INTERNATIONAL CONFERENCE ON **ENGINEERING AND PRODUCT DESIGN EDUCATION**
4 & 5 SEPTEMBER 2008, UNIVERSITAT POLITECNICA DE CATALUNYA, BARCELONA, SPAIN

INFANT SAFETY IN AMBULANCES: LEARNING FROM COLLABORATIVE INNOVATION

Dosun SHIN
Arizona State University, USA

ABSTRACT
In the winter of 2006, an industrial design team at a major university in the U.S. and a local enterprise began a joint project to design a safety device for children to be used in such emergency vehicles as ambulances and fire trucks. A faculty member in industrial design led the design team which included students, entrepreneurs, engineers and firefighters. This cross functional product development process enabled the team to take this project from a simple idea to a formidable product thereby revolutionizing safety for children in emergency transportation. Our goal was to ensure that all stakeholder needs were addressed through the design, making the product manufacturable, aesthetically appealing, and ergonomically comfortable.
Students catalyzed the design process with fresh ideas and creative input, while the firefighters offered valuable insights regarding safety, regulation and real-life experience in this critical design project. Students gained valuable real world experience and had the opportunity to learn by doing, the entrepreneurial firm got a close look at the inner workings of new product development, and the firefighters were able to play an integral role by participating in the design of a product that they will use. As the entrepreneurs and firefighters were educated about the value of design through first-hand experience, they became eager to explore other product ideas through future collaboration.
This paper illustrates the process of how an innovative life-saving product was developed by a multidisciplinary team and what design students learned about professional practice through their engagement in a real design project.

Keywords: Design collaboration, design innovation, emergency transportation product, entrepreneurship

1 INTRODUCTION
We are surrounded by countless products in our lives that provide us varying degrees of satisfaction. In many cases, low satisfaction levels are tolerable, but when it comes to products that relate directly to matters of life and death, things get serious. In such cases, good design is obviously not only a matter of people’s satisfaction with products but also about people’s lives. In any case, safety is the most crucial issue in developing products that both designers and engineers must consider with priority. There are also unique problems and strict regulations in designing life-critical products, and the only way to tackle them is through a multidisciplinary team that is able to incorporate perspectives, knowledge, and attitudes from several significant stakeholders in the design process.

In December of 2006, the department of Industrial Design at Arizona State University in the US was contacted by a group of local entrepreneurs for a possible joint project to design a safety seat product for children to be used in such emergency vehicles as ambulances and fire trucks. The brief project descriptions and time schedule were introduced to the faculty, but other details required for new product development such as engineering requirements, manufacturing guidelines and business plan were not yet clearly shaped. The entrepreneurs were operating on a tight timeline with the goal of product launch within 6 months, and it was a challenge to have the new product designed and manufactured within that time frame. The schedule for design process and design deliverables was outlined by the faculty and was approved by the entrepreneurs in the contract document.

The industrial design team was headed by an assistant professor with 7 years of experience in product development and expertise in assistive device design. The team also included two senior level industrial design students. The entrepreneur partners included an independent business consultant with over 15 years of Executive Management experience in a variety of industries, the head of Emergency Medical Equipment Research and Development for the City of Phoenix Fire Department with over 22 years of Emergency Medical experience, and a Captain on the Community Involvement Division of the Phoenix Fire Department with over 18 years of experience.

2 LEARNING TO IDENTIFY THE PROBLEM SPACE

Shortly after the contract paper work was completed, the first meeting was held to kick-off the project with the other team members from the Phoenix Fire Department. During the first meeting, the design team learned about the problems that the fire department had been facing for many years: namely the lack of child restraint systems within ambulances and fire trucks. The firefighters described the following challenges to the team: First, there is currently no safe method available for transporting infants whose parents are immobilized in an accident. Next, the only existing option is for a medic to hold the infant during transport to the hospital. However, if parents are not incapacitated they can hold the infant, which reduces the liability of the fire department. Lastly, there is an existing restraint system for *toddlers*, children classified in the 20-80lb range, but this is not safe for smaller infants and (according to the firefighters) offers numerous opportunities for refinement. The following data complemented the user interviews conducted by the design team and helped the students to learn about the problem from different sources and at different scales.

A study by the National Highway Traffic Safety Administration indicates that the correct use of appropriate safety seats for children has the potential to prevent as many as 53,000 injuries annually and may save up to 500 lives per year [1]. Traffic crashes are the leading causes of death for children of every age according to a report by the National Child Passenger Safety Week 2000. Statistics also indicate that restraint use in non-commercial vehicles for children from birth to age one is 97 percent, and 91 percent for children between the ages one to four [2]. While these numbers are encouraging, they do not address the potential for adult lap belts—which ride up over the stomach, shoulder and neck of the child— to cause serious or even fatal injuries. So, although safety belt use is high for children, they aren't necessarily the safest solution.

According to National Fire Protection Association (NFPA) reports, every week Emergency Transportation Vehicles are involved in an average of 307 accidents that result in an average of one death [3]. The existing toddler safety seat can be accessed by pulling a back seat cushion down, and is designed for children in the 20-40lbs range.

Once seated, the toddler is secured with a harness seat belt. No solution currently exists for safely transporting infants in the 5-20lbs range in emergency vehicles. Based upon the stakeholders' insight and additional research regarding emergency vehicle safety, the design team collectively crafted the following problem statement: how might we provide secure transportation for infant (5-20lbs) and toddler (20-40lbs) ambulance passengers that will fit inside the existing adult seat used by first responders. In response to the identification of this problem, the business experts and firefighters agreed that this opportunity gap warranted the creation of a new company known as Serenity Safety Products (SSP).

3 LEARNING TO ADDRESS THE PROBLEM VIA IDEA GENERATION

We started the process of design with a brainstorming session that included all stakeholders previously mentioned (faculty, students, firefighters, entrepreneurs). The primary goal of the brainstorming was to generate ideas that address the problem statement need for an infant seat and toddler restraint system that fit into a regular adult seat. In addition to the stakeholders and design team, a few ambulances and fire trucks were in attendance at this initial meeting enabling the students the chance to experience first hand the challenges and context under consideration. This physically interactive brainstorming helped the design team to quickly realize how little space was available for the product. The chair that was to be replaced with the new and improved Serenity Safety Products (SSP) chair was already quite small with minimal space constraints for the new design. During this interactive exercise, the students learned to gather critical information regarding usability, human factors and ergonomic issues, product interactions, etc. This information was collectively synthesized into the following insights:

Usability: 1) The existing toddler seat cushion does not attach after pulled down and it floats. 2) The chair can be rotated to face the door which facilitates the placement of the child in the seat by an adult. This feature is never used, however, because the firefighter is often holding the child unable to access lever to rotate.

Human factors: 1) The shape of the toddler seat and back cushion does not provide comfort while seated. 2) The seat belt is not height-adjustable so it is potentially unsafe depending on the size of the child.

Product interactions: 1) There are no instructions that illustrate how to pull the toddler seat down. Firefighters put their fingers in the gap to pull down. 2) The toddler seat belt is a complex mass of straps that make it difficult to understand how to securely fasten a child in.

The entire team generated numerous ideas and then evaluated them against the previously identified challenges. Eventually the team agreed upon one concept with a possible system mechanism for further development.

4 LEARNING TO DEVELOP AND REFINE THE CONCEPT

After the brainstorming meeting, the student/faculty design team started generating initial concept sketches through discussions and thumbnail sketches on a whiteboard in the design studio. The focus was on the functionality of the seat, as well as a loosely defined aesthetic image of what the product would look like. Eventually, the students agreed they needed to create a few renderings that allowed them to label and define the features of the proposed design including the location of the infant seat, sliding mechanism, retractable seat belts, and a toddler seat built into the seat back. Recognizing the value of integrating engineering expertise in this phase of the process, the faculty leader tried with little success to identify a local firm willing to work within the time and fiscal parameters of the project. This search continued throughout the concept refinement phase.

Without the benefit of an engineer on the team, the design students and faculty undertook the creation of a study model of the chair to explore the functional feasibility of the mechanism. It was difficult for the design team to figure out the mechanical aspects of the design and make a functional study model without the input of a mechanical engineer. The primary challenge was ensuring that the size of the standard seat would allow for the full-size infant seat and necessary mechanical components. The project leader chose to engage the team in a reverse engineering exercise and obtained two existing seats from an emergency vehicle and a standard infant. The team studied the structure of the seat's metal frame and the manufacturing materials used. From this exercise, the design team learned that the biggest challenge would be fitting the infant seat into the limited space underneath the regular seat.

The design team then constructed a study model, which allowed them to develop the initial concept mechanism and demonstrate it for the firefighters who then actively participated in a task analysis. Based upon this input from the firefighters, the concept was further refined, but the design needed additional optimization and parts reduction.

5 LEARNING THE VALUE OF ENGINEERING EXPERTISE

Three months into the project, the design team was still working without the benefit of an engineer who could verify the design mechanically and explore potential for production. Finally, when the study model was nearly finished, the project leader was able to secure a contract with a local engineering firm. The company had specific expertise in the area of safety requirements and regulations for seating products, and offered computer aided structural testing which was extremely valuable for the project.

An initial meeting was scheduled between the engineering group and the entire design and stakeholder teams. The design team presented all the research and development they had undertaken, including the rough study model. The SSP stakeholder team reiterated the necessary requirements for the project. The engineering group affirmed that they were capable of working within the compressed schedule of the project and agreed to join the design process. The students welcomed this addition to the team as they had learned, during concept development, the valuable contribution that the engineers would be making to the process.

6 LEARNING TO COLLABORATE

While the engineers were working on the structure of the design and exploring how to move the infant seat from underneath the adult seat, the design team was working in parallel to refine the aesthetic elements of the design, which had not been fully determined at this point in time. The two teams relied upon each other to shape the refinement of the final concept. The design team was faced with major changes in the mechanical structure, and hence, form, of the original concept. The two teams negotiated which aesthetical elements would be included in the final design based upon the engineering requirements. During the process of collaboration, both teams faced many difficulties in terms of communication, compromise, and coordination [4]. This experience was a hard but valuable lesson for the students who agreed that inclusion of engineering expertise earlier in the process would have improved concept development.

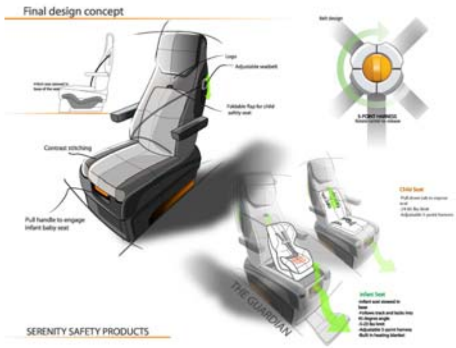

Figure 1 Concept rendering

7 LEARNING THE IMPORTANCE OF PROTOTYPING AND TESTING

Based on the concept presented by the design team, the engineers developed the seat mechanism. Instead of storing the infant seat below the adult seat, it was placed behind the back cushion. The function was clearly articulated in a working prototype and the concept addressed the design team's concerns about space limitations underneath the adult seat. The engineering firm further demonstrated its expertise via important tests, such as impact analysis and material tests, utilizing the CAD engineering drawings they had generated. Crash tests were successfully performed with the prototype and non-human dummies by the Center for Advanced Product Evaluation (CAPE). In addition, a professional crew was contracted to videotape contextual product usage of the prototype by firefighters with toddlers and an infant.

The student design team was disappointed to have little involvement in this phase of the project because their contract had expired. However, they continued to follow the project and its development, learning a great deal about the process of prototyping and safety testing that is essential for products developed for transportation and children. The students also received regular updates from the team leader regarding the process of contracting with a manufacturing company and generating CAD renderings to be used for SSP company brochure, website, and other publications.

Figure 2 Concept solution

8 CONCULSION: LEARNING OPPORTUNITIES

This project represented a unique learning opportunity for everyone involved. The students were able to experience a real-world product development process that involved various stakeholders and provided numerous lessons about user-centered research and design as well as safety concerns in the design of a product for transportation of children. They functioned as designers and learned to fulfill the role of 'co-operator' via communication with multiple stakeholders throughout the process [5].

The faculty leader also learned more about the process of managing a project within the context of a university collaborative with outside sponsors [4]. The entrepreneurs, as well as the firefighters, learned a great deal about the value of design and engineering in the transformation of an idea into a safe, marketable product and are looking forward to future collaborations.
Some of the direct benefits to the students involved in this project include the opportunity to work directly with stakeholders, working within the strict regulations governing development of life-saving products, acknowledgement of intellectual property via a patent with their name on it, royalties from product sales for the next 5 years, connections for possible future projects with the various stakeholders

In summary, and with attention given to the educative potential of such a collaborative partnership between an industry sponsor and a faculty/student design team, the following conclusions (as learning opportunities) are offered:

1) *Learning how to identify the problem space*. The students learned methods for collecting and analyzing data relevant to the problem space and how to create critical problem statements based upon input from the stakeholders.
2) *Learning to address the problem via idea generation*. Hands-on brainstorming with the stakeholders resulted in the students' ability to formulate solutions to the posed problems and generate criteria for selecting a concept solution to refine.
3) *Learning to develop and refine the concept.* Students used reverse engineering with existing products and made a 3D study model in order to understand fundamental functional mechanisms.
4) *Learning the value of engineering expertise*. Students appreciated the significance of multidisciplinary team for a new product development.
5) *Learning to collaborate*. Students were able to refine their abilities to communicate, compromise, and coordinate.
6) *Learning the importance of prototyping and testing.* Students were exposed to critical concerns regarding safety and regulations for a life-saving product.

REFERENCES

[1] U.S. Department of Transportation. National Highway Traffic Safety Administration. *Buckle Up For Love!* Report issued for Child Passenger Safety Awareness Week. (1991).
[2] National Child Passenger Safety Week 2000, Feb 13-19, 2000
[3] http://www.serenitysafetyproducts.com/ourproducts.php. [Accessed on 2008, 2 March].
[4] Shin, D. Collaborative Design: Shaping Assistive Technology Devices. In Proceedings from *the Eastman IDSA National Education Conference*. Dulles, VA, USA. 2005. pp. 145-153.
[5] Young, R.A., Van Der Veen, G.J., Illman, M.E. and Rowley, F.J.B. Creating Enhanced User Experiences: The designer is a 'co-operator' by facilitating communication. In S.A.R. Scrivener, L.J. Ball and A. Woodcock (Eds). *Collaborative Design: Proceedings of CoDesigning 2000*. pp. 37- 47 (Coventry University, UK, 2000).

Assistant Professor Dosun SHIN
Arizona State University
PO Box 872105
Tempe
AZ 85287
USA
dosun.shin@asu.edu
1- 480- 965- 7816