Role of Transformation Principles in Enabling Environmentally Significant Behavior

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Abstract
We describe studies undertaken to better understand the relationship between mechanical transformation principles and environmentally significant behavior (ESB). Five existing transformable products were studied, and two new products were developed to address the limitations in one existing product. We applied lead-user methods to study those who undertake various tasks in environmentally preferable ways despite obstacles, as well as undertaking such tasks ourselves. We found that transformation increases the portability of products that support ESB and thus spontaneity in undertaking ESB. We conclude that transformable products do aid in overcoming obstacles to ESB that are not yet addressed by appropriate infrastructure.

Keywords:
Design for Environment; Environmentally significant behavior; Transformation principles

1 INTRODUCTION

Transformable products change either spatially, by collapsing/ expanding, or functionally, by exposing new surfaces and features depending on product configuration. We noted a potential relationship between environmentally significant behavior (ESB) (Stern, 2000) [1] and transformation principles (Singh et al., 2009) [2]. This paper aims to further understand and explore this relationship such that it can be better exploited to support ESB.

Lead users provided the context where we first noted a relationship between transformation principles and ESB. Lead users are those who often have needs ahead of the general population, and in many cases, have already developed their own solutions to these needs. Lead users in ESB include individuals who perform physically or logistically challenging tasks using environmentally preferred modes of mobility, e.g., transporting furniture on public transit.

This paper is organized as follows. Section 2 presents related work in ESB, transformation principles, and lead-user methods. Sections 3 and 4 describe how a potential relationship between ESB and transformation principles was first noted, and five existing transformable products we studied to better understand this relationship. Observed benefits and limitations are summarized in Section 5. Sections 6 and 7 describe two transformable products, newly developed to address some limitations identified in one existing transformable product, and additional insights gained. Finally, we conclude and summarize in Sections 8, 9 and 10.

2 BACKGROUND

2.1 Environmentally Significant Behavior (ESB)

Stern (2000) defines environmentally significant behavior by:

1. Its direct impact on the environment (e.g., forest clearing, household waste disposal), and
2. An individual's intent to change (benefit) the environment [1].

While the effect of individual environmental behavior is limited, "the aggregate of such behavior" can have significant positive effect [1].

Stern identifies four types of intervention for ESB: (1) religious and moral approaches, (2) education, (3) efforts to change the material incentive structure of behavior by providing monetary and other types of rewards or penalties, and (4) community management.

We propose another approach, that of identifying, and overcoming through product design, obstacles to ESB.

2.2 Transformation Principles

Singh et al. (2009) compiled a list of transformation principles and facilitators observed in consumer products, patents, and biological organisms [2]. The three transformation principles, or generalized directives to bring about a certain type of mechanical transformation, are 1) expand/collapse, 2) expose/cover, and 3) fuse/divide. These principles aim to 1) change occupied volume, 2) alter functionality by revealing or concealing a new surface, and 3) divide a product into many parts or combine multiple parts into one. Example products that use transformation principles include 1) umbrellas that extend and collapse canopies, 2) laptops that conceal and reveal screens and keyboards, and 3) screwdrivers with exchangeable bits to accommodate various screw heads. In addition, twenty transformation facilitators (e.g., flip, fold, material flexibility) enable various types of transformation when applied together but cannot create transformation when applied singly.

Singh et al.'s transformation principles comprise one aspect of adaptable product design [3], and focus on physical principles involved in transformation or reconfiguration of products.

2.3 Lead-User Methods

Lead users operate under extreme requirements, experiencing needs that ordinary users may not (e.g., casual jogger versus the marathon runner who developed the Powerbar™). Solutions developed for extraordinary situations often benefit ordinary situations (e.g., anti-lock braking systems used in automobiles were developed for planes landing on aircraft carriers) [4]. Extraordinary lead-user methods aim to turn ordinary users into extraordinary/lead users by placing them in extraordinary situations [5].

Applied to the mobility/transit aspect of ESB, extraordinary users include those with a range of disabilities, the elderly, and those tending to young children. However, university student bicyclists can also comprise a class of **situational** extraordinary users, as argued in one of the student projects summarized below. Extraordinary situations include commuting with physical loads and under adverse