Advancing the Concept Development Process With Systems Thinking

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ABSTRACT

Collaborative teams from the University of Cincinnati were challenged to 'break the rules' by not following the traditional industrial design processes and methods for developing transportation products. The well-established design process for a typical automobile is usually accomplished in industry with limited regard to the environment the vehicle will operate within. Because this process is not inclusive of the broader surroundings, it has resulted in many of the growing challenges we now face. While applying strategic methods of systems thinking to the design development process unexpected opportunities were identified, which led to the development of several alternative mobility concepts. This paper presents three of these concepts as examples and discusses how systems thinking methodologies were applied.

Keywords: systems thinking, design strategies, transportation, design process.

1. INTRODUCTION – FUTURE MOBILITY AND URBAN DENSITY

Some experts say that the greatest migration in human history is happening right now as people are moving from rural to urban areas. This topic of urban growth is elaborated upon in Reinventing the Automobile, Personal Urban Mobility for the 21st Century by Mitchell, Borroni-Bird, and Burns when they state, *"The United Nations projects that 60% of the world's population will be living in urban areas by 2030."* Predictions for the number of people living on the planet in 2030 are estimated to be eight billion. This will result in energy usage increases that will double global energy consumption by mid-century or sooner. This will be necessary to accommodate the 10 to 14 billion people living on the planet in 2050 (Population Division of the United Nations Department of Economic and Social Affairs). When the worldwide population increases there is a rise in environmental issues. Today there are tremendous pressures in the form of pollution, energy security, global warming, consumption, congestion, parking, and traffic safety. In the future these matters are going to be of even greater concern.

Population increases and urban density will challenge public transportation infrastructures that are already struggling to meet the growing demand for transportation and basic mobility services. These megacities and future mega regions will be so dense that the place for the traditional car will rapidly decline. Today we are starting to see hints of this trend, as customers are demanding efficient and sustainable mobility solutions. To accommodate the expected increase in urban density, plans for investing wisely in basic core infrastructure needs should be considered now.

In The Dynamics of Global Urban Expansion, Angel, Sheppard, and Civco discuss the forces that will influence urban expansion. *"Aspects of the transport system that affect urban expansion may include the introduction of new transport technologies..."* Transportation costs, the amount of government investment in roads, and reliable public transport systems are aspects expected to act as catalysts for improvements to the existing infrastructure, however, there is an enormous opportunity for engineers and industrial designers to develop and implement new mobility options that are solutions to these global challenges. In order to develop these innovative products a new holistic approach to the design process is needed.

Solutions to these challenges are more likely to come from interdisciplinary teams with a range of different backgrounds. Industrial designers, engineers, and sculptors are the main professions we find within a traditional corporate automotive design studio. Marketing and accounting professionals are also part of the development process and influence the prod-

Computer-Aided Design & Applications, 11(S1), 2014, S44–S53, http://dx.doi.org/10.1080/16864360.2014.914408

uct development process through their contributions. However, this traditional approach gives designers a very limited perspective that relates only to the vehicle they are designing. Other disciplines involved in this process could contribute to a broader view, which would lead to more appropriately designed mobility solutions that work better within the environment with less of a negative impact on the global challenges we are now facing. Urban and regional planners, architects, landscape architects, city and government officials, and graphic designers are other experts that influence the shape of our built environments. Because products such as automobiles have a strong influence on the transformation of landscapes, the creators of these products should take responsibility for the impacts these products have on built and natural environment. Interdisciplinary teams are key in bringing this to fruition.

2. AN ALLEGORY OF OUR DILEMMA

Increases in worldwide population and environmental issues are deeply intertwined. Many of us are sheltered from the affects of our consumption, energy demands, and its immediate and future impacts on our planet. Most of us distantly observe this through small bits of this information from radio, media, and documentaries, not understanding these issues holistically on a global scale. Predictions range, however the results of global warming in long-term projections are catastrophic and beyond the imagination. There are many variables associated when human interact with nature, and many accounts can be sited as acts of destruction. There are also numerous examples of how conditions have improved through people getting involved. Regardless of the result of our actions, the future of life for humans and all of life on this planet are deeply connected. As Chief Seattle stated in 1852, *"What is man without the beast? If all the beasts were gone, man would die from the greatest loneliness of spirit. For whatever happens to the beasts, soon happens to man. All things are connected."*

The painting shown in Fig. 1 by Kevin Sloan, captures the essence of our connected relationship with nature and how intertwined our modern technologies are with the rest of life. This painting symbolizes the interdependence we share with nature. It also hints the potential impacts our technological environment has on what Sloan calls the "*... silent inhabitants - the animals and plants we share this world with."* It is also a reminder for us of the wondrous extraordinary beauty and balance that can be found in this world. It is my hope that this image sparks compelling conversations about our present technological advancements, which include aspects of our impact on nature. To the inquisitive mind this painting begs us to ask more questions and seek answers to develop a better relationship with nature in this quickly advancing technological age.

3. THE TRADITIONAL DESIGN PROCESS AND SYSTEMS THINKING

Vehicles are very complicated products that have multiple systems within them, and very specialized skills are required by the industrial designer to obtain optimal functionality as well as aesthetic grace when dealing with such complexity. From the perspective of an automotive designer working within the corporate environment, the scope of their responsibility is limited the vehicle, including the aesthetics, vehicle proportions, door cuts, ramp angles, occupant visibility, and other elements that relate directly to the product. From a systems thinking perspective these aspects are individual systems that must function as a whole. Door systems, storage systems, wheel systems, and window systems are only just a few of such interconnecting parts. Parameters that limit a designer's level of awareness to only aspects relating to the product reflect a traditional design process, which does not include aspects of how the product operates within its environment. Solutions developed in isolation produces a partial solution, which can lead to bigger problems.

In a traditional design process changes often occur. Design or engineering modifications in one area of the vehicle drives incremental changes in other areas. These design alterations are made with consideration to detailed specifications. Vehicle platforms, dimensions, and proportions are often times locked in by the time the project brief reaches the industrial designer. Working from this pre-existing package makes it very difficult for a designer to develop new and innovative mobility options. No matter how many changes are made during the design process, the end product is a variation of what already exists.

The reality of current mobility systems is that the existing infrastructure was created to accommodate the way we use cars and trucks. Individual vehicle ownership has brought great freedoms and conveniences to the way people live and work. The car and truck industry is rich with talented people focusing on putting these products into production, and this becomes the seed of corporate profits. These jobs and earnings influence the economy. No doubt there is a critical need and market for cars and trucks, but what about other mobility options for people who don't have cars or don't want them? What about mobility options that eliminates traffic jams? How about vehicles that don't pollute? With mounting real world challenges like urban population growth and density, shouldn't transportation be more sustainable?

4. APPLYING SYSTEMS THINING TO COMPLEX STRUCTURES

Ludwig von Bertalanffy (1901–1972) was a biologist who was widely recognized for his development in General Systems Theory (Minati and Pessa 2006). This

Fig. 1: This painting by Kevin Sloan titled *Modern Romance* represents the allegory of our dilemma, or the balance of human technology with the natural world. This 30"x24" painting was completed in 2012 and is included in this paper by permission of the artist.

defined new applications to numerous areas of study emphasizing holism as an approach to examine parts of a system in their context, as opposed to reductionism that consists in taking apart and reducing elements of a system for analysis. Looking at systems also emphasizes organisms as a whole with interdependent parts over mechanisms and machinery. In systems thinking, properties of the parts can only be understood by looking at their relationships with the whole system. In complex organized systems, new properties emerge from the interaction of the parts (Capra 1996).

When developing alternative modes of mobility designers must consider changes to the traditional design process and include a holistic approach that goes beyond the product to include infrastructure, recycling, natural resources, congestion, parking, climate change, and pollution. Then the design team will ask new questions about the existing system and the realities of its positive and negative attributes. This inquiry can influence the entire design development process. For example, how important are aerodynamic qualities when cars are stuck in traffic, or when the average speed within an urban area is less than 20 mph (Mitchell, Borroni-Bird, and Burns 2010)? How do we solve the problem of congestion on highways and in urban areas? If cars are parked approximately 90% of the time, how can we make this parking time productive? If vehicles are most often driven with one occupant, can we eliminate multiple seats and storage areas to reduce mass and costs? Visualizing new products as answers to these questions can have massive influences on the development of design briefs, which can guide the discovery of new transportation, infrastructure, and consumer paradigms.

Applying systems thinking to the transportation design process by introducing these enormously complex issues, however, is much easier said than done. Often times when exploring these aspects of mobility designers lose direction and become unsure about how to react to such immense issues, making it difficult for any product team to understand these challenges in detail. Too many unanswered questions can lead to confusion. When this happens, priorities become unclear, and deciding what kind of product to develop is impossible. It can be exhausting to dream of new products that keep the better qualities of an existing infrastructure to accommodate cars and trucks, and improve upon the inadequacies. However, at some point the team needs to let these real world challenges influence the invention of new products that are solutions to these issues.

In order to keep from becoming overwhelmed it is often times best for the design team to identify specific aspects of the bigger picture that will have the greatest impact on global issues. Selecting an area of focus can be challenging with unlimited issues of concern. To select this emphasis the design team needs to ask questions such as: What direction would have the greatest impact? What areas seem most interesting or unique? Which challenges mean the most to me as a designer? Questions like this assist the team in narrowing the scope of the project. This also allows the team to accomplish goals as they develop new vehicle types or segments that address challenges in selected areas. Since there are several overlaps between different real-world challenges, focusing on one or two may likely have a greater impact on numerous global issues. For example, when electrification becomes the area of focus, this also addresses fuel economy and emissions. Vehicles that have a small footprint solve problems relating to fuel economy, pollution, parking, and congestion.

Introducing systems thinking into the design process is complicated, but necessary for a new approach to design. Keeping an eye on the bigger picture helps to guide team decisions and the new product development process. It is also beneficial to explore the finer nuances of mobility systems and how they are used. There isn't a straightforward approach to this mile-high perspective that must shift into a deep dive to explore details up close. However, there are some general practices that teams can use to help them in this pursuit.

In The Fifth Discipline Peter Senge states that *"Systems thinking is based on a growing body of theory about the behavior of feedback and complexity – the innate tendencies of a system that lead to growth or stability over time."* Senge also elaborates on ways of explaining qualities of real life and offers some guiding steps to explore this. Often when we look at a challenging issue we only see the events on the surface, which are usually hints of something much bigger. When a design team focuses on a specific topic it may prevent them from seeing the complex realities that are under the surface.

Expanding on this perspective gives us insights into how to improve the traditional transportation design process to make better products. Through applying this systems thinking approaches we explore the product in greater depth when compared to the traditional design process. Systems thinking methods include a broader view, which facilitates the development of more appropriate products that are ideally not harmful to the environment and improve the conditions where the product will ultimately operate. This in depth approach into the product development process consists of four aspects of exploration relative to the product: 1) Current Situation, 2) Timelines, 3) External Forces, and 4) Holistic Systems Integration. (Fig. 2) These same aspects are explored relative to the people within the environment, the environment itself, and/or the people who will be using the product. Exploring these four steps within the studio environment takes thoughtful consideration. During this part of the process students and professionals are not looking for solutions. Instead, they are generating a better understanding of the current situation relative the topics they are focusing on. From this deeper holistic perspective designers are more aware and better design solutions are likely to emerge.

Below are detailed descriptions of each of these aspects relative to the diagram above in Fig. 2. In order to make the concept of systems thinking easily understood each aspect includes an example. The theme of electric vehicles and electrification is used in each example.

4.1. Systems Thinking Related to the Product

The process for relating systems thinking within the industrial design process has two major aspects to it. The first part relates to the product, which will be detailed in this section.

4.1.1. The product and the current situation

The first aspect relative to the product deals with the current situation. We look closely at what is going on. This involves a close study into what products are currently on the market. This is called benchmarking and product comparative analysis, which industrial designers do very well. An example of this would be researching current products on the market, including the Nissan Leaf, Tesla Model S, Chevy Volt, and Fischer Karma. When applied to specific brands this can be referred to product line-up or product portfolio. However, looking at broader aspects of a current situation goes beyond benchmarking to include broader issues such as how the products are selling and working. From this perspective we are only seeing surface situations and the general response is to *react*.

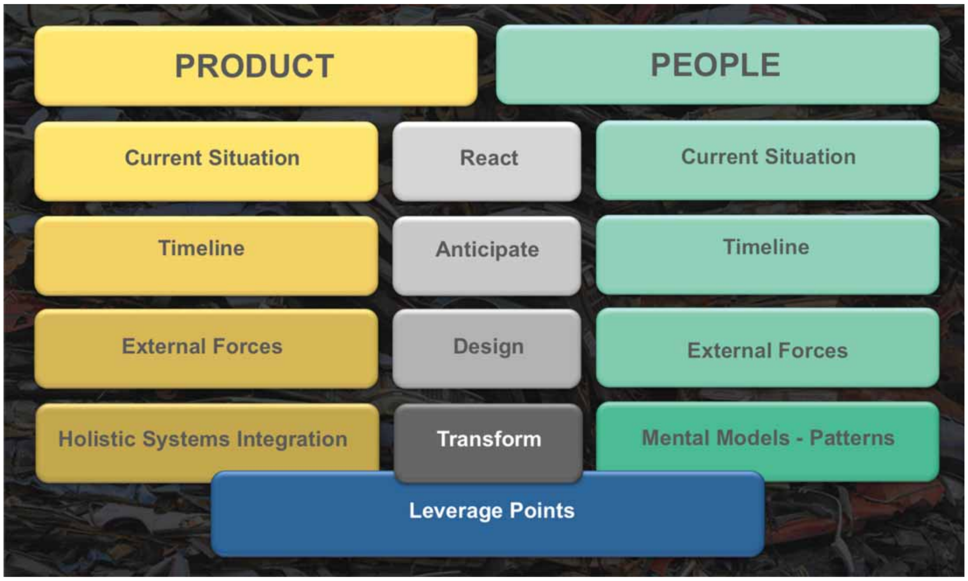

Fig. 2: Systems thinking as it relates to the industrial design product development process. This approach is especially helpful to apply in large-scale projects and products relating to mobility and transportation. This systems thinking strategy applies to products and people.

4.1.2. The product and the timeline

To move forward we must look deeper at patterns and trends. This can be accomplished by looking at what has happened in the past up to the present. It may be helpful to make a diagram or timeline that clearly shows historic events relating to the topic, product, or technology. This will also give us the ability to *anticipate* what might logically be coming next. An example of a timeline includes the following: The 1916 Detroit Electric car, the 1996–1999 GM Electric Vehicle Generation One (EV1), the 2002 Autonomy Skateboard Platform, the 2009 Personal Urban Mobility and Accessibility (P.U.M.A.), and the 2011 Electric Networked-Vehicles (EN-V) prototypes. Only now are we seeing hints of these advanced technologies in production with the Chevrolet Volt, the Nissan Leaf, and the Tesla Model S electric vehicles. Timelines can be open to creative interpretation and relate to other aspects of the project including timelines of technology, behavior patterns, or how habits have changed over time. This is important information, but the exploration of patterns and trends does little to aid in decision-making. To go deeper we must consider what are the causes of the patterns.

4.1.3. The product and external forces

Systemic structures or external forces contribute to patterns that *influence design*. Technological developments, corporate decisions, corporate profitability, government regulations, and infrastructure heavily influence the challenges in the implementation of electric vehicles. It is vital to understand how these systems have developed over time and how they have resulted in current habits that inhibit or contribute to change. Examples include; in 1916 the Detroit Electric car was extremely popular, but was shunned in 1939 when the combustion engine eliminated the need for a hand crank. General Motors leased the Electric Vehicle Generation One (EV1) from 1996–1999. Customers responded extremely positively to this car, however General Motors believed that the targeted market was an unprofitable niche and crushed almost all of these vehicles. Understanding these existing practices and external forces will assist in developing products and systems that can be implemented and sustained over a long period of time. In order have a greater influence on the development and implementation of these products the design team needs to explore the system holistically.

4.1.4. The product and holistic systems integration

This deeper level deals with the holistic systems integration, or a deep look into the products and the systems they operate within. Deep exploration into systems can help us to identify ways to *transform* or improve a system. Examples that relate to electric vehicles are charging stations relative to vehicle range and travel distances. An even deeper look into this would include charging times, ease of use, and ultimately the energy sources to charge the vehicle. If the energy source comes from a coal burning power plant then we would need to calculate carbon dioxide (CO_2) emissions. Coal plants with old technology contribute heavily to global warming. Modern nuclear power plants are safer than they have been in the past and with proper controls and inspections could be a much cleaner energy source.

4.2. Systems Thinking Related to People

The second major aspect of systems thinking within the industrial design process relates to the people that use or could potentially use the product. These people could also exist within a future system. The section below details approaches to systems thinking relative to people.

4.2.1. People and their current situation

When looking at the customer often times designers create personas of a make believe person that represents a specific market niche and lifestyle. These approaches can be helpful, but a more intimate understanding of the customer, on a micro and macro, scale can be much more helpful. Looking at a big picture perspective we include general information of a demographic area, including population density, average income, literacy, vehicle ownership, career paths, and family size. A closer look at the person who buys a specific product may reveal information that helps us understand why they may *react* to a product they own or how they might react to the introduction of a new product. This information can be gathered through direct interviews and videos of task analysis studies. For example, consumers respond to electric cars in a variety of different ways. Positive reactions may be that customers feel good about consuming less energy and not having to go to a gas station. They may be opposed to this idea because of battery replacements costs and recharging times. Even though these reactions are important to know and may be justified, studying events alone is not effective in developing new products beyond what currently exists.

4.2.2. People and timelines

Timelines are tricky when it comes to people. You can document significant events that have happened up to the current date through interviews. Or timelines can be developed to go to the anticipated date when they may depart. Calculations beyond the current date help us *anticipate* what they may be doing in the future and what things will be important to them. Timelines of people compared to timelines that are product or technology based can be interesting. As global warming issues become more of a concern to the mainstream population electric cars may be more popular within the future of the current customer who refuses to purchase one at this time.

4.2.3. People and external forces

External forces on individuals could influence the *design*. A straightforward example is if affordability is a factor then the product should be designed to be affordable to the customer. However, deep seeded issues exist and need to be identified. A lack of customer awareness of how an electric vehicle system operates may heavily influence the challenges in the implementation of electric vehicles. With this knowledge educational videos could be created to enhance the user experience. It is important to understand how these forces have resulted in current habits that influence purchasing decisions.

4.2.4. People and mental models

This approach to people includes thinking patterns, beliefs, attitudes, and values that allow a situation to persist. These mental models are the drivers of our actions and controllers of our interactions with a system. They can also be catalysts for change and *transformation*. Understanding these deep beliefs reveals the reasons why a person might be hesitant to purchase an electric vehicle or why they are standing in line to purchase the latest model.

4.3. Systems Thinking and Leverage Points

Powerful leverage points can only be identified through the deep exploration and understanding of these drivers within products and people. This approach identifies *leverage points* that when considered within the design process, can lead to the transformation of the way people think. This could also strongly influence the trajectory of a system.

4.3.1. Identifying leverage points for lasting change

These new systems thinking approaches within the design process may be difficult to incorporate into the traditional design process, but can reveal points of greatest leverage. Senge states, *"Systems thinking is a powerful practice for finding the leverage needed to achieve the most constructive changes."* Considerations to the systemic structures reveal such leverage points and opportunities to design enduring products that make improvements to the comprehensive system. Leverage points are different for each project and product. However, once we have discovered and explored the various leverage points through systems thinking we are better informed as to what areas to target for lasting change.

5. THE PORTABLE ASSISTED MOBILITY DEVICE CHALLENGE

In response to predictions of increased urban density and the growing stresses this will have on the existing infrastructure General Motors developed a concept brief, which challenged students in design and engineering to generate ideas for a Portable Assisted Mobility Device (PAMD). This brief was created through collaborative efforts with Partners for the Advancement of Collaborative Engineering Education (PACE), a group formed by General Motors to help facilitate interactions between industry and academia. PACE invited selected academic institutions to participate in this challenge. The University of Cincinnati accepted this invitation and in the fall semester of 2012 a studio was formed and students focused on this project.

The PAMD project brief was extremely comprehensive. Within the guidelines students were expected to design an electric or power assisted device with a small footprint. These concepts were also expected to integrate with public transportation. Systems thinking and integration methodologies were introduced into the design process. This was essential in developing concepts that identified products and needs that would not ordinarily be addressed within the traditional design process. This systems approach was achieved using two distinct strategies. First, the integration with public transportation led to extensive research of the urban environment. This resulted in the direct applications of function or logistical aspects of blending these two systems so they worked seamlessly together. The second strategy included studying behavior patterns and habits to connect the user with the product. Research concluded that educating the customer about these new products was a critical component.

To develop this project three different disciplines within the academic environment joined together; 1) an industrial design team lead by Professor Brigid O'Kane, 2) an engineering team lead by Professor Sam Anand, and 3) a graphic communication team lead by Professor Ben Meyer. Industrial design students focused on the product and aspects of related systems. Each of their concepts were developed as three-dimensional CAD models that we milled in the Rapid Prototyping Lab within the College of Design, Architecture, Art, and Planning. These physical 1/3-scale models were finished off with hard coat paint and detailed to look as if it were full size prototypes. Images of these models are included in the following examples. Engineering students advised various teams throughout the project and encouraged realistic parameters and goals. Graphic design students developed motion graphics pieces, websites, and applications, which clearly outlined the intended use of each new mobility device. The use of these graphic visuals helped to educate the people who would use the product, making each product easy to use and understand. User-friendly products are theoretically more attractive and more likely to be successful within the market.

6. CREATING THE TEAMS AND THE JIGSAW CLASSROOM TECHNIQUE

To manage these design teams, a cooperative learning technique was used to organize classroom activities and encourage positive interdependence among team members. There are several different cooperative learning models that could be used in this setting such as Think Pair Share, Reciprocal Teaching, and Round Robin. An approach that is commonly used in design studios is Student Teams Achievement Divisions (STAD). This process involves evaluating all individuals equally based on their team's performance. In a good team this model works well when all of the teammates encourage each other to perform at their best, however, the STAD model can also generate resentment and inefficiency if a teammate does not show the initiative or the level of productivity that is expected by the group.

For this project the collaborative studio was structured after Eliot Aronson's Jigsaw Classroom Technique. This cooperative learning approach involved training group members separately in their area of expertise so each member returned and shared their unique knowledge with teammates. For example, the industrial design students attended classes and lectures in their classroom and then shared their knowledge with their graphics and engineering counterparts. The graphics and engineering students followed the same model and also attended separate classes. This process encourages listening and engagement with individual group members who have learned unique material essential for group success and created efficient group learning methods that increased the variety of educational experiences and design solutions available in the studio setting. The jigsaw method also enabled individual members to attend classes simultaneously instead of teaching all of the students sequentially. As a result, the instructors were able to use extra class time for group discussions and collaborative meetings.

7. THREE EXAMPLES

The following projects focus on the results generated by the industrial design, graphic design, and engineering students. Within this studio a total of thirteen concepts were developed. Below are three design examples of the unique ideas that were developed for the PAMD project.

7.1. Cargo - A Bike Trailer and Shopping Cart

Industrial designer Leon Wenning and graphic designers Kevin Danielson and Lindsey Melling conducted research to obtain a better understanding of biking in an urban setting. From this data they discovered bicyclists could not easily transport several bags of groceries or other cargo from small shopping trips on a bicycle, bus, or subway. Research proved this to be a dominant challenge for riders that depend on public transportation and their bicycle. The design team focused on this issue by exploring shopping habits and the use of grocery carts. They noticed that a typical shopper often picked up last minute items that were not pre-planned. This activity can be difficult for

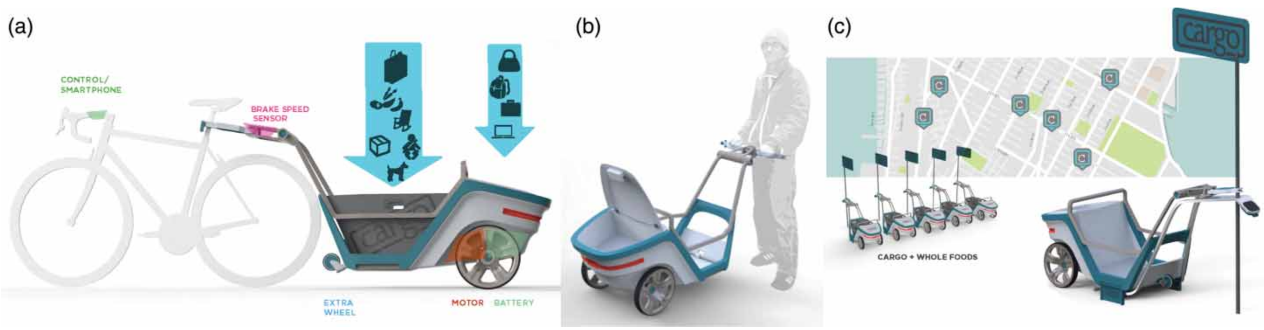

Fig. 3: The Cargo bike trailer shown in Fig. 3(a) converts to a shopping cart as illustrated in Fig. 3(b), that can be used in the grocery store. This concept is part of a rental system located outside grocery stores, as indicated in Fig. 3(c), so bicyclists can easily access these trailers where they need them most.

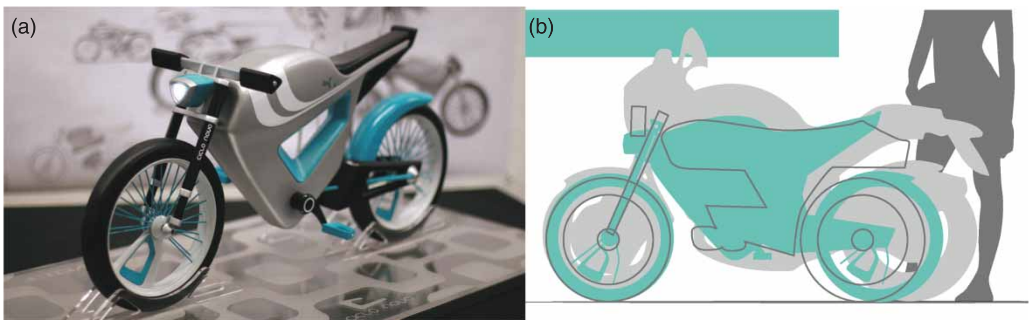

Fig. 4: The final model for the Ciclo Nova concept 4(a) was built in Autodesk Alias and 3D printed as a 1/3-scale model. A package drawing comparison 4(b) shows the Ciclo Nova size, which is smaller when compared to a traditional motorcycle, making it legal to ride on bike paths.

a bicyclist who does not have the extra space to carry these items.

After analyzing this data the team noticed that bike trailers address some of the issues discovered through research, but did not provide assistance when pulling heavy loads. Trailers also did not adapt easily to different shopping environments. As a result, the team developed a motorized bike trailer called cargo that converts into a shopping cart shown in Fig. 3(a) and 3(b). This design allows people to load their items in the store and immediately attach the cart to their bike outside the store. The process of loading and unloading items from a shopping cart to a bike trailer was eliminated with this design. The motor also provides assistance when pulling heavy loads, allowing the casual bike rider to use this device without strain or fatigue. A digital rental system outside grocery stores, shown in Fig. 3(c), was also developed to provide access for users who own this device. This concept can potentially be adapted within any urban setting and appeal to a very broad market.

7.2. Ciclo Nova - An Electric Moped Designed for Bike Paths

Ciclo Nova is a concept developed by industrial designer Miranda Steinhauser and graphic designers Brock Arthur and Kate Menkhaus. This design addresses issues related to urban transportation in South America. this design team researched various articles as well as community and regional planning publications for Rio de Janeiro. From this research they noticed that in the last decade, the number of cars in Rio de Janeiro has increased by 40%. As a result, traffic congestion has become a major problem. To address this issue, Rio has developed over 180 miles of bicycle paths that crisscross the city. This design was based solely on research articles and online surveys with individuals who live in that area. From this data the team found that the public would like to have a device that could travel longer distances and would give them the option to commute a portion of their journey with existing public transit systems. Using this data, the design team decided to develop a product that can be used on existing bicycle paths and travel longer distances without contributing to the air pollution that can exist in highly congested areas. The final design was a battery powered moped, which according to their research could legally travel on Rio's existing bike paths. This electric moped shown in Fig 4(a) is smaller than a traditional motorcycle making it ideal for these bike paths. These size differences are illustrated in Fig. 4(b). Charging stations referenced in Fig. 5(a) were designed to allow individuals to lock up and recharge their e-moped when they

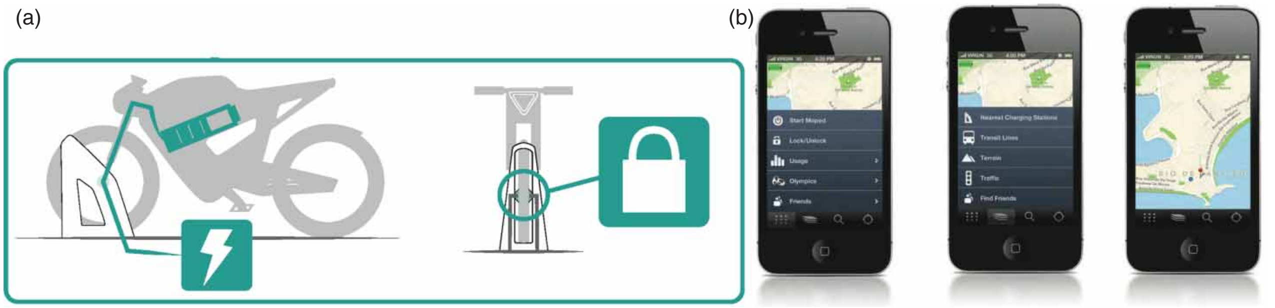

Fig. 5: Charging stations shown in Fig. 5(a) allows individuals to lock up and recharge their e-moped when they use public transit systems. Mobile phone applications in Fig. 5(b) were designed to allow riders to map out traffic patterns, existing charging stations, and transit lines.

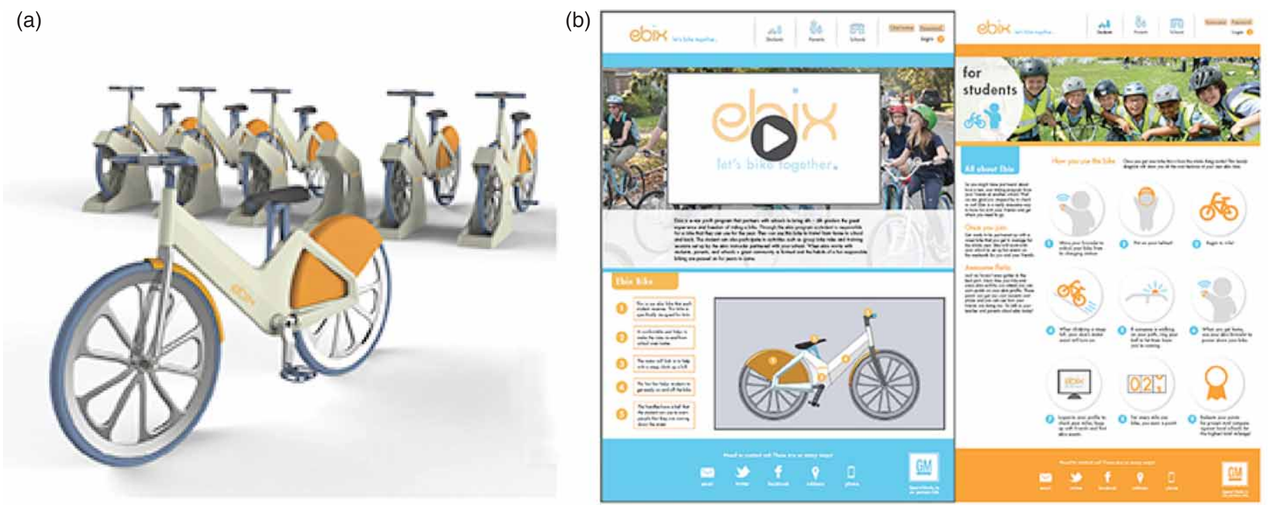

Fig. 6: The image in Fig. 6(a) shows the design of the Ebix concept. Fig. 6(b) is a screenshot of the ride-sharing program website for kids in elementary schools in 4th – 6th grades and their parents.

use public transit systems. The team also designed a mobile phone application that allows individuals to map out traffic patterns, existing charging stations, and transit lines on these bike paths. This feature seen in Fig. 5(b) was developed to seamlessly integrate this design with Rio's existing transit system.

7.3. Ebix - An Electric Assist Bicycle and Bike-Share Program for Students in Elementary

Product designer Winnie Chi and graphic designers Emily Scaggs, Elli Matejka, and Stephanie Szarwark created the Ebix electric bike concept shown in Fig. 6(a), which is a bike-share program for elementary schools. The primary interest for this project was to encourage bicycling and bike safety. The team conducted research to obtain a better understanding of biking in both urban and suburban settings in the Cincinnati area. This research included online surveys, interviews with parents and children, and a review of local accident reports involving bicyclists. From this data they discovered that many children were unaware of or did not practice bike safety. This included helmet usage, using hand signals, and understanding basic bike maintenance. They also noticed that children are more likely to be driven to school rather than riding a bike. To address these issues, the design team decided to develop a non-profit bike-sharing organization that would collaborate with local schools. Specifically designed for 4th- 6th grade students, the main component of this program included a power-assisted bicycle. After completing several safety training courses, these students would be allowed to rent an e-bike for a year and during that time have access to an online community of Ebix users. This site would track miles so kids can compete with their friends on the website and win prizes for accumulated miles, which is shown in Fig. 6(b) Parents would also have their own online profiles enabling them to contact other parents within the program. After participating in this program for a full year, the design team believed that a healthy habit of exercise and bike safety would develop for both the parents and kids who participate.

8. CONCLUSION

Within the industry, automotive designers typically focus only on the production vehicle they are assigned to work on and do not consider aspects of the environment that their products will operate within. Of course, new experimental vehicle types and technologies are developed within advanced automotive studios. We see evidence of this in concept and production vehicles; however, these advancements are incremental and evolutionary. In order to address the issue of urban growth more drastic change is needed. New and innovative modes of mobility need to be developed and the infrastructure needs to be designed and built to accommodate these new ways of getting around.

Innovative and alternative vehicles and devices are needed for conserving an ecological balance. We are at a pivotal time when pollution, global warming, and the depletion of specific natural resources are current global challenges. In the future the anticipation of population growth and urban density will make these matters worse if we do not develop new habits. Innovative technologies and mobility products can influence and change the behavior patterns of large segments of the population. As these new products are put into production and introduced to the market, early adaptors are likely to be the first users. Getting these products into the mainstream market could prove to be a daunting task, however, integrating systems thinking methodologies into the automotive production design process could manifest into a significant shift in developing products that are better suited for the environment and successful within local and global mainstream markets. The numerous reasons innovative eco-friendly products are slow to penetrate the mainstream market go beyond the scope of this paper. However, systems thinking methodologies gives product development teams essential tools for a deeper understanding of our actions and the forces at play that influence our interactions with systems. This new design process will also assist in identifying leverage points that act as a catalyst for positive and impactful change.

ACKNOWLEDGEMENTS

Professor Ben Meyer within the Graphic Communication Program was a key collaborator on the Portable Assisted Mobility Device (PAMD) Project. His student work is featured in all three examples section 7 and in Figures 5(b) and 6(b). He also contributed to section 6 of this publication.

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