create a meaningful material culture, functional products must be created in such a way that they are congruent with or informed by higher understanding” (Walker 2001, p. 39). Based upon extensive research, the Flo toilet is offered as a solution to the many challenges facing toilet innovation. The aesthetic treatment of form and materials is a step towards challenging cultural standards, yet it relies upon design paradigms that have already proven pleasing in countless products. The Flo toilet represents an object that can be used in the first years of life and into the twilight years, all the while contributing to the physiological health of the user. The Flo toilet represents a need for conscious discretion in water usage and an appreciation for the transparency of this act.



Figure 12. The Flo, a new paradigm for toilet design.



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