Using Design – Build Projects to Promote Interdisciplinary Design

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Ball Dispenser – a Lego RCX Interdisciplinary Design Project, spring 1999

The Crab – a Walkmobile Interdisciplinary Design Project, spring 2003
Abstract - The activity of real world design is a collaboration of individuals from more than one discipline. To address this important future work environment, student interdisciplinary design projects were created. For the past seven years, teams of students from the first year Engineering Design Graphics course in the College of Engineering and the second year Industrial Design Studio in the College of Architecture and Urban Studies have been teamed together to pursue design-build projects. In the initial years, push-pull toys were designed and constructed. Then LEGO Programmable RCX bricks were chosen as a medium for the interdisciplinary design projects. Last year, the students were charged with designing and building a “Walkmobile” walking device using a rechargeable electric screwdriver as the power source. The paper describes the project evolution over the years and serves as a record of an exciting and creative foundation design effort that promotes true collaborative interdisciplinary design.

Index Terms – design – build, first year design, interdisciplinary design

BACKGROUND

In the spring of 1997, we had a notion that a collaboration of engineering and industrial design students would bring about a new and exciting possibility for our students to experience the activity of real world design in their foundation years at the university.

The first year, we established teams of two students - one engineering student and one industrial design student. The project was called STILLS. In this project, the students were charged with designing a mobile or push-pull toy that satisfied certain criteria. There were 28 teams and about half the teams designed mobiles and half the teams designed push-pull toys. Most of the teams designed very innovative and interesting projects. AutoCAD drawings were made of each project, the industrial design students created posters, the engineers produced written reports, and the team delivered a final oral presentation 1. One outcome we discovered was that the volume of projects limited our ability to coach each team. Also, weaker teams did not have resources (additional members) to support them through hard times.

The following spring, we formed teams of four students each. Two engineering students and two industrial design students made up each team. The charge this year was to design a push-pull toy that would satisfy more rigorous criteria than was used the year before. The results of the larger team size and consequently smaller number of teams were mixed. Having fewer teams seemed to produce less fanciful toys. Larger team sizes meant that there were more internal resources available. We were also able to spend more coaching time with each team.

Spring of 1999, we formed eight teams of seven or six students each. Each team consisted of three engineers and four or three industrial designers. This team composition created a more resourceful group. It also resulted in a couple of teams having increased conflict among team members. To achieve a better team size, spring of 2000 we formed 12 teams of four students each. The newly released LEGO programmable RCX bricks were chosen as the medium for these interdisciplinary design projects. For this new project, each team of students was charged with designing and programming an autonomous guide vehicle (using the LEGO RCX bricks and Robolab software). The guide vehicle was required to travel a minimum of 15 feet and accomplish some designated action. The students also designed the site that the vehicle would traverse, as well as a “postscript” or added device, not to be made of LEGO that would attach to the guide vehicle and add to the mission of the autonomous guide vehicle. The resulting guide vehicles, sites, and postscripts varied greatly in their design concept, function, and mission. One vehicle moved along a horizontal wire and dispensed and sorted balls, another sought out colored dots in a particular sequence and when all were found, it unfolded like a flower and a third launched a parachute and subsequently performed a search and rescue. There were a total of eight designs. The LEGO RCX was an excellent choice as the platform for this design project. The common hardware of LEGO and the Labview based Robolab software gave a unified foundation as well as allowing the space for individual creativity 2. This Lego project continued for two more years.

The previous papers on our early efforts serve as a visual record of a dimmed boundary between industrial design and engineering students 3. They also serve to illuminate the possibility of a union between LEGO and "ordinary" materials in unified design efforts. They also serve as documentation of our foundation efforts. Our current work with the “Walkmobile” builds on this strong foundation and carries the design-build concept to more technical and freeform designs.

NARRATIVE

Alexander Calder, who was a mechanical engineering & designer who evolved into an artist, described his mobiles as “abstractions which resemble nothing in life except their manner of reacting” 4 as Marcel Duchamp is credited with naming these works of Calder as “mobiles,” it may be important to remember that, in French, the word also means motive. Mobility suggests a relationship between elements—something moving with respect to something else or because of something else. This relationship in turn can introduce mediation between materials or illuminate where mediation might occur. In essence, mobility compels one to look at the joint between dynamic and static elements and the junction of different materials. At this fundamental level, one might look at mobility as part of a platform serving as a foundation for design education.

As industrial design is gaining prominence at Virginia Tech, and when the university is strongly focused on bridging academic areas, it seems an opportunity time to consider the blend of areas of thought which might compose a foundation in industrial design for both designers and engineers. What is
at the core? We looked at Stanford University as a model for blending engineering and art as a base for product design and then noticed Virginia Tech’s traditional separation of the two. We welcomed the opportunity to provide a meeting for engineering and industrial design students. Our broader goal was to have students from both worlds look at something together and then through each other’s lens – to add not only their particular view of the world but also their view which now changes as a result of this new relationship.

What might be at the common core of such an association? Materiality certainly stands as common to these fields of study. How materials come together, how those decisions are made, becomes the substance of dialogue between industrial designers and engineers—the joint and materiality.

As teachers, we came together seeing a possibility of illumination in the way students view their work as designers. That possibility is modeled in the work of Alexander Calder. His work is an expression of a blended view, where the boundary between the pragmatics of movement and the form of movement dissolve in the process of making. Clearly, he makes this melding appear seamless and effortless. However, the relationship or hierarchy between form and function is probably the base issue of division between the fields of engineering and industrial design. We thought that looking at Calder’s work as a precedent for understanding movement might serve as a starting point for dialogue between these two groups of students. Calder’s training from the Stevens Institute of Technology and his early work as an engineer serve as a balance and compliment to his eventual development as an artist of mobiles.

Perhaps it is better to talk about the lightness and lyric of movement before talking about pragmatics in order for students to imagine the possibilities of form. The objective here is to have industrial design and engineering students see the possibility of art in movement in order that art might always be an aspiration in the form of all design endeavors. We also strive here to have the students discover that some intangibles such as poetry–dance–in movement are indispensable rather than extravagant, and that poetry, too, can be efficient.

How and in what form does a teacher bring this perspective to a student? Perhaps the answer originates in the examination of current engineering and industrial design education. The education of first and second year engineering students at Virginia Tech is primarily analytically based. Engineering students are also isolated from other related disciplines on campus. As strong believers in broad-based education as the best preparation for a creative and productive life and career, we aspire to involve the engineering students in the physical design world at an early stage in the educational process. We felt that engineering students could nurture in parallel practical and aesthetic sensibilities from direct collaborative contact with industrial design students.

A hands-on, physical design project in their freshman year would broaden their experience and give them an appreciation for the discipline of industrial design.

Industrial design students in many schools have little immediate connection to engineering. Once they reach beyond preliminary ideas and refinement, industrial design projects are often intuitively analyzed. The introduction of engineering analysis and testing to support intuitive thinking adds tangible dimension to the design process. The blending of intuition with analytical thinking–designer with engineer results in the design being more comprehensive and compositional and the designers and engineers being more whole.

The activity of real world design is a collaboration of individuals from more than one academic discipline. In response to this reality, we introduced these collaborative design projects in two previously unrelated courses: a second semester freshman engineering course and a second semester sophomore industrial design studio.

THE PROJECT FOR THE FIRST TWO YEARS

Initially, we presented a project of mobility with two possible deliverables. We called the project STILLS, emphasizing the final deliverable which is a graphic plate, or stabile representation of movement. Half of the group of students were charged to design and construct a push-pull toy and the other half, a mobile. The following are the project briefs delivered to the students at the introduction of the project:

STILLS: a mobile

mobile: movable; capable of moving readily; flowing freely, as a liquid; changeable or changing easily in expression, mood, purpose; quickly responding to impulses; a piece of sculpture having delicately balanced units that move independently.

brief: design, construct and document a mobile. This is a project about developing an understanding of moving parts—parts moving with respect to one another. It is a project about an IDEA about mobility. What orders your design decisions about movement? This is your idea. Consider balance, joinery, elegance.

deliverables: as a team project you should provide the following: a full scale functioning prototype; a written abstract which explains the IDEA of your mobile; a written report for engineering students; a graphic report for engineering students; a graphic plate which includes the abstract, photographs (“stills”–the stabile representation of movement) and drawings of your final prototype. Teams should make independent decisions about their division of labor.
STILLS: a push-pull toy

**push**: to press against in order to move away; to move in a specified way by pressing; to urge to some action or course; to make a path by thrusting obstacles aside.

**pull**: to take hold of and cause to move toward or after oneself or itself; to propel by rowing; to draw out for ready use.

**brief**: design, construct and document a push-toy or a pull-toy. This is a project about developing an understanding of moving parts which render a reply—when moved, something is heard, felt or seen as a result of mechanical movement. It is a project about an IDEA about mobility and cause-and-effect. Consider the user.

**deliverables**: as a team project you should provide the following: a full scale functioning prototype; a written abstract which explains the IDEA of your toy; a written report for engineering students; a graphic report for engineering students; a graphic plate which includes photographs ("stills"—the stabile representation of movement), one of which should include a user, and drawings of your final prototype. Teams should make independent decisions about their division of labor.

LegoPOSTSCRIPT

In the third year of an industrial design / engineering student collaboration, the project brief included a component: the Lego Robotics Invention System. Using one of the systems, student teams were asked to utilize the given materials to develop a guiding vehicle, a path/site for its travel, and finally (NOT using Lego materials), what we called a "postscript". This feature could be a trailer that accompanies the vehicle, or a tower that attaches to the vehicle or any other concept that is mobilized by the vehicle. The requirements for the postscript were the following:

- It must be made from materials other than Lego except for necessary use of sensors or motors.
- It must attach elegantly to the guiding vehicle.
- The vehicle and postscript must travel a distance of at least 15 feet in the course of its journey.
- It must REACT at some moment during the journey. Something in the path must cause a mechanical action in the postscript. For example, a left turn might always cause a flag to go up.

There were 8 teams of 7 or 6 members. Each team was comprised of 3 integrated Project Teams.

As a way to generate some immediate familiarity with the LEGO RCX bricks, we set up a contest called the "LEGO RCX Challenge". In the challenge, teams of four students designed an autonomous vehicle that would be capable of negotiating a course twelve feet square with obstacles placed randomly in the space. To win the challenge, a vehicle needed to negotiate the course and run over an 8-inch by 10-inch target of black paper within five minutes. The teams could design either a wheeled vehicle or a tracked/treaded vehicle. The vehicles had three inputs (two touch sensors and one optical sensor) and two outputs (two motors). Most vehicles were successful and all students got an excellent quick immersion into the world of Lego Robotics. The students were now ready to move on to the more demanding design of the legoPOSTSCRIPT project.
THE PROJECT FOR LAST YEAR AND CURRENTLY

Walkmobile – 2003 & 2004

For the past two years we created a project called the Walkmobile. Last year we had eleven teams of six students and this year we had seven teams of nine students, five engineers and four designers. The students were charged with forming a working team, researching, designing, building, testing and demonstrating a walking device.

Charge – Create a walking device using a rechargeable screwdriver. The device should be robust and aesthetically appealing.

Milestones:
Friday, Feb. 27, 2004 3:00 pm in Cowgill Hall - Project Kickoff meeting
Friday, Mar. 19, 3:00pm in Cowgill Hall - Presentation of Project Management Plan, concepts, research, mock linkages, etc.
Friday, Apr. 2, 3:00 pm - Presentation of firm ideas, sketches, working joints & linkages, etc.
Friday, Apr. 9, 3:00 pm - Presentation of Prototype, Inventor/Cobalt/CAD drawings, report draft, etc.
Friday Apr 30, 3:00pm - Final Presentation and Demonstration of Working Walkmobile

Each team, as a group, should prepare a single written document that includes:

Title Page- project name, team number & name (if one), team members, team leader indicated, date
Abstract – outline the parameters of the project for a general audience.
Search – explain and document how outside influences affect design.
Constraints – outline the implicit and explicit constraints and their effect.
Criteria – define the critical issues that inform the design process.
Design process – show the design process from birth through walking.
References, Specifications, Parts list, Cost list

Each participant should prepare:

Participant Log– each student must prepare a log of your activities and experiences. Discuss the project, your ability to interact and participate with the team. Elaborate on successes and failures.

Peer evaluation – a form will be given out on 04/09/04 due 04/30/04.

Project Grading:
Grading - Individual grades will, in part, be based on:
peer evaluations of team members’ participation
the instructors’ evaluation of the written report
the instructors’ evaluation of the oral presentation
evaluations of the project by the instructor and by classmates

Your individual grade could be higher or lower than the team’s project grade

CONCLUSIONS AND ASSESSMENT

This collaborative effort between Engineering and Industrial Design is a continuing project. We have received previous grant funding from the Center for Excellence in Undergraduate Teaching (CEUT) at Virginia Tech. The grant was awarded for development of an annual joint endeavor between engineering design graphics and the sophomore design studio. The completion and dedication of the Frith Freshman Engineering Design Laboratory and accompanying donations from industry have provided new resources to expand this interdisciplinary design concept in the future.

As we began this experiment, we thought that we were looking for an understanding of elegance in the students’ work, and indeed we found this in a significant portion of the projects, but we also discovered a profound elegance in their partnerships. We continue to search for means of evaluation of the project. We began this process several years ago with a series of questions for the students. The first set was an anonymous questionnaire, which asked the students if the
project affirmed or altered their view of their own discipline or their partner’s discipline. The majority of the responses indicated an increased understanding and appreciation for their partner’s discipline and an affirmation of their own. From one engineering student: “There is more to engineering than taking in information and spitting out solutions. There is a creativity and freedom in design.” From one industrial design student: “This project has grounded my romantic view of industrial design. Now, I have experience that supports the idea that communication between professions is very important.” In the current team grouping we found that most of the teams worked well together. In two of the teams that did have significant conflicts, the conflicts were between two members of the same discipline. Also, the lack of strong work ethic (getting the job done) on the part of a few students did create isolated friction. There was never a sense of designers versus engineers. The large teams seemed generally to work well. We will probably continue working with teams of four to seven members.

The assessment of the projects is based on the elegance of the design, whether the design achieved the team’s stated goals, did it work at the final demonstration, teamwork and team interaction, and the final reports. This year the final reports and presentations were outstanding. We attributed this to the large team size that allowed two to three students to place major attention not only on the design, but also on the report and presentations. The final demonstration of these projects has become a well-attended event that faculty and students eagerly await at the end of spring semester. We hope that the success of the project presented in this paper will serve as a model for other diverse disciplines seeking more interaction and collaboration. It takes the commitment of the faculty and the willingness of the students to participate. If you begin it, it will succeed.

REFERENCES