Collaborative Design: Shaping Assistive Technology Devices

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Introduction

The process of product development typically involves the active participation of individuals from a wide range of distinct disciplines such as engineering, business, sociology, and psychology, among others. It also requires infrastructural facilities for the purposes of research, prototyping and manufacturing, and marketing, to be provided by diverse range of organizations. Large research universities with a wide range of disciplinary expertise and infrastructural facilities provide a fertile ground for experimental and innovative collaboration. This collaboration offers an excellent pedagogical apparatus and model for shaping the future of design education.

What is collaborative design?

Collaborative design is a group activity in which design professionals or design teams work collaboratively with different disciplines by sharing their expertise and responsibilities through the design process to reach a successful design solution. Typically, large-scale projects involve experts from multiple disciplines or groups related to the project. Industrial design is not creatively generated in fine arts and concerned principally with aesthetics, but rather a product-development process requiring many different perspectives and the expertise of various disciplines. Industrial design works in collaboration when individuals from different areas of study work jointly toward a design solution that is agreeable to all involved.

What makes a successful collaboration?

A successful collaboration requires trust, mutual respect, shared vision, frequent communication, and flexibility. It also claims a significant amount of time to develop and deliver.

- **Leadership and teamwork** are the essential requirements for a successful collaboration. The leader of the collaborative team must set the vision, goals, roles, tasks, and responsibilities for each member or small group. The participating team members must develop cooperation and respect to create an environment of truthful and innovative communication. The challenges of leadership are membership continuity, cultivation of common language and method, facilitation of member growth, active engagement of members’ knowledge bases, and effective coordination of work.

- **Ownership and partnership** are also key elements to each team member. There should not be an employee-employer relationship. If this relationship is broken among the team members, the success of the collaborative work is threatened. A team member who takes on the role of employer may acknowledge responsibility for the project overall, but may divert his/her focus and energy from the workings of the project itself. This is one of the general mistakes that can cause a team failure.
• **Communication** is another skill required for collaboration between different disciplines. It is necessary that team members communicate constantly and honestly with each other with open minds and mutual respect. The members must exercise active listening skills in order to “learn to listen and listen to learn.” Though each discipline uses particular terms, they must be explained by common or intuitive words to enable others to understand. It is important to understand and communicate among the different areas.

• **Brainstorming** allows participants to evoke a lot of diverse ideas and suggestions with different points of view. The project leader must provide these opportunities to everyone without any bias. All of the ideas and suggestions must be recorded and organized to collect all possible scenarios and directions for the project. There should be no argument and no friction. The team members must respect each other and listen, no matter what is suggested during the brainstorming.

• **Qualities and values** of each member or group are the most important requirements for a successful collaboration. Finding the right individuals or groups from different disciplines to participate enables more possibilities for a successful collaboration. To foster integrative thinking among the different disciplines and to encourage successful collaboration, the participants must feel partnership for the team while contributing their individual expertise and knowledge.

**The role of each discipline**

![Diagram of the role of disciplines](image)

- Social status/position
- Human-object relationships
- Cultural significance
- User studies
- User-centered design
- Interface
- Usability
- Aesthetics
- Sustainability
- Brand development
- Financial planning
- Marketing plans
- Sales strategy
- Pricing strategy
- Market research
- Advertising
- Public relations
- Functionality
- Manufacturing process
- Materials
- Technology application
- Prototyping

• **Industrial design** Industrial design shapes the interactions between users and objects by considering diverse questions. Once a project proposal is initiated within a business or marketing division, industrial design starts by identifying the user, the relationship between the user and the product, the uses of the product, the important interactions between the product and user, the opportunities to make the product successful, the technology required to understand the product, and the possible design solutions that will appeal and satisfy both the user and the company identity. Industrial design is not a simple activity dealing only with visual styling.

• **Business** At the stage of design conceptualization, business and marketing plays a critical role in coming up with marketable ideas and proposals. Business and marketing experts investigate the product’s value and the possibilities of success in creating
proposals with other disciplines. The primary roles and responsibilities of business and marketing are to determine the appropriate database and collect corresponding information for new product development, such as product cost and value, consumer needs and user preferences, marketing strategy and management, sales strategy, public relations, and brand naming and advertising. Typically, business experts contribute to the development of a new product by analyzing the accessibility of the market and determining the possibilities of a product’s success in the market.

- **Human factors engineering** Human factors experts provide statistical data and information to designers in approaching the physical interaction between products and users and enable designers to shape more precise and universal outcomes. They have specialties in cognitive psychology, anthropology, human factors engineering, and ergonomics. The roles and responsibilities of human factors specialists are to keep the focus on the users by dealing with physical, cognitive, social, emotional, and cultural issues that have significant bearing on the success of the design. They also conduct ergonomic evaluations and anthropometric studies to gauge human dimensions and their impact on products.

- **Science and engineering** Scientists and engineers provide technology and appropriate mechanisms to make products work efficiently and determine the reliability of the product. They approach tasks scientifically and logically in order to acquire accurate data and facts. They conduct a number of tests and experiments with prototypes to find out the most suitable mechanisms and structures. Their contributions in product development are significant and deal with issues such as material investigation, rapid prototyping, engineering drawing, cost-effective assembly, and manufacturing process. Typically, mechanical engineering and bioengineering work closely with industrial design.

- **Interaction design** As an extension of interface design and graphic design, interaction design concerns not only physical devices but also intangible things such as software and services. Interaction design collects the information relating to user experience, envisions new opportunities for the product, and explores the relationship between the object and user, such as intuitiveness and responsibility of design, graphic elements, and emotional effects caused by the product. The role of interaction design is to provide not only visual graphical user interface but also a better communication between product and user.

- **Social Sciences** The role of the social sciences in design is to analyze the relationships between people and things, such as material desires, social status, symbolic meanings, and other cultural issues relating to objects. Anthropologists typically conduct participant observation, perform interviews, and take photographs and videos in their data collection. In design collaboration, people coming from psychology, sociology, and anthropology identify the social meanings of products, cultural constructions, and issues of ritual and routine.

The role of participants in university collaborative projects

- **Faculty** Finding the opportunities for interdisciplinary collaboration and developing the community are the most important roles of the faculty. The faculty initiating the project contact other faculty or representatives in other disciplines.
relevant to the project and introduce the proposal respectfully. Once availability and interest are expressed by the representatives, a certain number of qualified students who are interested in the collaborative project are recruited, by several means, from the faculty in each discipline. Before the project begins, an informal conversation among representatives from the each discipline will be required. During the course of this conversation, participants will identify the project goal, the timeline, the deliverables, and the accountability of each discipline. Faculty are responsible for advising and facilitating students, providing directions and guidance, coordinating the schedule, and instructing the students. It is desirable that the faculty representatives attend all meetings with students, thereby making it possible to determine which disciplines are contributing effectively, what other input is needed from other disciplines, and how to transition to the next stage.

One other important role of the faculty is to distribute the group’s successful accomplishments through public presentations or papers. These activities can bring about more opportunities for collaboration and can help the community to develop subsequent projects and education programs. The biggest advantage of distributing the achievements of collaboration is that they can be published and discussed from many different perspectives, depending on the participating disciplines: design, business, engineering, sociology, psychology, and so forth.

- **Students** Participating students must be very skilled and qualified in their disciplines and they must be enthusiastic about the project. In general, faculty in each discipline involved in the project chooses approximately the same number of students from each discipline for balance in performing the physical research and presentation. Students will conduct the majority of the research. Therefore, they must recognize the project goals and their individual responsibilities from the first meeting with all participants. Once the responsibilities for each discipline are identified, students typically divide the tasks into assignments for each individual, and they arrange their own flexible small-group meetings. Presentations of work are made collaboratively, by the whole group, regardless of the nature of the material being presented. The primary responsibilities of students are to find information, analyze the data, and convey the findings to other team members using acceptable communication tools. Many different inputs and responses are generated during the presentations. Students must try to incorporate all opinions generated by members from other disciplines and accept the facts without serious argument. Heated arguments can arise unexpectedly among students because of the multiple perspectives resulting from different fields of study. Attending faculty must manage this situation effectively to avoid any project-threatening conflict. All participants must use common vocabularies in delivering and transmitting their knowledge and information. Particular languages or special terms used in each discipline can create confusions and frustration among the team members, and this can harm the teamwork and the established relationship between the members of the team. It is important that students learn from other disciplines and inform their own knowledge of product design.

- **Sponsors** The role of sponsors is to provide the professional criticism, feedback, and technical support such as technology and to function as a partner, not a client. The presence of the sponsors will lead to quality research from very skilled students coming from different backgrounds of study. New methods of approach in conceptualization and creative outcomes can be expected through the collaboration. Sponsors should not force students in the directions that they want to see the research go, but should try to make students more flexible in doing research to produce diverse variations of the result. They do not necessarily need to attend all meetings with other teams but they are invited in major presentations to offer criticism and professional input. Sponsors are not always aware of
academic requirements, and it is the job of the involved faculty members to make sure that the educational goals are met during the project.

Difficulties Facing Current Practices
The difficulties in collaboration are communication, compromise, and coordination (CCC).

- **Communication** Communication is a tool by which one person influences the cognition of another consciously or unconsciously using any kind of visual or verbal materials. However, communication in design collaboration is one of the most common problems, since there are people from multiple disciplines working collaboratively. Common challenges include precisely conveying knowledge and expertise through communication without losing the original meaning, and effectively accepting and understanding the information of the other participants. The vocabularies and symbols used in disciplines such as business, engineering, sociology, and psychology can be extremely different. Cognitive ability to understand communication materials also varies widely among individuals. Design disciplines rely mainly on visual communication skills. On the other hand, engineers are most comfortable when presenting their expertise and data using intricate graphs with calculated figures. Social scientists often communicate in a more theoretical manner, which can cause misinterpretation among other team members. A common language and method must be used for optimum communication among the team members, and the communication channel must be open at all times.

- **Compromise** Another difficulty in design collaboration is that each discipline can have different interpretations of problems and they have different methods in approaching problems. In other words, each discipline has different anticipation of and hierarchy for the solution. This can bring about unforeseen arguments or conflicts among the team members. For example, the focus of businesspeople is to make products marketable with various marketing considerations, including consumer preference and product longevity. Engineers are focused on developing the most appropriate mechanisms and trying to determine the cost-effective manufacturing techniques and materials. Industrial designers approach design with the considerations of aesthetic and functional hierarchies. These disciplines have different priorities in the process and are required to make certain compromises through exchange of views in order to gain maximum benefit from the collaborative design attempt.

- **Coordination** Since collaboration consists of different groups of people from diverse disciplinary teams, organization and program coordination are some of the most difficult jobs in design collaboration. Who will be team leader depends on the origination of the project. In the case of product design and development in collaboration, industrial design typically becomes the core coordinator and leads the project. Managing team members, coordinating meeting schedules, establishing time frames, attaining funding, and conducting research are the primary roles of the coordinator, and require a high degree of skill and experience.

Advantages and Values
The advantages of design collaboration include the following:

1. Accurate research and results from different disciplines
2. Mutual responsibilities and roles
3. Extensive opinion and input
4. Qualitative research and opportunities
5. Professional practice and anticipation
In the process of product development, there are several issues that must be addressed and resolved precisely and this work should be conducted by skilled professionals. It is impossible for industrial designers to obtain all of the knowledge that individuals in other disciplines possess. Furthermore, it is not necessary that an industrial designer master the knowledge to do thorough ethnographic research. Finding right the people from the right discipline and requesting the inquiries is a much smarter strategy than searching reference resources alone. This approach will also save a lot of time and effort, and will yield accurate information and materials.

Collaboration as a Design Pedagogical Tool

- **Benefits for students and ID courses** The distinct advantages of this practice for design education and specifically students of design include the following:
  1. Opportunity for and exposure to work in a multidisciplinary environment
  2. Preparation and training for the real world situation/scenario
  3. Hands-on learning and training in complete product development process
  4. Learning and exposure to teamwork, knowledge, organization, responsibility, communication, and professional practice

Large Research Universities as Fertile Ground for Collaborative Design

Many industrial design programs strive to apply design collaboration as a pedagogical tool in design education. Research-based universities provide an ideal environment for work with other disciplines for industrial design faculty who seek the opportunities. The methodologies of design collaboration have been created in industrial design programs and interdisciplinary design collaboration labs have been established at many universities in the U.S. New teaching and research methodologies are applied to industrial design for collaborative work and undergraduate and graduate students from other disciplines register for these collaborative courses. They learn teamwork, knowledge, organization, responsibility, communication, and professional practice through the courses, which can be the best model and practice in design education.

How to Bridge the Opportunities in the University Environment?

A university is the ideal environment to make design collaboration occur. There are a number of different disciplines and programs to which industrial design can contribute for research and many are also interested in collaboration. Identifying ways to bridge the opportunity in university environment is the first assignment for faculty.

- **Contact methods** There are several ways of contacting other disciplines for collaboration in design within the research universities.

  1. Industrial design initiates projects and finds relative disciplines in the university with which to work. This is typically how industrial design connects other disciplines; in this case, industrial design will be the core team and will take the lead. The project must be clarified and have a certain direction in order to convince other people to become involved. Well-defined parameters for the project, the purpose of the design project, the estimated participants and group, anticipation of the result, the technology to be applied, the role and accountability of each discipline, current funding or grant opportunity, a specific timeline of the project, and enthusiasm and trust for the project are the key elements that industrial design faculty must convey in contacting other disciplines. Who will participate depends on the type of project being considered, e.g., a medical product, a consumer product, an assistive device, sports equipment, transportation, and so forth. The number of team members and time frame are based on the scale of the project.
2. Industrial design faculty finds the opportunities to contribute industrial design expertise by investigating current research being conducted in other disciplines at the university. The range of contact area can be wide, but industrial design typically interacts with engineering departments. The most important part in this contact method is to find the interesting research or technology that will allow industrial design to develop the research for humanizing the technology. Industrial design faculty must be prepared to present the abilities and contributions of the industrial design team relevant to the potential project. Strong portfolio and other professional experience related to the area can create a compelling conversation.

3. When technologies or concepts are discovered from other disciplines, industrial design contacts them and proposes a new product-development scenario based on their current research. Industrial design will be the leading team in this case and find other relative disciplines to participate in the project. When contacting other disciplines, industrial design must mention where the technology or concept was originally initiated to give other participants more confidence and interest in the proposal.

4. Industrial design conceptualizes a new product to manufacture and finds industries—from local companies or large corporations—to participate in the project. Since the related industries are likely to have substantial resources and information in that area, the research can start smoothly with their assistance, interest, or financial support. Once an industry is involved in the project as a partner or sponsor, industrial design contacts other disciplines through the university. This method can make the proposal more professional and can offer more potential to prospective participants of the project from other disciplines. The opportunity to receive government grants can be more easily generated with this model.

- **Grant opportunities** One of the advantages of design collaboration is grant opportunities, whether from local industries or government agencies. Funding resources affect a lot of issues in design process, deciding such factors as the number of participants and the depth of research quality. Working with other disciplines collaboratively in the university environment can create more opportunities to apply for government grants from such organizations as NSF, NIH, NASA, and SBIR. Although industrial design is rarely the main contractor, the exposure to and participation in funded projects as a subcontractor is still hugely beneficial. It is a great prospect for industrial design programs and faculty achievement. It is very unlikely to find funded research projects in industrial design programs but many industrial design programs in the U.S. are striving to find funded projects in collaboration regardless of the amount of money. This opportunity provides huge mutual benefits in design education and enables the participants to achieve qualitative, research-based solutions. Science and engineering departments have proficient experience in and capability of submitting government proposals, as compared to departments in the design discipline. Therefore, working closely with them can increase the opportunities for funded research projects. Industry-sponsored collaborative projects supported by local companies and large-scale corporations have been coming through the industrial design programs at universities and creating successful academic research among students and faculty.

- **Building networks** In general, it takes a certain period of time for junior faculty to build a network with other departments or programs within a university. Building the connections
and relationships with other disciplines is based on faculty interest in the project and occurs by contacting people directly or indirectly. Calling or e-mailing individuals working in other disciplines or organizations in order to introduce the project and requesting an informal conversation over lunch can be a great start toward building a university network. If colleagues already have connections with other disciplines, they can help to build new relationships as a bridge. Once the relationship is built with other disciplines or organizations, the university networking has already started and a lot of invisible opportunities to meet diverse experts who have connections with the individual or programs begin to surface. Many opportunities for sponsored projects from industries are offered from alumni or personal relationships. Therefore, keeping in touch with former students is also advantageous. Meeting individuals working at various areas through any kind of social or commercial gatherings – such as conferences, forums, exhibitions, and workshops – is a good way to build networks.

Case Study: Collaborative Design in Institutional Context

Robotic upper extremity repetitive therapy device, ASU

The “robotic upper extremity repetitive therapy device” was designed to improve the quality of life for stroke patients. It was a funded university research project sponsored by the National Institutes of Health (NIH). In total, five different disciplines (including local companies) were involved and worked collaboratively on this project. This case study will illustrate the advantages of collaborative work in the educational environment. The origination and motivation of the opportunities, the composition of the participants, grant opportunity, team operation, roles, responsibilities, and the achievement of the project are discussed in detail.

How collaboration got started

Kinetic Muscles Inc. (KMI), a company based in Tempe, Arizona, is the creator of a stroke-therapy device to supplement the work of physical therapists. The Hand Mentor® works the affected wrist and fingers of a patient, assisting in muscle-stretching and simultaneous neural re-networking around the damaged brain cells. The mechanism is driven by an air muscle and a microcompressor. A microprocessor measures the duration of activity and records the therapy iterations completed by the patient. The patient’s recovery requires “massed practice,” or repetitive and long practice sessions each day with this device.

KMI successfully applied for and received Phase I and Phase II NIH Small Business Innovation Research (SBIR) grants to develop this product’s feasibility and to then to commercialize the Mentor. Arizona State University (ASU) School of Design professor Donald Herring, IDSA, and former ASU industrial design student Rob Schultz, along with the bioengineering founders of KMI, designed the Mentor over several years. The success of this product and its technology application was familiar to NIH. NIH subsequently sought responses to its request for proposal (RFP) to develop a low-cost, take-home robotic upper extremity stroke therapy device. Jim Koeneman, PhD., of KMI, and Professor Jiping He, Ph.D., of ASU’s Herrington Bioengineering Department, collaboratively wrote a successful proposal advocating the use of KMI’s air-muscle technology (employed by the Mentor) as the basis for a feasible repetitive arm-training device for simple reaching activities to improve the daily lives of stroke patients.
Two contracts were awarded nationally out of some 40 proposal submissions. KMI has developed two iterations of the Robotic Upper Extremity Repetitive Training (RUPERT) device at this time and is developing a third-generation prototype this year.

- **Participants and Structure** The NIH contract was awarded in the fall of 2003. ASU became the prime contractor for RUPERT’s development process with professor He as the primary investigator (PI). KMI’s Koeneman was designated a co-PI and received a portion of the contract funds for the physical development of the robotic device while several collaborating disciplines across campus received funds to employ graduate-student skills in the development process. Professor Thomas Sugar, Ph.D., of mechanical engineering and robotics, received funds for a master’s student and a doctoral student involved in the application of “spring over muscle” technology in the actuator area of RUPERT’s development. Professor Herring received funds for several master’s-level graduate students to work on the design and prototyping of the robot. Professor He hired a doctoral-level bioengineering student who developed bioengineering models of the arm linkages and participated in the development of a biofeedback system. Richard Herman, M.D., of Banner Good Samaritan Regional Medical Center in Phoenix, received funds for a physical therapist (PT) to oversee user fitting and testing of the prototypes on a small number of approved stroke subjects.

These entities work separately within their respective fields of expertise and are coordinated by Professor He in ad hoc meetings to discuss specific topics, quarterly goal update meetings, and monthly phone meetings with the NIH team overseeing this project in Washington, D.C. There are annual NIH visits to the ASU and KMI sites to review progress.

- **Accomplishments** The ASU/KMI collaboration has been successful in developing and now refining an inexpensive take-home, upper-arm stroke-therapy robotic device. Continuing work, based on the feedback from early testing, focuses on strengthening the robot’s structure, making it as light to wear as possible and refining the sensors, muscle activators, and other mechanisms to provide smooth and ergonomic function for the user. In addition to the success of product, this collaboration provided a lot of benefits to students in education.

**Conclusion**

Design collaboration is an ideal pedagogical tool in education as industrial design is not a study pursuing only visual styling. Only collaboration can make design complete and successful in the marketplace. With the mutual benefits of a collaborative design process, industrial design programs and faculty can develop interdisciplinary design and development processes involving upper-division-level students and can strive to discover opportunities at universities and within industries. As educators, designers, partners, and friends, we all know how the time and effort
required for collaboration can pay off. The role of design faculty is certainly altered in light of these new collaborative opportunities and operational structures. Collaboration provides an unprecedented opportunity for the design faculties to contribute to the discipline at academic as well as commercial or industry levels. As the roles and responsibility of industrial designers grow, design collaboration is required in order to stay competitive and relevant in a changing global design scenario and to improve the quality of our society.

References


4. See note 3 (above), 8.

5. See note 3 (above): 10.


8. See note 7 (above).


11. See note 1 (above).

12. See note 10 (above).
