Designerds!: Television as a Tool for Design Education and a Medium for Problem-Based Learning

by

Chandler Hatton

Submitted to the Department of Mechanical Engineering
in partial fulfillment of the requirements for the degree of

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Abstract

Many individuals have limited knowledge of engineering. As a result, high school students are often unaware of opportunities in engineering professions. Designerds! is a television show pilot targeted toward a young audiences that provides an introduction to product design. The pilot documents product development by engaging MIT graduate students in a collaborative, real world design challenge. The semester-long project followed the progress of two groups of MIT graduate students as they developed concepts for new musical instruments. Participants worked together to bring their instrument from the initial brainstorming stage through prototype production. The Designerds! program aspires to simultaneously educate groups of graduate students by facilitating Problem-Based Learning and to inform youth about product design through television media. The goal was to demonstrate the emerging educational opportunities provided by the entertainment industry. Furthermore, the project was intended to foster a collaborative design environment in which MIT graduate students work cooperatively on a design project, building teamwork, and leadership skills. The project successfully demonstrated the media's potential for teaching skills for product development and promoting the engineering profession. However, uneven commitment from the graduate student participants and limited access to human and material resources precluded successful organization of a cooperative learning environment. The success of future projects is dependent upon proper institute support and improved commitment from participants.

Thesis Supervisor: David Wallace
Title: Associate Professor of Mechanical Engineering

Acknowledgments

The producers of Designerds! would like to thank the graduate and undergraduate student participants. These students include members of Team Stradivarius: Jeff Chambers, William Fienup, Marc Graham, Howard Kellogg, Stephen Sohoumos, Richard Timm, Brian Urban, and Danielle Zurovcik and members of Team Christofori: Andrew Carvey, Brenden Epps, Melanie Howell, Shauna Jinn, Kevin Lin, Hong Ma, and Quinn Mahoney. Contributions from the mentors David Wallace, Meejin Yoon, and Martin Demaine are greatly appreciated. The producers would like to offer a special thanks to Priya Desai, Alex Romaniuk, Analucia Berry, James Penn, Craig Jimenez, and the CADlab for their support on and off set. Funding for the pilot was provided by the MIT Council of the Arts.

I would like to thank those that helped edit and format the document: David Wallace, Anat Burger, Andrew Carvey, and Nikki Hatton. I would like to thank my co-producer and mentor Barry Kudrowitz. Finally, I would like to thank my family for their love and support.

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Chapter 1

Introduction

Knowledge of design principles can be beneficial for many fields of study. A general product design process can be used as a template to develop concepts for anything from a biomedical device to a television program. However, most individuals have limited formal knowledge of the methods of product development. Furthermore, the public has little understanding of engineering practices and the types of projects that require the expertise of engineers [7, 8]. While students enrolled in universities such as MIT may have a better understanding of the activities comprised by engineering, they still may not have been exposed to the depth and scope of opportunities afforded by training in product design.

A review of journals such as the ASEE Journal of Engineering Education [4, 11] reveals that, increasingly, there is belief that the classroom should moving away from traditional lecture-based instruction. Within the academic community there is a high demand for programs that teach-by-doing. The construction of an academic environment that can reproduce the challenges faced by professional design teams may provide better preparation for engineering students. Due to the increasing influence of television programs, media has been suggested as a tool for the promotion of the engineering profession. The pervasive nature of television has created viable opportunity for education.

The Designerds! TV pilot project was conceived as a program to simultaneously teach the design process, inform viewers about the field of engineering, and create a cooperative learning environment for MIT graduate students to interact and develop skills outside of the classroom. Students expand their teamwork, communication, and leadership skills through participation in activities that stretch the limits of their creative and academic experiences. The pilot program can be evaluated as both an opportunity for graduate students to engage in independent design-oriented Problem-Based Learning and as an educational TV program that promotes engineering design.

As a structured Problem-based Learning initiative, Designerds! had two objectives. The main objective was to involve students in a cooperative, multidisciplinary exercise. The secondary objective is to execute a design challenge; the success of which is contingent upon the development of an effective group dynamic. The Designerds! television program can be assessed in terms of it's ability to engage the audience and foster a positive outlook on engineering in addition to its capacity for instructional communication of the design process.

Effective implementation of the Designerds! television pilot would indicate that media is a powerful tool for teaching the design process and confirm the importance of media in developing popular perceptions of engineering. The outcome of the television pilot is dependent on the activities of the graduate students and upon institutional support. Following the creation of the pilot, Designerds! requested of formal support from MIT in the form of a Graduate Student Life Grant, which would allow the program to be institutionalized as a yearly activity. Unfortunately, the Dean of Student Life was not able to offer the program funding.

The educational component for the graduate students working on the projects in the show is different from the educational value of the show itself. The television program does not require the generation of a viable solution to the design challenge, so it should be evaluated independently of the Problem-based learning exercise.

1.1 About this Thesis

Graduate student Barry Kudrowitz asked me to join him in producing the Designerds! pilot. As co-producer, I assisted in structuring the project and instructing the

Designerds! participants. I was behind the camera at weekly team meetings and I played a large part in the editing and compilation of the pilot.

The appeal of the project was the opportunity to create a Design TV program to document the product design process. The program was targeted to a young audience with the goal of being entertaining and moderately educational. Barry Kudrowitz proposed new forms of musical instruments as a potential theme for the show because of the creativity, versatility, and relative accessibility of the challenge. The participation of professors and instructors from mechanical engineering, architecture, kinetic sculpture, and music backgrounds imparted the potential for strong design and innovation.

The project aimed to discover whether media is an effective tool to teach engineering design skills. Furthermore, the project endeavored to document the construction of a creative design environment. This thesis focuses on the documentation and critique of the Designerds! pilot as an example of media-based teaching and Problem-Based Learning. The chapters that follow outline the creation of the Designerds! pilot and provide a review of the successes and areas of needed improvement. Upon initiation of the project, the hypothesis was that the pilot would be successful in teaching the design process through the exhibition of graduate student designers. We found the pilot to be an effective method for informing audiences about product design, yet we struggled with the learn-by-doing aspect of the project as a result of poor participant commitment and inadequate access to necessary resources.

Figure 1-1: Designerds! poster announcing the December 16th Showing.

Chapter 2

The Idea

Designerds! is a television show pilot that documents the product design process. The show challenges graduate students to work toward the development of a unique product. Teams of interdepartmental students address a design challenge by carrying out a concept from initial brainstorming through prototype production.

Upon completion of the project, the success of the teams' efforts was evaluated by MIT design professors. The pilot and the prototypes were displayed for the MIT community to promote engineering and inform the community of the role of engineers in contemporary society. Participants with developed skills in various areas of design become role models for an audience that was less familiar with the responsibilities and opportunities given to designers.

Designerds! differs from current TV programming in that it is based upon teaching the design process. Rather than focusing on the final product or generating a recipe for the construction of a specific item, Designerds! captures the unscripted interactions of engineering and design students working toward a common goal.

The use of graduate students promotes the role of engineer/designer on a variety of levels. Within the MIT community, Designerds! was planned as a showcase for collaborative design efforts. A project that encompasses multiple disciplines to create a unique product can act as an inspiration to graduate and undergraduate students alike. Furthermore, the pilot can inform the undergraduate community of opportunities in design. The pilot can help to elucidate the techniques required for successful design as well as inform undergraduates about the skills that are brought to the table by individuals from various disciplines. The positive depiction of engineering and design may help underclassmen orient themselves and their interests within the MIT community.

Chapter 3

Background

3.1 Problem-Based Learning

The post WW2 model for engineering curricula has been to focus on science and mathematics before engaging students in design-based engineering courses [4]. This academic program is commonly referred to as the "engineering science" model. The strengths of this model are in students' ability to accurately relate physical phenomena to a system of equations and the resultant testability of student comprehension. Dym et al explains that "the majority of the educational content taught in today's engineering curricula is an epistemological approach, systematic questioning, where known, proven principles are applied to analyze a problem to reach verifiable, "truthful" answers or "solutions" [4]

Despite the utility of the engineering-science model, the sole application of scientific and mathematical principles to arrive at a unique solution is incongruous to the problems professional engineers encounter. Engineering design problems are often tackled with iterative loops involving decisions based on a variety of factors, combining a mix of creativity, domain knowledge, skills, and process. Seldom is there only a single good solution for a single.

"A common premise of [engineering science] is that a specific answer, or a specific set of answers, exist for a given question... Questions that are asked in design situations, however, often operate under a diametrically opposite premise: for any given

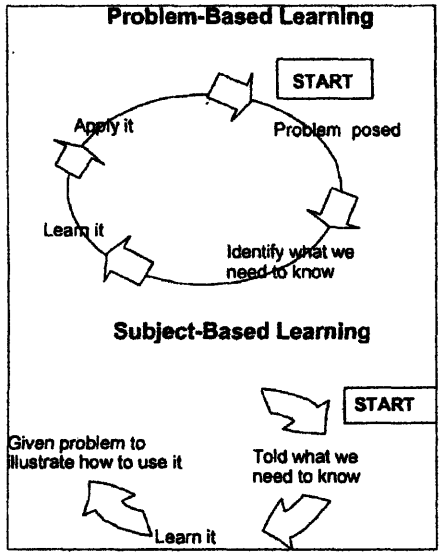

Figure 3-1: Diagrams of Problem-Based Learning and traditional, Subject-Based Learning [11].

question there exist multiple alternative known answers, regardless of being true or false, as well as multiple unknown possible answers." [4]

Challenges that have multiple alternative solutions operate at the concept level rather than only the domain knowledge level, requiring designers to build upon facts to generate possibilities. [4]

The construction of solutions from previously unknown possibilities through evaluative questioning cannot be produced in the traditional classroom environment. In many schools and universities a new style of learning, Problem-Based Learning (PBL), has been adopted. PBL has been formally described as "learning that results from the process of working toward the understanding of the resolution of a problem" [11]. Figure 2 diagrams the differences between PBL and traditional, Subject-based learning.

The adaptation of a PBL engineering curriculum results in the inclusion of a series of cornerstone and capstone classes in which students learn by solving real-world problems [11]. Dym reports that "changes in engineering education were inspired by employers who indicated a need for engineers who are not only experts in their domain, but who are also adept communicators, good team members, and lifelong learners" [4]

PBL requires interdependence between individual team members or subgroups [11]. The success of projects is dependent upon positive cooperation between team members who are individually accountable for specific project components [11]. Interdependent interchange within a design team is essential for a successful PBL environment. Students who engage in PBL activities experience heightened faculties for decision making, teamwork, communication in various design languages and integration of design systems [4.]

MIT's undergraduate and graduate engineering and design curricula include strong examples of high level PBL in a classroom setting. However, due to the unique learning goals and skill sets of each academic department, few projects incorporate students from multiple departments or from a broad range of academic levels. Furthermore, PBL projects are experienced only through graded coursework.

While reports such as the work by Dym et al. are based upon studies of undergraduates, it might be assumed that similar trends occur in graduate education with the primary difference being the role of the instructor. Whereas the instructor is prominently engaged in directing the design process for undergraduates, graduate students are expected to work more independently. It may be useful for graduate students to work cooperatively on projects proposed by other graduate students with minimal instructor involvement. An additional benefit is increased exposure to technologies that students are not ordinarily exposed to in classroom settings.

3.2 Product Design Process

Even within the walls of MIT, many versions of the product design process are taught and implemented. In their text, Product Design and Development, Ulrich and Eppinger provide a summary of the generic design process, which can be modified and applied to any project. Six essential phases of project development are identified: Planning, Concept Development, System-Level Design, Detail Design, Testing and Refinement, and Production Ramp-Up.

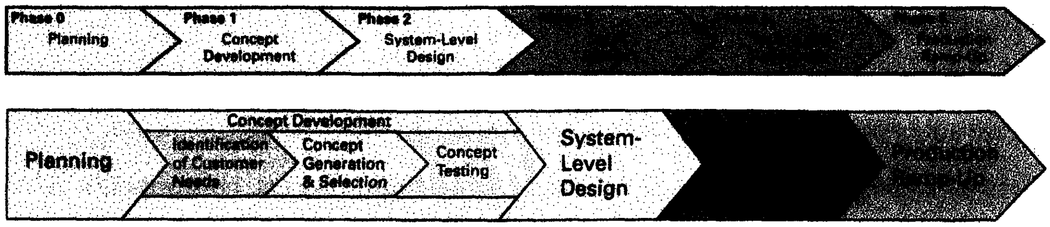

Figure 3-2: **The Product Development Process** The product development process has six steps, each of which may be emphasized or combined, depending on the nature of the product. Designerds! focused on phases 0-3, stresses the planning and concept development stages. The development of new musical instruments closely resembled an abbreviated version of the process described by the lower arrow. [12]

The six phases may be emphasized or combined, depending on the nature of the project. Designerds! primarily focuses on planning and concept development, which is described by phases 0-3 (0-2 on the lower diagram). This project, like many similar research-oriented design projects, does not address the testing and refinement necessary to enable proper production ramp-up and mass manufacturing. The project's development phases are more accurately described by the lower arrow (above), which highlights the concept development phase.

Phase 0: Planning is characterized by brainstorming and concept selection. Tools for effective group ideation and evaluation are the basis for creative design. Phase 1: Concept Development requires a product description (sometimes referred to as a product contract). The product description is a statement of the concept goals and key functions of the product. As shown in Ulrich and Eppinger's diagram, concept development begins with a statement of the needs that the product aims to satisfy. Designers must then identify a pool of potential designs which might be capable of meeting those needs. Technological research and sketch modeling activities occur at all phases of the design project and as tools for the analysis of the feasibility of potential products.

Once the team has reached a common understanding of the product, innovative system-level and detailed design work can take place. Phase 2: System-Level Design is characterized by product prototyping. Mockups and prototypes of varying com-

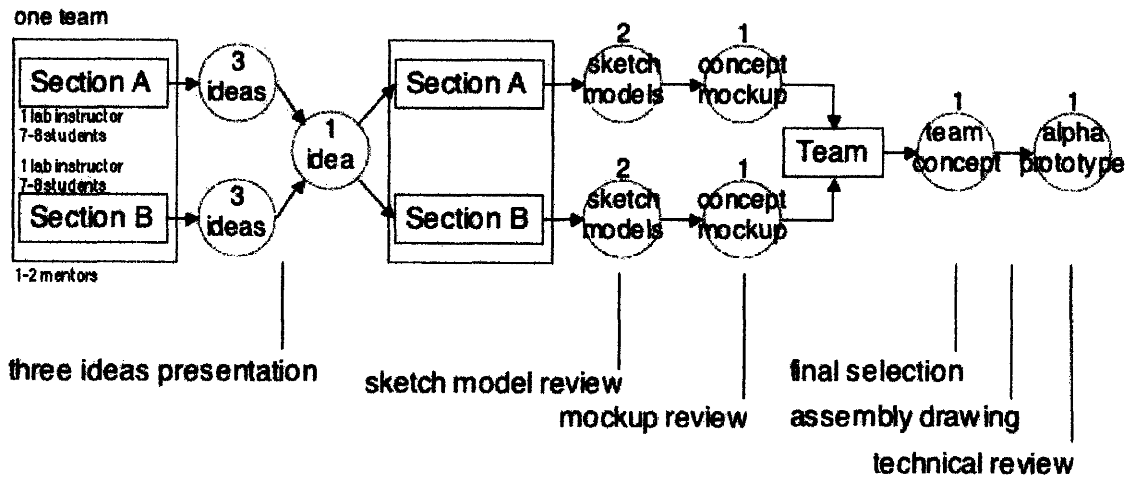

Figure 3-3: **Diagram of Project Workflow** Diagram of project workflow from Professor David Wallace's product design course, "The Product Design Process" [1].

plexity allow designers to work out the product form, user interface, and aesthetics. Prototyping also initiates the task of identifying and reconciling design details. A detailed diagram of the generic product design process is given in Appendix A.2.

MIT's Mechanical Engineering capstone course in engineering design, "2.009 The Product Design Process" taught by Professor David Wallace provides a more detailed description of the concept development procedure followed by Designerds! The class is divided into design teams of fourteen to sixteen students, which are initially split into two subgroups of seven or eight students each (sections A and B). Each subgroup conducts intensive research and brainstorming to arrive at three ideas for potential products. These ideas are refined and presented to a panel of instructors, who make recommendations to help the teams select a single concept to pursue. Sketch models and detailed mockups flush out ideas of form and function. Eventually the subgroups are combined into a single design team. As a team, one of the two section's mockups is chosen as the basis for the team's final concept. Through further concept refinement an alpha prototype is constructed and presented for review by the Mechanical Engineering department at large.

3.3 Engineering in Media

While engineering maintains a prominent role in the wellbeing of contemporary society, engineering professions are poorly understood. MIT's Dan Frey states that "engineering is perceived by much of the public as inaccessible, boring, and staid and engineers are perceived as nerdy and socially inept" [6]. These perceptions can be changed through positive enforcement of engineering.

Agencies such as the National Science Foundation (NSF) support television programs targeted toward young audiences that strive to transform youth enrollment in engineering curricula. The NSF is currently funding the production of Design Squad which illustrates high school students solving design challenges. Design Squad premiers in the fall of 2006.

Because careers in engineering should be supported at every stage of academic development, the appeal of engineering professions should be demonstrated to individuals in university programs as well as students high school-aged and younger. The cooperative environment of Designerds! exemplifies the use of modern media to promote engineering on a university campus. In addition, Designerds! builds the engineering skills of student participants while providing a forum for social and educational interaction between various departments.

In the past, techniques commonly used in media development have informed an understanding of engineering. Design strategies such as storyboarding are commonly integrated into the product design process to help designers refine concept ideas and identify details of user interaction. Projects that promote interaction between individuals from different fields create opportunities for the adaptation of techniques and strategies which may be mutually beneficial for the fields of study.

Chapter 4

Project Goals

4.1 Goals for Participants

Many students do not have the opportunity to implement design projects beyond the scope of their graduate laboratories. The real world experience of working in a group of peers to address a design challenge in a stress-free, non-academic environment provides a different learning opportunity. Many graduate students enter MIT without prior knowledge of the product design process and/or are in need of experience in collaborative design. Designerds! was conceived as a means to inform graduate and undergraduate students about product design. The program also was intended to educate groups of graduate students in the product design process through participation a collaborative group project.

Designerds! unites real-world experience and formal training. MIT graduate students enter Masters or PhD programs with varying skill sets. Designerds! was intended to provide students who do not have the prerequisite training to enter rigorous design courses an opportunity to "learn by doing" as they interact with group members who have formal design training. The appeal of the program to students with strong design skills is the opportunity to discover the many ways that a single problem can be addressed by interacting with peers from different departments or academic backgrounds.

Through participation in the Designerds! television pilot, teams of graduate students were educated in the classic design process and instructed in specific design techniques. The program supplied teams with a budget, schedule, and design challenge. While the pilot filming schedule necessitated the completion of specific stages of the design by specific dates, teams were independently responsible for the timely generation of a prototyped solution. Participation in the pilot allowed students build teamwork, communication, and leadership skills.

4.2 Goals for Viewers

By bringing individuals from various departments of MIT together, Designerds! fostered a collaborative environment, which will hopefully persist beyond the lifetime of the project. The pilot production provides an opportunity for high-visibility success necessary to showcase the benefits of interdepartmental cooperation. Participation in non-academic educational activities that allow students to interact and learn from their peers could greatly augment MIT graduate (and even undergraduate) culture. Perhaps the pilot will inspire further examples of student-initiated collaborative group projects.

As a television program, Designerds! should entertain viewers as well as teach the design process. Viewers should gain an accurate understanding of the various stages of product development as well as the tools and techniques used to move through the process smoothly. To help elucidate the process, two hosts verbalized the project development phases. The hosts were Barry Kudrowitz, a masters student in Mechanical Engineering, and David Wallace, a Mechanical Engineering professor specializing in product design.

The visibility of student involvement in engineering projects in popular media will initiate a gradual shift in perspective of engineering professions. University-aged students are young enough to be attractive to junior high and high school-aged kids as well as fellow graduates and undergraduates. The intense, yet diverse, backgrounds of the students who participated in the pilot ensured dynamic interaction. The program is meant to inspire and inform rising students.

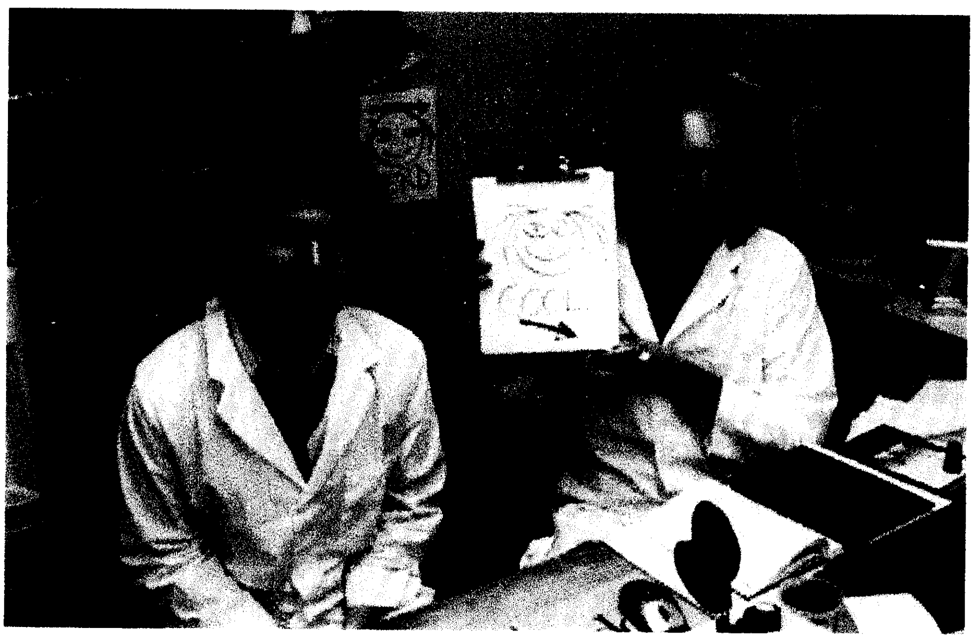

Figure 4-1: Designerds! Hosts Barry Kudrowitz (left) and David Wallace (right)

Chapter 5

Schedule

The schedule for design work is dependent upon the nature of the project, the number of participants, and the deadlines set at the onset of the design process. Some projects are developed over the course of several years, others several months. The timeframe for this project was constrained by the academic semester. For a typical design project, approximately 10% of the project time is devoted to planning and concept development, 30% to system-level and detail design, and the remaining 60% goes into testing and refinement [12]. However, in this project, a disproportionate amount of time was devoted to planning and concept development.

The project was only intended to demonstrate the design process through initial prototyping; therefore extensive testing and refinement did not take place. The scope of the project was constrained by the student skill set and the accessibility of human support resources. Scheduling was adjusted to allow design skills and techniques to be presented to the groups in their weekly meetings. This format built up the participants' skill sets, providing a foundation in brainstorming, concept development, and modeling techniques for students with little design education. Limitations in the available budget and facilities precluded much of the final detail design and prototyping.

Other semester-long design courses have followed a similar schedule. 2.009 The Product Design Process, taught by Professor David Wallace, is a good example. The class allocates three weeks for initial concept development and product planning.

Table 5.1: Designerds! Project Schedule

Week 1	9/9/05	Announce TV show, and recruit participants
Week 2	9/16/05	Briefing session, students are assigned to teams
Week 3	9/23/05	Brainstorming session, selection of four potential ideas
Week 4	9/30/05	Selection of two concepts to for sketch models
Week 5	10/7/05	Presentation of sketch models
Week 6	10/14/05	Sketch models reviewed by mentors, and one is selected
Wks. 7-10	11/11/05	Presentation of alpha prototypes
Week 11	11/18/05	Prototypes are reviewed by mentors
Wks. 12-13	12/2/05	Final video editing is completed
Week 14	12/16/05	TV show screening and product presentation

During this time multiple concepts are pursued. Students then spend approximately four weeks working out system-level and detail design issues. Around week seven the product undergoes significant testing and refinement so that the final prototype can be presented by week thirteen. In this case, the three stages of design described above have a project time ratio of approximately 3:4:5. [1]

Because Designerds! required time at the beginning of the semester to recruit participants and time at the end of the semester to compile and edit the film, the design process had to be compressed into nine weeks. The three stages had a project time ratio of 2:3:4, as detailed in the schedule below. In both Designerds! and 2.009 the building and testing periods are abbreviated because the products do not go into immediate production.

Chapter 6

Budget

Due to limited funding, teams were given $250 to design and prototype a new musical instrument. The teams' budgets were funded by a Directors Grant from the Council of the Arts. The budget proved to be restrictive. Were funding available, a budget of $2000 per team would be more appropriate. Costs for producing the pilot were minimal, given that the camera, tripod, and video-editing software were made available by MIT's CADlab. Only the DV tapes had to be purchased.

Chapter 7

Project Execution

7.1 Designerd Selection

To recruit participants, Designerds! held an information session and briefing open to the entire graduate community. In particular, students from mechanical engineering, architecture, business, computer science, and electrical engineering were encouraged to attend. As a result of frequent oral reminders, many of the attendees were mechanical engineering students and acquaintances of producers Barry Kudrowitz and Chandler Hatton.

Barry Kudrowitz briefed potential Designerds with a short presentation about the goals and requirements of the pilot. During the briefing session the theme of "New Musical Instruments" was revealed. Students interested in participating in Designerds! were asked to fill out a short questionnaire, which required them to indicate their name, course of study, any special skills, schedule availability for group meetings, and interest level on a scale of one to five (Appendix A.1).

Designerds! had considerable appeal; more students expressed interest in participation than could be accommodated. Sixteen students were selected from a pool of approximately thirty. Students who were asked to participate in the project were those that had indicated a high level of interest and commitment to the project. These students had circled interest levels of four or five on the questionnaire, and were, therefore, identified as the students most likely to follow through with the design challenge.

Two teams of eight were selected in a manner that maximized diversity of academic background, race, gender, personality, design skill set, and interest level. One student on each team was an MIT undergraduate in the Mechanical Engineering program. The two teams were each assigned a formal group meeting time that all of the group members could attend (based on their response to the questionnaire). Group meeting times were scheduled for a three hour block one evening a week. The producers attended these meetings, mentoring and filming the groups. The teams were named after former musical innovators Stradivarius and Christofori.[1]

7.2 Brainstorming

The first group meeting for Team Stradivarius and Team Christofori was a brainstorming session. The Designerds were introduced to their teammates and then instructed in brainstorming techniques as taught in MIT Product Design Course 2.009 and described in Ulrich and Eppinger's Product Design and Development [1, 12]

Brainstorming should be done in groups of five to fifteen people. Fewer than five participants may reduce the number of concepts generated while more than fifteen participants may contribute to segmentation within the group. A few general guidelines were followed to insure the success of the brainstorming sessions: No ideas should be disregarded as "silly", as they may contribute to plausible concepts. All ideas should be recorded. Some constructive criticism may take place, keeping in mind that concept refinement and selection occur at a later stage in the design process. Brainstorming sessions should not last longer than thirty to forty-five minutes, since teams tend to lose focus in longer sessions. [1, 5]

The popular brainstorming technique used in the initial brainstorming session was for students to sit around a table and sketch concepts on pieces of eight and a half by eleven paper with markers. Students held up their sketch for the group to see

[1] Antonio Stradivarius, 1644-1737, made significant contributions to the geometry of the violin. Bartolomeo Christofori, 1655-1731, is known as the inventor of the piano.

and explained their idea. Concepts were labeled and passed to a facilitator, who pinned them in a visible location. The role of the facilitator was given to a different student halfway through the brainstorming session to maximize student involvement and to give students an opportunity to interact in a variety of roles. The format of the organized brainstorm allowed students to build off of the ideas presented by their teammates, encouraging them to engage in a discussion of potential design concepts.

The success of the brainstorming process is dependent upon the students' ability to listen to each others' ideas without passing judgment on the feasibility of specific concepts. A brief warm-up allowed the teams of students to become comfortable with their teammates, with the brainstorming process, and with the cameras.

The brainstorming session ran for forty-five minutes. Since many ideas are thematically similar, it is common to spend a few minutes grouping ideas from the initial brainstorm before selecting which concepts to pursue. All group members should be actively involved in grouping. One common method for grouping is to have the entire team silently reorganize the ideas on the wall where they have been pinned up.

Despite host David Wallace's assertion that the Designerds should "review the ideas and group the ones that are similar", grouping of ideas did not take place prior to concept selection due to space and time constraints. However, some combining naturally occurred as the ideas were reviewed. For example, during the concept review for Team Christofori, Andrew Carvey suggests that Barry Kudrowitz combine two ideas, which resulted in the concept described as, "the-pimp-leg-walking-music-that-plays-how-you-walk-pimp-your-walk". If two similar ideas received many votes during initial concept selection they were combined. Often concepts are generalized and explored before they are fully defined through the system-level and detailed design.

the brainstorming session, teams were asked to review their ideas and select three or four concepts to pursue. The popularity of each concept was evaluated democratically; students voted by placing a post-it note on each of their top three ideas. The four ideas that received the most votes were carried over to the next stage of the design process.

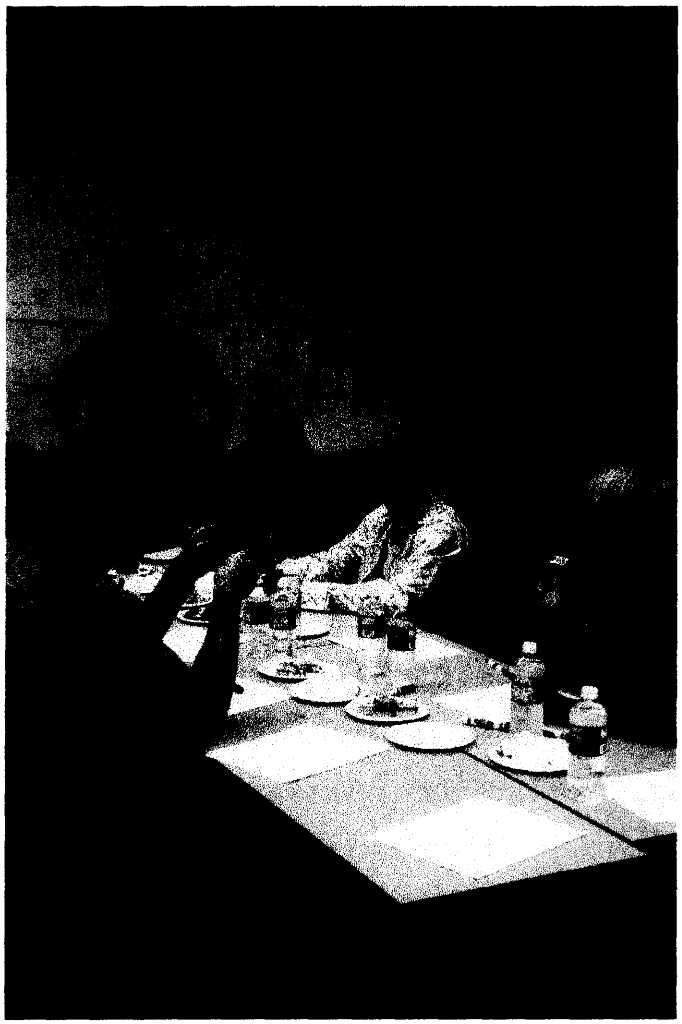

Figure 7-1: **Brainstroming Session** Barry Kudrowitz instructs team Stradivarius in brainstorming techniques.

Both groups produced a large number of ideas, many of which were similar. The initial concepts for Team Stradivarius included the "Musical Suit", which could be played by moving zippers, buttons, and snaps; the "Piano Drop", a piano-like percussion instrument that produced sound from the impact of water droplets on a surface; the "Electric Paint Guitar", a guitar-like instrument that produces sound corresponding with strokes on a musical canvas; and a musical urinal, referred to as the "Potty-Tooter". The group expressed significant enthusiasm for each of these concepts.

Team Christofori emerged from the brainstorming session with three ideas. One idea was to have water dripping on stuff (similar to Team Stradivarius' "Piano Drop"). Another idea was to create an organ-like instrument that produces sound by resonating air inside long, curvy pipes decorated with streamers. The third idea was to mix light and music by placing LEDs inside clear glass instruments. In reference to the instrument ideas generated by Team Christofori's, Designerd Shauna Jin did not express a great deal of excitement. However, as the ideas become more developed group members became more excited and involved.

7.3 Concept Development

At their second meeting, teams were asked to narrow their four ideas from the brainstorming session down to two concepts. The teams were introduced the Pugh chart as a method for concept selection. The Pugh concept selection method is a simple way to decrease the overall number of concepts while improving those that remain [9]. Ulrich and Eppinger describe the process in six steps:

Using the selection matrix, concepts are compared to a baseline, which has the neutral rating of zero for each of the selection criteria. Selection criteria may include factors such as ease of manufacturing, product durability, and portability etcetera. Concepts are scored with a (+), (0), or (-) for each of the selection criteria; net scores are tallied and concepts ranked. Concept ideas may then be improved based upon the results of the selection matrix; often ideas are combined or eliminated. It

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