1-1-2016

Lessons Learned from a 10-Year Collaboration between Engineering and Industrial Design Students in Capstone Design Projects

Jay R. Goldberg
Marquette University, jay.goldberg@marquette.edu

Pascal Malassigné
Milwaukee Institute of Art Design

LESSONS LEARNED FROM A 10-YEAR COLLABORATION BETWEEN ENGINEERING AND INDUSTRIAL DESIGN STUDENTS IN CAPSTONE DESIGN PROJECTS

Jay R. Goldberg[1] and Pascal Malassigné[2]
[1]*Marquette University*
[2]*Milwaukee Institute of Art and Design*

Engineers and industrial designers have different approaches to problem solving. Both place heavy emphasis on identification of customer needs, manufacturing methods, and prototyping. Industrial designers focus on aesthetics, ergonomics, ease of use, and the user's experience. They tend to be more visual and more concerned with the interaction between users and products. Engineers focus on functionality, performance requirements, analytical modeling, and design verification and validation. They tend to be more analytical and more concerned with the design of internal components and product performance. Engineers and industrial designers often work together on project teams in industry. Collaboration between the two groups on senior capstone design projects can teach each to respect and value the unique contributions each brings to the project team, result in improved design solutions, and help prepare students for future collaboration in industry. Student feedback and lessons learned by faculty and students from a ten-year collaboration between engineering and industrial design students from Marquette University and the Milwaukee Institute of Art and Design, respectively, are presented. Students learned to communicate with people in other disciplines, appreciate the complementary skills of each discipline, and value different approaches to problem solving.

Keywords: industrial design, multidisciplinary teams, capstone design, design collaboration

Corresponding Author: Jay Goldberg, jay.goldberg@mu.edu

Introduction

The technical, human factors, and aesthetic aspects of design help create value and enhance the overall perception of quality.[1] A well designed product satisfies all customer needs, meets all required specifications, incorporates basic human factors principles, and is sensitive to aesthetics and market perception.[2]

Engineers and industrial designers are problem solvers who use their design skills to develop new products that meet their customers' needs. Their approaches to problem solving are different, and they emphasize different aspects of design. Engineers focus on the technical aspects of design such as functionality, performance requirements, analytical modeling, and design validation. They tend to be more analytical and more concerned with product performance and the design of the internal components that make the product work.[3] For example, engineers developing implantable medical devices are concerned with issues such as corrosion, wear, degradation, strength, and fatigue life. They perform calculations, use a variety of analytical tools (such as finite element analysis), and conduct bench tests to ensure that products are made from materials with the appropriate design characteristics (strength, biocompatibility, biodurability, etc.) and will safely perform as required. Industrial designers focus on aesthetics, ergonomics, usability, safety, and the user's experience. They tend to be more visual and more concerned with the interaction between users and products. For example, industrial designers are concerned with the psychological impact of a product's design on the user or potential customer, usability (ease of use, low potential for error), safety (no sharp edges or other potential hazards), quality of the overall product experience, and perceived value of the product.[1] Engineers and industrial designers share a heavy emphasis on the customer, manufacturing methods, costs, and prototyping, and make extensive use of Computer Aided Design (CAD) and 3D modeling.

When engineers enter the workforce, they will be expected to work on multidisciplinary teams typically

consisting of members of research and development, marketing, production, finance, regulatory affairs, and other departments. Depending upon the type of products being developed, industrial designers are often assigned to the project team to work with engineers on the design of the new product. Industrial designers are uniquely qualified to assist with specific aspects of product design. However, many engineering students (and faculty members) are not aware of what industrial designers do and the role that they can play in new product development. Effective collaboration between biomedical engineers and industrial designers requires an understanding and appreciation of the contributions each can make to the project and team. To prepare these groups of students to work together during their careers, a formal collaboration between biomedical engineering students from Marquette University (MU) and industrial design students from the Milwaukee Institute of Art and Design (MIAD) was created in 2006.

Previous Work

Early results of the MU/MIAD collaboration described here have been reported previously.[4-6] A few similar collaborations have been established at other schools, involving different levels of collaboration between students from different disciplines, and inclusion of industrial design (ID) topics in freshman and/or senior capstone design courses. Some universities have a college of engineering and a school of art and design, making it easier to create and manage collaborations between the two disciplines.

The MU/MIAD collaboration was established in 2006, prior to most similar collaborations that exist today at other schools. It involves engineering and industrial design students working together on senior capstone design projects. It includes an ID module during the fall semester of the two-semester MU senior design course consisting of presentations by MIAD faculty on aesthetics of design, communicating ideas, converting specifications into concepts, and a hands-on workshop on creating mock-ups and prototypes.

At the University of Cincinnati, collaboration between business, industrial design, and biomedical engineering students began in 2002. Students are teamed with a physician to study a particular medical device, learn how it is used, and determine how it could be improved. The business students identify stakeholders and determine regulatory status, the industrial design students conduct task analyses, and the engineering students analyze the device and determine how it functions. This experience provides students with the opportunity to work on multifunctional teams and develop "cross-language skills" needed for careers in new product development. Engineering students complete this course prior to enrolling in the required senior capstone design course. The business and industrial design students are invited to continue their multifunctional team experience via participation in senior capstone design projects.[1, 7]

At the University of Illinois at Champaign-Urbana, collaboration between engineering and industrial design students began in 2008. Teams consisting of two engineering and two ID students work together on projects during the freshman and later years. Design thinking is introduced in the freshman graphics course, which includes lectures on ID topics.[8]

More recently, at the New Jersey Institute of Technology, students from the Department of Biomedical Engineering and the School of Art and Design began working together on senior capstone design projects. Teams are required to design and build devices to help people with disabilities.[9]

MU/MIAD Collaboration

Each year from 2006 to 2015, six pairs of junior level MIAD industrial design students, enrolled in a one-semester industrial design course, were assigned to each of six biomedical engineering senior capstone design projects consisting of senior level biomedical, electrical, computer, and mechanical engineering students. The MU capstone design course began in August each year. In November, MU teams interested in working with MIAD students presented their projects to the MIAD students. In December, MU students proposed a final concept for further development and in January, presented these concepts to the MIAD students who then selected the projects they wanted to work on. Due to scheduling limitations of the MIAD industrial design program, collaborations began in January and ended in March. Beginning in January, the MU and MIAD students worked together to further develop and refine concepts proposed by the MU students at the end of the first semester of the multidisciplinary capstone design course. Prototypes were built using resources from both schools which included a machine shop and 3D printers located in the MU Discovery Learning Laboratory, and clay, foam, and fiberglass molding equipment available in the MIAD 3D Laboratory. Designs were verified by the MU students and validated by the team. The MU students continued their work and completed their projects in May, when the course ended.

The goals of these collaborations were for students to 1) learn about each other's disciplines, 2) be exposed to different approaches to problem solving and ways of

thinking, and to 3) enhance students' design education, and 4) improve the quality of prototypes created by the project teams. In May 2015, a qualitative survey, consisting of four questions, administered online and open for one month, was used to solicit feedback from all members of the teams regarding what they learned from their experiences working together and their suggestions for improving the collaboration.

Results

Responses to the survey questions below were received from 9 of 30 MU students (30%) and 9 of 12 MIAD students (75%) participating in the collaboration. Quotes representing common themes are presented below:

What did you learn about each other's discipline?
"Industrial design is less technical/math based; with more thought on emotion and interaction of the device."
"We have very different approaches to solving a problem and we could complement each other in a respectful manner."
What did you learn about working with engineering/industrial design students?
"Communication is essential. Each major has its own vocabulary and what makes sense to one group may not to another. Learning each other's language is essential."
What differences/similarities in problem solving, design, and project management did you observe between engineering and industrial design students?
"Engineers did not know how to visualize at all. It was so exciting to be able to help them with this. Likewise, my lack of knowledge in terms of engineering was readily supplemented by the engineers. Great balance."
Similarities: *"Identifying the problem; attacking it one piece at a time; devoted and passionate about the project. Both followed schedules, gave presentations, needed to explain their ideas to other disciplines."*
Differences: *"Engineers focus on how the device will function; MIAD students focused on the human interface and appearance."*
Do you have any suggestions for improving this collaboration?
"It would be better if the collaboration could start a bit sooner so that both groups are on the same page throughout the beginning of the project."
"Have designated meeting times to help with more collaboration with MU students."
"It would be nice if they (MIAD students) were able to stay with us until we are 100% done."
"Meet during class time as well as having scheduled class time for engineers and designers to collaborate."

Discussion

The results of the survey indicate that the MU and MIAD students recognize that each discipline has a different focus, its own language/vocabulary, and different approaches to problem solving. Engineers noted that ID students emphasized aesthetics, and used drawing and sketching as preferred tools for design and communication. ID students noted that engineering students emphasized more analytical approaches to design with a focus on functionality, and testing to verify designs. Both groups noted that there were many common aspects of the design and project management processes that were shared between the disciplines such as problem identification, passion for the project and the quality of the final design, use of schedules to manage the project, and communication of project status through oral presentations. They viewed differences in approaches to problem solving as being complementary to the skillsets of students from both disciplines, and felt that both groups could work well together with mutual respect to solve problems.

Survey results indicated a strong desire among students to work together from the start of the MU capstone design course until the end. Students preferred to join the team and begin work on the project in August instead of January, and continue working until the project is completed in May, instead of March. MIAD students wanted to be involved as early as possible in the design process, including identifying customer needs, establishment of target product specifications, and concept generation and selection. They suggested that class time be provided to meet as a team.

Students concluded that good communication was required for a successful project experience, and that learning each other's disciplinary language was essential to understanding each other. They recognized the need for engineering and industrial designers to be able to explain ideas to people from other disciplines.

Recommendations

Over the last ten years, we have learned many lessons regarding the structure and management of our collaboration between engineering and industrial design students. Based on our experience, observations, and feedback from students, we recommend the following for capstone design instructors interested in establishing similar collaborations:

- Capstone design faculty should carefully screen potential collaborative projects to determine if significant industrial design work (other than just aesthetic improvements) is actually needed.

- To improve outcomes, participation in a collaborative project should be voluntary, not required.
- When soliciting participation from ID students, engineering students should present their projects, not capstone instructors.
- If possible, allow both groups of students to work together from the start of the project until the end to improve continuity throughout the entire project. This will allow all students to participate in the customer needs identification process, establish target specifications, and contribute to the early generation of design concepts. It can help build trust among team members, and create a sense of joint project ownership and greater commitment to the project and team.
- To avoid confidentiality issues, industry-sponsored projects should be carefully considered for potential collaborative teams. Industrial design students need to be able to include their work in their design portfolios and thus may not be willing to sign agreements that limit their ability do so.
- To better prepare for engineering/ID collaborations, it would be helpful to introduce ID topics to engineering students early in the curriculum, encourage development of 3D modeling skills (such as SolidWorks), and provide opportunities for students to develop sketching and visualization skills.
- Encourage students to share the title of "designer" with ID students and faculty. Often, industrial designers refer to themselves as "designers" and engineers as simply "engineers". Similarly, engineering students often think only of themselves as designers. Recognize that both groups are designers (and problem solvers) who emphasize different aspects of design and bring complementary design skills to the project team.
- Engineers often view the design process as linear (disciplined) and industrial designers view it as non-linear (chaotic). Recognize that the process involves iterations that are non-linear, but that to comply with international standards and regulatory requirements, phases may need to be completed in a specific order.

Conclusion

We found that engineering and industrial design students tend to emphasize different aspects of design, reflecting the emphases of their respective curricula. Student feedback and instructor observations over the last ten years indicated that these collaborations helped students 1) learn to communicate with people in other functional disciplines, 2) develop an appreciation for the complementary skills each discipline brings to the project, 3) learn that there is more than one way to solve a problem, and 4) develop an appreciation for different approaches to problem solving and ways of thinking. Evaluation of final prototypes indicated that the overall quality of product design increased when engineering and industrial design students worked together.[1] We found that the most successful collaborations involved students with excellent communication and teamwork skills.

Acknowledgments

The authors would like to thank the National Institute of Biomedical Imaging and Bioengineering for their partial support of this collaboration through Award Number R25EB013070.

References

1. Hyman, W. A., and Privitera, M. B. "Looking Good Matters for Devices, Too", *Medical Device and Diagnostic Industry*, May 2005.
2. Goldberg, J. R., Malassigne, P., and Privitera, M. B. "Engineering/Industrial Design Collaboration in Capstone Design Projects", *Capstone Design Conference 2010*, June 2010, Boulder, CO.
3. Prince, M. "Industrial Design Meets Engineering", *Appliance Magazine*, 66(5), June 2009.
4. Goldberg, J. "Biomedical Engineering/Industrial Design Collaboration in Senior Design Projects", Senior Design, *IEEE Engineering in Medicine and Biology Magazine*, 26(4) May/June 2007, p. 98-99.
5. Goldberg, J. R., *Capstone Design Courses: Preparing Biomedical Engineers for the Real World*, Morgan and Claypool Publishers, 2012.
6. Goldberg, J., Privitera, M. B., and Malassigne, P., "Benefits of Collaboration Between Biomedical Engineering and Industrial Design Students", *Proceedings of the 2007 Annual Meeting of the Biomedical Engineering Society* (CD ROM), *Los* Angeles, CA, September 2007.
7. Privitera, M. B., and Zirger, B. J. "Letting the Grain Out of the Silo: Transdisciplinary Product Development Education", *Innovation*, Quarterly Publication of the Industrial Designers Society of America, Winter 2006, pgs. 49-51.
8. Leake, J. M. and Weightman, D. "Engineering and Industrial Design Education Collaboration", *Proceedings of the American Society for Engineering Education*, Vancouver, BC, Canada, June 2011.
9. Florida, R. "Mixing it Up at NJIT: Engineering and Design Students Work Together", New Jersey Institute of Technology, http://www.njit.edu/features/innovations/biomed.php Accessed January 2, 2016.