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**INTERDISCIPLINARY GRADUATE DESIGN PROGRAMS:
RESULTS AND RECOMMENDATIONS FROM A NSF WORKSHOP**

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ABSTRACT

Improving the creativity and innovativeness of U.S. graduate students is a mandate for national competitiveness and social well-being. Despite this imperative, many are uncertain about how to *best prepare* students for tackling the complex design problems of the future, some that we know about and others yet to be uncovered. With this in mind, we convened a two-day workshop at the National Science Foundation (NSF) in Arlington, VA to discuss the challenges, successes, and future directions for interdisciplinary graduate design programs that have recently emerged or are being established to address this critical need. Not including NSF personnel, 42 people from academia and industry gathered to learn about nine existing interdisciplinary design programs. Three panels were also held to discuss: (1) overcoming interdisciplinary differences in research and teaching, (2) industry perspectives on interdisciplinary design programs, and (3) future directions and program developments. A number of common themes emerged from the workshop, including the disciplinary characteristics of interdisciplinary design, the varying perspectives on the design process, pedagogical approaches toward teaching interdisciplinary design, structuring interdisciplinary design degrees, and sustainability of an interdisciplinary design discipline. Based on the dialogue at the workshop and our analysis of the common themes, we offer ten recommendations divided into three areas: (1) advance interdisciplinary design activities, (2) enhance interdisciplinary design programs, and (3) support interdisciplinary design research.

1 MOTIVATION FOR THE WORKSHOP

The need to improve the creativity and innovativeness of U.S. graduates from all disciplines is a matter of national importance. Increasing our innovativeness not only improves the likelihood of creating a competitive economic advantage at local and global levels but also increases the probability of

producing social-innovations (e.g., medical advances, alternative fuels, and affordable information technology) which, in addition to being economically viable, stand as substantive and necessary contributions to society as a whole [1]. A recent report by the Council of Graduate Schools [2] on American competitiveness and innovation states that, “The United States must increase the number of graduate education programs that reflect the interdisciplinary dynamism characteristic of most innovative research centers” (p. 19). They call for an increase in interdisciplinary training: “interdisciplinary research preparation and education are central to future competitiveness, because knowledge creation and innovation frequently occur at the interface of disciplines” (p. 18). The benefits of such training have been corroborated in many empirical studies (e.g., [3]). The National Innovation Initiative Report [4] also stressed the importance of such training, asserting that successful innovation is inherently multidisciplinary – requiring input from individuals with varying backgrounds, talents, and areas of expertise. True innovation, the report states, occurs at the *intersection* of multiple disciplines rather than isolated within them. The criticality of innovation to American success is also echoed in a recent report to the Secretary of Commerce by the Advisory Committee on Measuring Innovation in the 21st Century Economy [5], which noted the rapidly closing gap between the U.S. and the rest of the world. Innovation is identified as a historical area of strength and one in which we should invest to enable continued leadership.

Despite the imperative for training an innovative workforce, we are uncertain about how to *best prepare* our students for tackling the complex problems of the future, some that we know about and others yet to be discovered. Moreover, it remains unclear how we can best overcome the departmental “silos” that have arisen in academia, thus preparing students for the unique multidisciplinary challenges that they will face. Consequently, the motivation for this workshop was to explore the best practices of established and

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emerging interdisciplinary graduate programs in design – those that have successfully managed to navigate the disciplinary boundaries that hinder many other’s attempts. Through this workshop, we provided a forum for the design community to discuss the challenges, successes, and future directions of these programs and gain insight into how to construct, grow, and sustain interdisciplinary graduate programs that prepare students for successfully leading design projects and performing interdisciplinary design research. An overview of the workshop follows. Section 3 summarizes the programs discussed at the workshop along with the panels. Common themes that arose from the workshop are discussed in Section 4, and recommendations from the workshop for NSF and the design community are given in Section 5.

2 OVERVIEW OF THE WORKSHOP

The workshop took place over the course of two days (May 29-30, 2008) at the National Science Foundation (NSF) in Arlington, VA. Not including NSF personnel, 42 people participated in the workshop with large representation from architectural design, engineering design, and industrial design, as well as psychology, business, education, and computer science, specifically human-computer interactions. Several industry practitioners also attended the workshop. Figure 1 shows a photo of the workshop attendees; the list of attendees can be found online at the NSF workshop website: http://www.design.psu.edu/NSF/workshop_May08/.



Figure 1. Workshop attendees

The workshop began with lunch on Thursday May 29, during which time Dr. Adnan Akay, NSF Division Director of Civil, Mechanical, and Manufacturing Innovation (CMMI), and Dr. Judy Vance, NSF Program Director for Engineering Design, provided opening remarks to the group. Dr. Simpson, the lead workshop organizer, then introduced the goals for the workshop, and finally, the attendees introduced themselves. The rest of the day was devoted to presentations by leaders from nine interdisciplinary design programs – eight based in the U.S. and one based in the UK. Speakers were allocated 20 minutes for their presentations followed by 10 minutes for questions. Discussions continued informally over dinner and a reception that evening.

3 DESIGN PROGRAM AND PANEL SUMMARIES

A summary of the design program presentations and panel discussions follows. Slides and video-taped presentations are available online for viewing at the NSF workshop website: http://www.design.psu.edu/NSF/workshop_May08/.

3.1 Product Development, Brigham Young University (Presenter: Spencer Magleby)

BYU experienced early success in the early 1990s with its undergraduate product design program – a collaborative effort between mechanical engineering, manufacturing engineering technology, and industrial design. The program’s success was attributed to strong administrative support, enthusiastic faculty, and good industrial relationships. This early success led to a desire to expand these collaborative relationships, particularly with the college of business in anticipation of an increase in early product exploration as well as improved leadership orientation among students. A graduate program was created wherein students simultaneously earned an MS and an MBA. Initial efforts placed the MBA students on design teams, the results of which were problematic largely due to conflicting cultures and student personalities, particularly when the MBA students “took charge” without the team’s consent. Where the collaboration was more successful, however, was among faculty members. This highlights a key theme emerging from the workshop, one that was expressly noted by Dr. Magleby: faculty members are the driving force behind multidisciplinary collaborations – their energy drives the success of a program. As a result of these successful faculty relationships, a graduate degree in interdisciplinary product development was instituted involving engineering, business, and industrial design. Early efforts were also driven by a desire to pursue a grant from NASA that called for multidisciplinary teams. Although the logistics were challenging, the program was established and the team was able to successfully receive the NASA grant – a critical step in solidifying the young program. Currently, the program brings in 8-12 students per year, with the number being limited by the time and resources of the faculty involved. Lessons from the program (formally established in 1995) include the importance of creating a sense of identity and culture for the students since they want to belong to and be part of something tangible. Dr. Magleby also noted how important it was to retain known or recognized degree titles (e.g., MS, MBA) to reduce confusion about product design degrees. Program coordinators also continue to struggle with managing the integration of two strong academic cultures: engineering and business. A final takeaway was that successful integration requires faculty that are committed and excited about interdisciplinary collaboration.

3.2 Product Design & Innovation, Rensselaer Polytechnic Institute (Presenter: Dean Nieuwma)

The Product Design & Innovation program at RPI is based on the integration of technical, social, and design elements based on the premise that interdisciplinary efforts are the *only* way to be successful in design. The program is for undergraduate students and is largely studio based. The studio is a hybrid of studios commonly used in architecture and more typical lecture-based formats. With regard to academic structure, the core degree offered is housed in the social sciences (STS = science and technology studies) and is titled: “Design, Innovation and Society”. Within this degree students choose a specialization track, with the most common being mechanical engineering (around 80% of the students). Additional tracks include other types of engineering (e.g., electrical) as well as tracks in business. In reality, students in the program most often begin as mechanical engineering

students. They typically apply to the program because of their desire to engage in tasks that allow for greater creativity. Courses are chosen to best represent the three main areas (technical, social, and design), and the studios also vary by track, emphasizing certain areas based on the interests of the students. These differing studios, moreover, will often include faculty members from differing areas to best represent the content areas. Each year, roughly 30 students are admitted to the program. As noted by several others, choosing a name for such a program was a unique challenge. In the specific case of RPI, requirements from the state have resulted in a name change for the program highlighting how difficult even simple elements such as a program title can be. Additional challenges include difficulties in obtaining resources. Dr. Nieuwma noted expressly that RPI operates on a fairly minimal budget. Despite these challenges, the program is doing well and has recently received recognition nationally as well as within their home institution. It is hoped that with this recognition some of the above challenges will be alleviated.

3.3 InnovationSpace, Arizona State University (Presenter: Mark Henderson)

The year-long graduate program at ASU represents the collaborative efforts of industrial design, engineering, and business. Leaders within the three areas have supported the InnovationSpace program, while offering a substantial amount of funding to pursue the unique opportunities emerging from these collaborations. The program is largely product based – as such, the driving force of the program is developing products that are useful, possible, desirable and “good” or have a positive social impact. These core elements also help dictate the roles of the various disciplines involved. For example, business has much to offer with regard to understanding given markets and whether products are seen as desirable within those markets. ASU established several key partnerships outside of the program, including research centers (e.g., Center for Cognitive Ubiquitous Computing) and multiple corporate sponsors (e.g., Proctor & Gamble). Roughly 35 undergraduate students are admitted each year, and the application process is very competitive. The program formally starts in August and typically begins with students being presented with a broad problem that they must solve through the development of their product. In the spring, ideas are finalized, and the prototyping process begins. Dr. Henderson commented on challenges related to patent rights and intellectual property, noting that successful products share royalties among the university, program, and student(s). The success of this program has led to an emerging graduate “Skysong” program, which began officially in January of 2008. Other multidisciplinary partnerships have also emerged from the success of InnovationSpace, including opportunities to pursue innovative solutions to address global issues (e.g., developing smokeless fuels for fires in rural areas).

3.4 iFoundry, University of Illinois-Urbana Champaign (Presenter: David Goldberg)

The iFoundry program at UIUC is brand new, having been approved by the dean only two weeks prior to the NSF workshop. Developed for undergraduate students from various backgrounds, the students enter the program and, through support of the administration, ultimately receive formal degrees from their home departments. Dr. Goldberg

discussed the challenges of developing an interdisciplinary program emphasizing design. He noted that these barriers exist largely because universities and similar institutions (e.g., NSF) emerged to offer a specialized form of training to prepare students for a much different work environment than today. In contrast, today’s problems are markedly different from those in the past, and as such, new approaches are required. Although we might understand this intuitively, the current university systems in which we operate are based on previous needs and stand as notable barriers to developing new training methods for students. Dr. Goldberg cited several sources to illustrate his point using the common misperception that architects and engineers are largely similar, with the distinction between the two being that “architects are creative and engineers are not”. Other noted barriers include a form of academic NIMBY (not in my back yard), where we might say we want change and innovation – as long as *our* course is not changed. To combat these barriers, iFoundry was established to pilot programs where innovative ideas and approaches are embraced, with faculty and students facing fewer organizational constraints. These pilot programs should be comprised of faculty who express a strong interest to work and collaborate in them. This theme was common to the workshop, namely, *faculty must be passionate and take an intrinsic interest in collaborative, multidisciplinary efforts in order for them to succeed*. Finally, Dr. Goldberg suggests that collaboration among programs is a necessary component for success. This collaboration may simply be information sharing (e.g., best practices) or more formalized partnerships. The presentation concluded with a discussion on what engineering students lack with regard to design-related issues. Specifically, Dr. Goldberg felt that they: (1) lack the ability to ask questions of their clients, (2) have difficulty labeling new concepts, (3) have trouble modeling qualitative causal chains, (4) are not adept at decomposing ambiguous problems, (5) lack the capacity to measure, (6) have an inability to draw/visualize, and finally (7) have difficulty communicating potential solutions. Thus, emerging design programs should take steps to remedy these deficiencies and provide students with an enhanced and expanded skill set.

3.5 Product Design, Leeds University (Presenter: Alison McKay)

The Product Design program at Leeds University in the UK has been in place since 2003 and has had considerable success since its inception. Comprised of collaborations among engineering, industrial design, and psychology, the program offers both undergraduate and graduate degrees (BDes = Bachelor of Design and MDes = Masters of Design), and currently graduates roughly 40 students in the bachelor program and 10 students in the masters program each year. Contrasting many other programs in the UK, the Product Design program does not have a strict requirement for mathematics, although the program is selective on other criteria. Instead, the specific mathematical courses needed for design are taught within the program itself. This allows for a greater variety of students (e.g., students who are more focused on visual arts) while ensuring that they ultimately graduate with the requisite skills for design. The students in the program typically view themselves as engaging in applied problem solving, highlighting a common theme among presentations: *when forming a design program, the emphasis*

should be on a problem and how to solve it rather than labeling and definitional issues. Dr. McKay also discussed training students in design, noting that they train students on how to think rather than imparting facts that might be perceived by students as having indefinite applicability. Dr. McKay emphasized the relationship between research and training, suggesting that by having outstanding researchers as faculty members, the students are provided with the best training possible. Research is also an important part of the students' lives as well, and they are required to learn about, as well as engage in, several research projects. As expected, the program at Leeds faced challenges similar to those at other universities including an initial lack of resources and financial support. Fortunately, the program was able to secure a substantial amount of support from the university by aligning the program's goals with the strategic long-term goals of the university – a key to securing the funding necessary to pursue the Product Design program. In addition, faculty members partnered with members of industry with these partnerships supplementing institutional support. These partnerships were also important in revealing several key needs of industry-members, who frequently offered guest lectures to supplement those given by faculty. For example, their industry partners indicated that they desired students with expanded skill sets beyond those found in typical engineering students.

3.6 Segal Design Institute, Northwestern University (Presenter: Don Norman)

In a dramatic contrast from the comprehensive four-year program at the University of Leeds, the Segal Design Institute at Northwestern University offers undergraduate courses and certificates in engineering design but does not grant undergraduate degrees. In fact, the institute is affiliated with two full-time graduate-level degree programs: (1) a management program in design and operations, which combines a Master of Business Administration with a Master of Engineering Management, and (2) a Master of Science in Engineering Design & Innovation, a one-year program focusing on a human-centered approach to engineering design. Housed within the Robert R. McCormick School of Engineering and Applied Science, the institute is supported by a \$5 million private donation and stands independent of all engineering departments. Dr. Norman outlined many practical problems that limit the effectiveness of the institute's mission to train students in the process of design from conception through production, largely focusing on issues stemming from the dependency on faculty affiliations with the institute to support teaching and research related to design. Since all faculty affiliated with the institute must first be hired within a traditional engineering department, exceptional candidates for the institute are often dismissed because their proposed research is viewed as too "soft" to match the goals of the department. If a new professor with a design focus *is* hired, often the goals outlined for the tenure process do not reward the new faculty for the time commitment required to also support the institute's goals. The inability to hire faculty directly and the reliance on affiliations mostly from tenured faculty again emphasizes the theme from the workshop that *success in these programs is often fueled solely by the dedication and energy of the faculty supporting them.* Dr. Norman stated, "What we are trying to do as practical designers does not fit within a university," and highlighted the

need to better recognize work in design. Other notable challenges include problems faced with balancing the teaching expectations of engineering and business students and the necessity of developing quantitative views of the general principles being applied in order to create the academic depth required for a new discipline and to receive greater funding.

3.7 Product-Architecture and Engineering, Stevens Institute of Technology (Presenter: John Nastasi)

Housed within the Department of Mechanical Engineering, the Product Architecture and Engineering Program at the Stevens Institute of Technology has, according to the program's director and practicing architect John Nastasi, "focused on dissolving boundaries between disciplines and the boundaries between academy and practice". Within the graduate-level program, students are taught common methods that are applied at different scales and for different products, with an emphasis on closed-loop practical projects that the students complete, either individually or in teams, from conception through implementation and testing. Students work in semesters with a ten-course curriculum that stresses fundamentals, while working on one or more projects concurrently. The program offers a unique opportunity for students to pioneer new design methods while immersed in practical projects, with examples presented that ranged from the design of a carbon-fiber bicycle, to a hybrid surfboard design using computational fluid dynamics, to the design of an architectural structure for a church using complex computational geometric methods. Mr. Nastasi stressed that no official studio time is designated for student project work and indicated that coordinating the timing of projects with corporate needs was often a challenging issue. The program, which opened in 2004, currently has 25 students that are all financially supported by industry sponsorship. One challenge expressed by Mr. Nastasi was the slow increase of student applications for the program, stating that although companies are eager to sponsor projects and hire the graduates, programs such as those offered by Harvard, Columbia, and Yale still capture the attention of most students; however, he has been pleased with the diverse student pool that has participated.

3.8 Design & Management, Parsons The New School for Design (Presenter: Scott Pobiner)

The Design & Management program is one of the largest at Parsons The New School for Design, with around 500 undergraduate students currently enrolled. In his talk, Scott Pobiner indicated that many of the students who enter the program, which grants a Bachelor of Business Administration (BBA) degree, are often interested in industrial design but want to "blend the ethos of design with the practical skills of a business degree". He described the goal of the program as training the students to walk a tightrope between the disciplines of industrial design, social science, and business and indicated that students also often work very closely with graduate students from specific disciplines (e.g., the School for Social Sciences). During the course of his talk, Mr. Pobiner described an undergraduate curriculum that trains students to understand inquiry better than action and to develop an understanding of how design impacts business and society, addressing areas such as the lifecycle of a product, the business in relation to the product, the ecological and economical sustainability of a product, and the strategy of

design relating the actions that are planned to the actions that are taken. The four-year program requires students to take 136 credits that focus on business, management, design studios, design strategies, and seminars. A major challenge that was noted was the difficulty in balancing the amount of information that they are trying to teach their students with a manageable course load, a challenge often confronted by the interdisciplinary faculty themselves. He also stated that the cross-discipline undergraduate curriculum is viewed much like undergraduates who could enter the interdisciplinary graduate programs being discussed at this workshop.

3.9 Design Science, University of Michigan (Presenter: Panos Papalambros)

Approved in 2006, the program at the University of Michigan offers a PhD in Design Science with 8 students currently enrolled for the fall semester of 2008. Described as the study of “the creation of artifacts and their embedding in our physical, psychological, economic, and social environment” by Dr. Papalambros, the program is housed within the Rackham Graduate School and is supported by faculty from many different departments in the School of Art and Design, the School of Business Administration, Psychology, and Engineering. Since faculty are not hired directly as Design Science professors, this program exhibits similar challenges to other programs in that faculty interest drives any affiliation with the Design Science program and time spent with the program must be delicately balanced with the promotion and tenure requirements of a faculty’s home department. However, some of the interdisciplinary barriers are mitigated by the unique structure of the university, where the Rackham Graduate School – not an individual department – houses the graduate degrees offered by the university. The program, only in its second year, requires a student to have a Master’s degree prior to becoming a PhD candidate and to have two dissertation advisors from two distinctly different disciplines (i.e., advisors in two different engineering departments does not count). Funding graduate students is a challenge common to the other programs, and students admitted into the Design Science program are required to find their own funding for two years.

3.10 Panel 1: Overcoming Interdisciplinary Differences in Research & Teaching

Five panelists – Dr. Richard Gonzalez from the University of Michigan, Dr. David Goldberg from the University of Illinois at Urbana-Champaign, Dr. Dean Niesma from RPI, Dr. Don Norman from Northwestern University, Mr. John Nastasi from Stevens Institute of Technology, and Dr. Seth Orsborn from the Missouri University of Science & Technology – led the first panel discussion, which focused on the challenges and successes encountered from the cultural differences in research and teaching in interdisciplinary endeavors. The main themes that emerged during these discussions included: the difficulties in leading interdisciplinary departments, the problems that often arise from integrating vastly different cultures into teams with balanced leadership and authority, criticisms regarding the intellectual merit of interdisciplinary design research and teaching efforts in this area, incompatibilities of current career reward structures that may hinder interdisciplinary endeavors,

and challenges that emerge from proposing collaborative research to NSF. Each of these themes is summarized next.

Leadership Challenges & Recommendations: This first theme touched on the challenges that faculty and department heads/chairs must overcome when dealing with joint faculty appointments in the context of multidisciplinary research. Cautioning that it takes a significant amount of extra work from both the faculty and head/chair to be successful, Dr. Gonzalez stressed the importance of selling the merits of the research and value of intellectual products (e.g., portfolios, peer-reviewed journal papers and proceedings, successful grant proposals) to colleagues within the university who will be reviewing their dossiers at annual reviews, promotions, and tenure. In addition, the point that the faculty members must make a consistent effort to stress the merits of their research to peers outside of the university was emphasized. Finally, to help keep the joint appointments running smoothly, the head/chair must facilitate communication within the department to ensure different views are represented and work across schools and colleges to ensure that the deans know that the multidisciplinary appointments support college initiatives.

Challenges Arising from Integrating Distinct Academic Cultures: This second theme underlined the differences and resistances to integrating different disciplines and the imbalances in leadership and authority that may arise when different cultures are integrated. Defining a discipline as “an established social grouping of individuals who share an interest in (passion for) and knowledge of a particular subject matter,” Dr. Goldberg related that differences in disciplines that do not originate from subject matter are potential sources of misunderstandings and conflicts in interdisciplinary endeavors. He also indicated that the assumption of the coincidence of disciplines, departments (organizational structures of people), degrees (organizing structures of coursework to disseminate and assess the mastery of knowledge), and “digs” (location of resources) leads to an increasingly unsatisfactory situation. Having low boundaries between the departments or disciplines to be integrated was noted as a significant benefit toward supporting interdisciplinary efforts. A suggestion offered during the panel session was to start to break down interdisciplinary barriers by crossing boundaries and publishing design-related articles in major journals of other disciplines (e.g., the Harvard Business Review). One concern raised during the discussion warned of the potential power of quantification in disciplines such as business and engineering effectively “colonizing” the other disciplines represented (such as architectural design or industrial design). The development of a common language between disciplines was seen beneficial as well as dangerous since it has the potential to enhance understanding while reinforcing the possibility of “colonization”.

The differential authority of various knowledge domains or different approaches to problem-solving was also raised as a challenge to successful interdisciplinary interactions. The importance of recognizing and understanding how power is manifested through disciplinarity when talking about and planning for interdisciplinary endeavors was stressed. Since different knowledge domains grant different levels of authority to the various approaches to design, we must confront and recognize problems that are likely to arise when

striving for equal partnerships with disciplines where design is more marginalized (i.e., has less authority). Dr. Nieuwma described how RPI has had success in balancing the authority of different disciplines by purposefully recognizing and addressing this problem in the classroom by team-teaching studio courses. By having a team of instructors from many areas of design in the same classroom, the different approaches to solving design problems must be defended for their relevance and validity, allowing the students to witness and participate in the type of negotiations and decisions that take place during the design process.

Critical Views of Intellectual Merit & Unsupportive Career Reward Structures: Another major theme that emerged not only during the panel discussion but also throughout the workshop was the strong influence that the reward structures in universities and companies have on the success of interdisciplinary design endeavors. Remarking that, “within a university, the ‘hard’ always drives out the ‘soft’”, Dr. Norman used the example that engineering was once very practical with applied training but has now become very theoretical, focusing on physics, mathematics, and science – the general philosophy being that the fundamental theory should be taught, while the practical knowledge can be acquired when in industry via on-the-job training. Criticisms of the intellectual merit and the low prestige of interdisciplinary design research and teaching arise not because of an inability to communicate the value of the work but rather because of the reward structures of many universities and companies that assign merit based on the ability to bring in grant money, publish research findings in peer-reviewed journals, or to reach a financial target. Since designers tend to be generalists, the reward structure set up in universities fails to recognize successes in having a very broad but shallow base of knowledge rather than becoming an in-depth expert in a particular field. This is also true for many short-sighted companies, where early design decisions that cause initial budgets and deadlines to be overshot but later result in significant savings in time and money downstream (e.g., during manufacturing) are often not recognized and rewarded but may instead be punished. A suggestion that the National Science Foundation offer overt sources of interdisciplinary funding was offered as a potential step toward matching the objectives of interdisciplinary design research to the current academic reward structures.

Collaborative Research through NSF: The final theme discussed during the first panel session centered on the challenges associated with initiating successful collaborative research projects through NSF. One drawback to research that was raised is the lack of interdisciplinary review panels at NSF for design research proposals, which inhibits serious interdisciplinary discussions on the merit of the proposed research. A related problem pointed to the tendency of interdisciplinary research proposals to be dominated by a single discipline while weakly utilizing other disciplines for a mono-disciplinary goal, instead of being a truly interdisciplinary endeavor. Part of the problem is that a PhD is a relatively uncommon degree in fields such as industrial design and visual arts, which may factor into their involvement, or lack thereof, with NSF proposals and review panels. A suggestion offered by Dr. Vance was for the

community to write recommendations to NSF regarding the changes and suggestions to improve this. There was also some discussion about creating a separate government agency to support innovation and research not bound by the traditional rules of established disciplines – specifically a *National Innovation Foundation* which was also recently advocated by several think-tanks [6] – to provide avenues to pursue funded interdisciplinary research efforts unhindered by the stringent requirements of many NSF programs.

3.11 Panel 2: Industry Perspectives on Interdisciplinary Design Programs

The panel of industry practitioners provided a practical touchstone for many of the workshop discussions. The industry panelists represented a range of corporate needs, environments, and philosophies: Gretchen Gscheidle, HermanMiller, Inc.; Christopher Hosmer, Continuum; Chris Kasbach, BodyMedia, Inc.; Steve Sanderson, SHoP Architects; and Keith Zobott, Honeywell International. Their comments and the resulting discussions followed four general topics: the skills and attributes of program graduates, the attributes of the program itself, industry’s perspective on academia, and the relative merits of different approaches to design. These are summarized next.

“We need designers who can convince the strategy team to put a solution on the roadmap and then shepherd it through development.”

Skills & Attributes of Graduates: A theme throughout the entire workshop was the importance of both *breadth* and *depth* in the experience of program graduates. *Breadth* in experience enables graduates to develop a vocabulary that facilitates communication across disciplines and throughout the product development process. They can broker relationships between groups that might traditionally be completely isolated from each other within an organization. It also provides a diversity of experiences from which designers – be they from engineering, architecture, industrial design, or some other discipline – can draw as they approach new opportunities and interact with co-workers. Panelists emphasized the importance of diversity in the design process as well as the education process. Most industry teams consist of members from diverse academic and ethnic backgrounds, which panelists felt was an attribute of a successful team.

Breadth by itself is not sufficient, however. *Depth* is also important as it provides an opportunity for students to develop particular skills such as rigorous thinking. Since generalists are often undervalued, depth in an area will also help the graduates to be valued in traditional ways within an organization. Finally, a certain amount of technical expertise is required in the development of most artifacts, and we do not always know in what areas depth of knowledge or understanding will be required. For this reason many companies have multidisciplinary design teams that are populated with people with broad experience bases, each with depth in one of a wide variety of disciplines.

There are other attributes that employers value or expect in graduates from an interdisciplinary design program. They should be “plate spinners”, capable of moving from task to task efficiently. They should be able to write, speak, and present in mature ways. They should be able to use these skills to pose questions well. They should be humble and

capable of working well in teams. They should also be proficient in a number of methods of concept realization or visualization, from sketching to rapid-prototyping. Their portfolios should be self-contained and demonstrate that they have worked on the entire lifecycle of a range of projects.

“Focus on the product lifecycle in your programs, all the way from communicating with your customers, getting clear needs defined, out into operations and manufacturing.”

Program Attributes: As interdisciplinary graduate design programs are developed, they should keep a focus on the desired attributes of the programs’ graduates. With that in mind, the panelists had several recommendations for the curriculum and teaching strategies within such programs. First, programs should foster the development of *teamwork skills*. Consequently, it is permissible to have teams that are not comprised of the most complementary people since it is unlikely to always be that way in industry. Second, programs should encompass the entire lifecycle of products. Graduates should be required to have experiences across this breadth while developing depth in an area of interest. This requires program flexibility, e.g., a core set of required experiences followed by a student-prescribed course path for depth. Third, students need a variety of design realization experiences. Engineering designers might need to learn how to sketch while industrial designers might need experience with rapid-prototyping. Everyone needs the hands-on experience.

“The school that I’m in has more barriers than most of the companies that I’ve worked for.”

Industry’s Perspective on Academia: Students are often taught to expect a rigid corporate climate filled with cubicles and restrictions on creativity and interaction; however, some companies are turning the tables. The traditional academic structure is being outpaced by the dynamic requirements of today’s marketplace. Companies, driven by necessity, are breaking down barriers and requiring multidisciplinary interactions within their organizations. However, the university is currently perceived as a place where these kinds of activities are more difficult to achieve, particularly when they are across colleges. One obstacle to this could be the methods by which faculty are evaluated: will faculty participating in these types of initiatives meet traditional metrics by which promotion and tenure are awarded?

Multiple panelists encouraged academia to remain focused on the final product (i.e., the students) as interdisciplinary graduate design programs are developed with the caveat being that the final product needs to be identified first. What “role” do these graduates play in an organization: are they “design-savvy engineers”, “engineering-cognizant designers”, “design leaders”, “entrepreneurs”, or some new breed of designer? Once our “output” is identified, then the direction that the graduate programs should take will become clearer. This will also assist in measuring the success of the graduate programs and could eventually lead to some standardization, such as a common degree.

Philosophy of Design: While globalization remains an important aspect of design, some companies are shifting from a “design anywhere, build anywhere” approach to a more local one. While some elements of a product might be designed at a central location, finishing elements are often designed within a

region, for a region. Many pressures (e.g., rising transportation costs, environmental issues, societal impacts, cultural differences) are causing more products to be manufactured in the same region in which they will be used. By designing and building in a local context, companies are better able to meet the needs of the local markets. A company’s focus on innovation in the process used to develop products is as important as (and can lead to) innovation in the products themselves. It is important that companies figure out how to actively work on both aspects of design. Within the process, it needs to focus on the entire lifecycle of the product, which requires both the breadth and depth as described earlier. The process also needs to incorporate elements of knowledge capture, ensuring that companies do not need to reinvent old technology as employees and projects change. While less restrictive product development processes have important elements that can lead to innovation and reduce time-to-market, the stage-gate process serves a useful purpose, particularly in larger organizations. It is important that students learn how to work within both frameworks, sometimes at the same time.

3.12 Panel 3: Future Directions & Program Developments

The final panel included Dr. Mark Henderson from Arizona State University Polytechnic, Dr. Scott Hudson from Carnegie Mellon University, Dr. Ann McKenna from Northwestern University, Dr. Panos Papalambros from the University of Michigan, Mr. Scott Pobiner from Parsons The New School for Design, and Dr. David Weightman from the University of Illinois at Urbana-Champaign. The discussion centered around three issues: (1) what constitutes the discipline of design, (2) what would a graduate program look like, and (3) what are possible next steps. Each of these is discussed in the following paragraphs.

A Discipline of Interdisciplinary Design: Do we need to evolve or design a new discipline to make this initiative sustainable, and if so, what would it be called? This question arose several times over the course of the workshop and consumed much of the last panel discussion. Panelists thought such a discipline would be characterized by its focus of study, subject matter, methods, language, metrics, ethics, and so forth; however, they felt that simply calling such a discipline “design”, while correct, would not be helpful since “design” has different meanings to different constituents. The idea of *design thinking*, as advocated by Tim Brown [7], CEO of IDEO, was also raised and debated by the panelists and the audience. Because design is inherently interdisciplinary, it will be important to examine – and resolve – differences in the design processes as understood within different disciplines that participate in design activities.

Graduate Program Structures: Designing education programs must consider learning, teaching, as well as assessment. For a graduate education in interdisciplinary design, one might use a model of ‘T-shaped’ graduates: depth in one discipline (e.g., industrial design, mechanical engineering), with broad knowledge of all aspects of design, production, and sales. In this case, several advocated that the undergraduate degree could provide the stem of the T while the graduate degree in interdisciplinary design would provide the broad exposure to all aspects of design. For this form of

education, MS, MA, or MPD (Master of Professional Development) could all be appropriate degrees.

Meanwhile, other workshop attendees thought that the undergraduate degree might in fact be the breadth, and that a deep knowledge of design might constitute the stem for graduates. This is an issue yet to be resolved. There was general agreement, however, that a professional masters program should use problem-based learning (studios would play an important role), have a focus on outcomes (portfolios created by students), and allow for the possibility of a team thesis since interdisciplinary design invariably involves teams.

Finally, panelists noted that a “discipline” requires research in the subject area. Hence offering a graduate degree that provides deep knowledge of design should lead to a PhD. PhD recipients might also form the pool from which to draw future faculty in this discipline.

Next Steps: Panelists recommended that the next steps in the development of such a discipline and associated curricula should include a report to NSF summarizing the deliberations, conclusions, and recommendations of the workshop attendees, papers comparing perspectives on interdisciplinary design education, and one or more collaborative proposals to NSF. This paper – specifically the recommendations in Section 5 – constitutes the report that was submitted to NSF as suggested by the workshop attendees.

4 COMMON THEMES FROM THE WORKSHOP

A number of key themes emerged during the workshop. The following lists the key topics that were identified during a brainstorming session at the end of the workshop.

- Differences in language/perspectives on design
- Balanced representation of these perspectives in the room
- Design as a discipline – what is a discipline? what do we call it? do we even need one?
- What types of students are we trying to graduate (e.g., design-savvy engineers, engineering-cognizant designers)?
- PhD vs. MS vs. MEng vs. MDesign or some combination thereof – what are the roles of each?
- Qualitative vs. quantitative research and analysis vs. synthesis
- Lowering barriers to perform interdisciplinary design work, research, and teaching
- Use of common technology can help lower barriers through a common language
- Understand design thinking as espoused by IDEO’s Brown [7]
- Start-up issue vs. sustainment (the “high-energy state” analogy used by Dr. Magleby)
- Academic home? Handling of teaching credit, tenure, evaluation, etc.
- Transcending design’s disciplines – not co-located; different languages and personalities; respect for each other; metrics for success
- Focus on the project/work/product using team-teaching, problem- and studio-based instruction

We grouped these topics into common themes, which are discussed in the following paragraphs.

Varying Perspectives on Design: Because of the diverse backgrounds of the workshop attendees, there were discernible differences between the disciplines regarding the definition of design. To the engineer designers, design seemed to represent a scientific process with measurable outcomes for performance. Associated with this position was a preference that the inquiry of design be one that merits doctoral-level research. Among the industrial and architectural designers, design resembled a cultural and artistic inquiry wherein meaning, use, and material tectonics are translated into a physical product. This process was acknowledged to be somewhat ambiguous, intuitive, and reflexive – and often without reliable predictive outcomes. The business school faculty and industry practitioners partially mediated these two perspectives, introducing the concepts of *desirability* and *value* as being somewhat quantifiable through the context of product sales. Products were divided into three broad groups: (1) industrial (e.g., jet engines), which are primarily functional and require engineering design, (2) consumer (e.g., furniture), which primarily require industrial design working in conjunction with engineering design, and (3) cultural (e.g., architecture, art), which primarily require architecture collaborating with industrial design or engineering design.

Pedagogical Mechanics: Everyone was in agreement about the benefits of collaborative teams comprised of engineers, industrial designers, and business people for consumer goods and architects and engineers for homes and building systems. However, there was little consensus regarding the ideal training methods for such teams, other than the successes reported by several attendees in holding group studios where various disciplines collaborated with each other to develop projects. The challenges in this include identifying the discipline(s) that leads the initiatives and the extent to which the others are involved, particularly as the project evolves. One panelist recounted the combination of all three parties in an academic setting, wherein the business students nominated themselves to “be in charge”, resulting in disgruntlement among the team members and little conclusive evidence that this was the best strategy.

Thus, the question arises as to appropriate training methods. One argument advanced was to take people of *depth* in a given field, then to forge these skills into *breadth*, reaching across disciplines. This approach suggests that each field would further development in its own area while being exposed to the other disciplines. Such an approach lends itself to the aforementioned “group studio” approach, in addition to individually-focused discipline-specific courses that would offer exposure to other discipline concerns, while adding depth to their inherent skill areas.

Academic Home: The issue of having an “academic home” for interdisciplinary inquiry was a relevant concern. If any single discipline is to solely host such an inquiry, the result will undoubtedly be a perceived (or real) value dominance of this discipline. While this may in some ways be desirable (for reasons such as program validation, attraction of funding, and/or desired student types) this may in other ways work against the notion of discipline parity. Many attendees mentioned their desire – and those of their faculty colleagues – to collaborate inter-departmentally. These same people also identified a number of hurdles resulting from college

structures based upon discipline-specific studies (described by one as “medieval”) that were either difficult or impossible to overcome in order to realize their collaborative desires.

Pertaining to this topic are the logistics of transforming “faculty heroics” (required at program startup) into a sustainable program that does not continually exhibit extenuating demands or over-burden the faculty involved. Challenges to overcome include compensation for various faculty from different departments, course buyouts, budgetary restrictions, time releases, tenure considerations, among others. In some ways, the complexity of these concerns suggests that one optimal strategy (if possible) is the creation of a new standalone entity within a university context. If a “College of Interdisciplinary Studies” were created with a new set of policies, this might be simpler than trying to modify existing policies within three different departments trying to collaborate. Additionally, such a college might facilitate collaboration of any number of different disciplines.

Degrees Conferred: In general, two different degree models might be explored: (1) a uniform program length with different degrees conferred upon the different disciplines involved, or (2) a two-tiered program of differing lengths with differing degrees. In the first case, the program could be one or two years in length commensurate with the degree offered: MEng or MPD for one-year programs and MS and MBA for two-year programs. Alternatively, tiered programs could offer lesser degrees (e.g., MEng) for students that complete the first tier while greater degrees (e.g., MS) would be offered after successful completion of the entire program. In both cases, continuation to a PhD degree in the discipline(s) might also be available to those interested in pursuing it.

Choosing between degree models would largely be based upon the types of students involved. Several workshop attendees advocated programs that permitted mid-career or executive participation. If this sort of student is desired, then a tiered program might be preferable to allow for shorter duration experiences as well as deeper courses of study. The added benefit of a tiered program is that students who pursue the advanced tier(s) may participate in the education of students in the introductory tier in a mutually beneficial fashion for all of the students.

Disciplines & Boundaries: There was a poignant discussion regarding whether design was a *body of knowledge* or a *method/process*. The determination of this choice has political ramifications because of existing academic disciplinary identities (and funding). In the end, Dr. Weightman’s suggestion that “design is a process” illuminated the prospect that the creation of what “has never been” is a process equivalent to the analysis and understanding of “what is”. *In other words, design and the scientific method are two equivalent and equally valid approaches to finding or creating new knowledge – the purported purpose of a university.* A possible conclusion, then, is that academic disciplines (if they should exist at all) are subject-based, i.e., what one studies creates disciplinary boundaries, not how one studies it. This specification of design as a process would then discourage the creation of a “design school”, but at the same time, raise the status of design to be equal to that attributed to scientific pursuits funded by NSF.

Scholars often enjoy disciplinary boundaries because it provides them with an identity. Currently, the academic programs discussed in the workshop often survive “on the passion of the participants” as many pointed out because they are doing something that has no individual identity. If one raises the status of design within a subject-based disciplinary department, then we may not need to create a new identity for design, yet a new approach may have advantages.

Design Status & Rewards: Dr. Nieuwsma and several others noted that the status of design is low in some parts of the university and needs to be raised. This perspective was assumed as universal with a lot of nodding heads from those with engineering backgrounds while those in industrial design and architecture looked astonished. As an example, in architecture, those in engineering often serve secondary functions, and faculty associated with engineering usually hold lower status. The most revered architecture schools (e.g., Harvard, Columbia, Yale) focus on form and philosophical interpretation to the exclusion (and perhaps even derision) of engineering drivers of efficiency, function, and performance.

In order to integrate engineering and industrial design education, there must first be an understanding of what the criteria for success is – for faculty and students alike. These ideas were raised frequently during the workshop and cannot be ignored: where are “successful” publishing outlets for faculty working in design? There is wide variance between departments regarding the definition of “research”. Some departments give little credit to conference presentations, textbooks, co-authored papers, and popular publications pertaining to a professor’s academic “research” during promotion and tenure review, while other departments may consider these accomplishments worthy of Full Professor status. Likewise, what is considered “successful” student placement: being hired by a multinational corporation, working for a small community based program, or starting a company? This is another issue that remains open for debate.

5 CLOSING REMARKS & RECOMMENDATIONS

All of these questions lead back to the purpose of the workshop, namely, exploring the need for creating interdisciplinary design education and the resulting opportunities that arise. What matters in interdisciplinary work is not the different knowledge bases, *per se*, but rather the different ways of approaching problems – and the value generated from these differing views and perspectives. The more that individual disciplines become multi-lingual in their approach, the better we can understand and solve the problems in front of us as well as the unknown ones that lie ahead. Therefore, continued funding for efforts to gather and publish the findings of a wide-variety of stakeholders in the design process is highly desirable.

Nearly everyone commented that the workshop exceeded their expectations in terms of experience and value. Many were very positive about the friendly and open discussion among the many disciplines involved in design – with representation from across the broader design community for perhaps for the first time. Several attendees also valued what they had learned from the program overviews on Thursday, from the nascent programs to the well-established ones. This positive assessment was undoubtedly connected to the repeated recommendations for follow-up workshops with even

broader disciplinary participation. There was a sense that this diverse and collegial group gives a rich opportunity to reframe how many teach, and more importantly, think about design.

Based on the topics that arose during the three panel discussions, the workshop attendees were asked to present their overall thoughts and recommendations for next steps during the final workshop session. These recommendations are summarized as follows.

5.1 Advancing Interdisciplinary Design Activities

The following recommendations are intended to help advance interdisciplinary design activities.

Continue design discussions through follow-up workshop(s): Many attendees suggested having a follow-up workshop within the next 4-6 months to continue the discussions about design. Others suggested a series of workshops, perhaps hosted by different schools with existing interdisciplinary graduate design programs, permitting attendees an up-close look at a different program at each workshop. One participant suggested “Start collaborating now! We should have a goal of two [Engineering Research Center] proposals [for the next submission cycle].” Others suggested continuing communication in some forum, perhaps electronic (e.g., blog, email, etc.).

Explore the creation (or evolution) of a separate design discipline: One recommendation was to develop the base elements of a new discipline of “design”; others argued that such a discipline already existed and that it just needed to be evolved. Many agreed that calling it “design” was insufficient since design has different meanings to different communities. This exploration should include related work (e.g., design thinking [7]) to understand what it has to offer.

Promote better appreciation of design and design research: Given the low status that it is often attributed, we need to start exploring ways to increase people’s appreciation of, and for, design, in all its forms. This begins with a better understanding of each other’s role within the process of design, and how that role varies based on the products being designed, be they industrial, consumer, or cultural. Others suggested having small groups of faculty (and students) attend each other’s conferences and meetings. For example, engineering designers involved with ASME’s Design Engineering Technical Conferences should invite industrial designers and architects to attend and participate in sessions and panels at the conference and vice versa, e.g., engineering designers should consider attending relevant IDSA (Industrial Design Society of America) and AIA (American Institute of Architects) conferences, among others.

5.2 Enhancing Interdisciplinary Design Programs

The following recommendations are intended to enhance the development of interdisciplinary design programs.

Define the desired knowledge, skills, and abilities of graduates from these programs: Industrial-organizational psychologists typically use KSAO, shorthand for Knowledge, Skills, Abilities and Other, for job analysis [8,9], and the same could be applied to the graduates from these programs. For example, graduates might be expected to have a basic knowledge (K) of design history (or engineering, or architecture, etc.); computational skills (S) and proficiency in using certain types of software; the ability (A) to manage

projects and work well in teams; and have an intrinsic interest in creativity (O).

Create courses that engender understanding of the different disciplines involved in design: Several potential courses were suggested to facilitate the development of new interdisciplinary design programs, including *Design/Business Appreciation for Engineers*; *Engineering/Business Appreciation for Industrial Designers*; and *Engineering/Design Appreciation for Businesspeople*. Such courses would help overcome perceptual barriers between the various disciplines involved in design, including engineering, industrial design, architecture, art, psychology, business, etc.

Catalogue (and standardize) different design degrees: While many degrees exist, there were suggestions that perhaps two types of graduate degrees would be appropriate: (1) a degree at the master’s level to prepare practicing designers, and (2) a PhD for research on interdisciplinary design to extend the field and provide the faculty base for the discipline. If the degree name(s) could be standardized, then it would increase the recognition of these individuals within the field (e.g., most people know what a MBA is).

Identify and document supportive administrative structures within the university: We need to identify appropriate incentives for faculty working in the “high energy” states needed to initiate such programs and sustain them. We also need to document successful university models that have helped (a) initiate and (b) sustain interdisciplinary graduate programs such as these.

Use design principles to design interdisciplinary graduate design curricula: Once we have defined the KSAO for our graduates, developed courses, agreed upon degree offerings, and identified suitable administrative structures, we can design specific interdisciplinary graduate design programs. We recognized that multiple solutions will exist depending upon the student body, program size, location, etc., and it will be important to define suitable metrics for success for both students and faculty as part of this process. This will facilitate evaluation and benchmarking.

5.3 Supporting Interdisciplinary Design Research

The following recommendations were offered to support design and design-related research.

Utilize available funding opportunities at NSF: Many workshop attendees felt that NSF already had a number of opportunities to help move this initiative forward. These opportunities included (1) continued support for follow-up workshops that might be hosted by different universities; (2) a detailed benchmarking study of existing interdisciplinary graduate design programs where a diverse team of faculty and industry practitioners would be supported to travel to 5-10 existing programs and write a detailed report summarizing the state-of-the-art and future programmatic directions; and (3) special and general support for research and graduate education in interdisciplinary design (e.g., Engineering Design and Innovation Program, CreativeIT, IGERT, ERC).

Expand scope of NSF solicitations and review panels for interdisciplinary design activities: Many attendees recommended that NSF should consider new program solicitations focusing on interdisciplinary design research,

design assessment, codifying design thinking, and related topics. It was suggested that such topics might best be captured through NSF's new Emerging Frontiers in Research and Innovation (EFRI) initiative. Attendees also recommended that NSF consider having non-engineering design faculty on review panels, or sending such proposals out for review by such faculty (and industry practitioners). This would allow their voice to be heard and improve their competitiveness when pursuing funding opportunities for interdisciplinary design research. While not specific to the outcomes of this workshop, we are pleased to note that the Directorate for Engineering is now piloting a new panel review procedure for interdisciplinary research proposals (<http://nsf.gov/eng/general/IDR/index.jsp>).

In closing, attendees were very positive about the friendly and open discussion among the multitude of disciplines involved in design – with balanced representation from across the broader design community for perhaps for the first time. Given this interest, we have started a national dialogue that is continuing this year through a series of follow-on workshops supported by NSF. The purpose of this *Design Workshop Series* is two-fold: (1) to explore design as an instructional discipline by investigating existing programs while shaping emerging ones, and (2) to broaden and focus the discussions while expanding participation from other disciplines. This will be accomplished through three two-day workshops hosted by our partners in this effort, namely, the University of Michigan (6-7 November 2008), Northwestern University (16-17 April 2009), and Stanford University (29-30 August 2009). A half-day workshop will also be held at the NSF Grantees Conference in June 2009. We look forward to engaging the larger design community, and hope that by working together we can improve the art and science of design.

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