Integrated Design Education:
Shifting the design paradigm

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ABSTRACT: Professional and student architects, engineers and contractors are learning the integrated design process through a course called DesignShift™ Charrette. The DesignShift format has been created to explore methods and technologies to bridge the independent silos in today’s design and construction industry. Funded through Energy Design Resources, the curriculum has been taught to a wide range of California university students and design team professionals. The program was introduced to undergraduate and masters of architecture students as a four-hour class and has evolved to one- and two-day workshops for students and professionals. Participants are tasked with developing strategies in a team setting for new buildings that focus on high performance solutions. The curriculum includes training in: (a) process change in integrated design intent, solutions and strategies; (b) process-oriented tools that create the infrastructure for integrated design; and (c) quantitative analysis tools that provide a network of information to guide integrated design decisions. The instructors address how to implement integrated design, present a process to achieve integrated design, and provide tools that can be used in charretting and early design processes. This paper provides an overview of the DesignShift process and outlines its history, curriculum, team dynamics and implementation components.

Keywords: integrated design charrette, zero net energy buildings

1. INTRODUCTION

The DesignShift™ Integrated Design Process and Charrette Delivery System is an educational program developed to train both students and professionals in methods that support collaboration, systems thinking and integrated design and construction efforts. The course breaks away from traditional fragmented design and construction models to teach a holistic process that encourages interdisciplinary participation in the early design stages for streamlined project delivery of a high-performance building. Attendees learn a replicable process that emphasizes team dynamics, tools and case studies to directly influence the built environment toward Zero Net Energy (ZNE) design.

The concept was launched in 2008 by key members of the Energy Design Resources (EDR) statewide team in California, who identified integrated design as an industry strategy with high potential to impact building efficiency. Southern California Edison (SCE) spearheaded the concept development. The integrated design initiative was developed in response to the goals of the California Long Term Energy Efficiency Strategic Plan, specifically strategies for new construction goals toward ZNE and heating, ventilation and air conditioning (HVAC) optimization for California’s climate. Since its inception, the course has evolved into a flexible curriculum that has been tailored to accommodate students or professionals with varying levels of experience, typically delivered in one- or two-day workshops. More than 200 participants have completed the DesignShift program, which so far has been offered through 16 California universities and two public utility training centers. Workshop participants have included students from California State Polytechnic University, Pomona; California Polytechnic State University, San Luis Obispo; University of California, Santa Barbara; University of California, Berkeley; University of California,
Davis; and Stanford University, among others. Feedback is collected following each workshop, resulting in a continuously refined workshop model.

The program continues to be supported by the EDR statewide team, which includes representatives from SCE, Pacific Gas and Electric (PG&E), San Diego Gas and Electric (SDG&E), Southern California Gas Company, and Sacramento Municipal Utility District (SMUD). EDR offers tools, educational opportunities and other resources to the building community to support the design, construction and operation of more energy efficient buildings. Energydesignresources.com is a key resource to design teams in California and has provided the opportunity for workshop participants to attend the workshop free of charge.

2. CURRICULUM

The DesignShift curriculum encourages participants to practice skills in systems thinking, integrated design and collaborative communication with the goal of bridging independent silos that inhibit integrated design. Participants learn about the fundamentals of climate change, energy consumption data, various integrated design and zero net energy definitions, appropriate design and technology principles and industry case studies of successful integrated design projects, so they are better equipped to communicate realistically about the importance of setting, communicating and reaching high performance goals.

Additionally, the charrette – a collaborative session where a group of individuals craft solutions to a design problem – introduces participants to working together with industry tools in the early design phase of an example building project to create integrated design solutions. Participants spend a significant portion of the workshop in small teams exploring an integrated systems approach on this mock project.

Each person is assigned to play a different role on the design team. The experience highlights the interplay between disciplines and offers opportunities early in the design process (Fig. 1) to create quantifiable, integrated high-performance building solutions and to exercise communication skills. Individuals are matched as much as possible to their real-life roles or area of expertise (e.g. owner, architect, engineer, civil engineer/landscape architect or contractor).

![Energy Savings During Design Phases](image)

**Fig. 1: The best opportunities for optimizing integrated design are early in the process when changes minimally impact cost. Inversely, the effort and cost increase as the design process progresses.**

The four primary learning objectives and curriculum goals are to:

A. Explore the importance and benefits of an integrated design approach that emphasizes cross-discipline participation to achieving ZNE building goals
B. Create an understanding of project management delivery structures associated with integrated design
C. Explore a suite of software tools for use during the early design stage to quickly guide a project in setting attainable goals
D. Experience a repeatable project methodology that promotes passive design approaches, encourages new technology and addresses larger infrastructure issues.

2.1 Curriculum Development and Approach

The DesignShift Charrette is presented in an interactive format over one or two days for professionals or students respectively. Since the first workshop event in 2009, post-workshop surveys have informed course designers of ways to refine the curriculum to fully engage participants and use class time more efficiently. For example, the student workshop was lengthened from one day to two in order to cover each topic more fully; and the online design competition timeline was revised to better suit the students’ needs. The professional charrette presenter lineup was modified to accommodate the one-day format based on feedback from participants.
Additionally, a set of adult learning principles used by the SCE Energy Education Center guided the presentation and hands-on learning format. These principles emphasize the inclusion of a lesson plan with clear alignment of learning objectives with specific outcomes; learner-centered content decisions; participatory activities; stand-up presentation; and effective group facilitation. These principles ensure that a variety of learning styles are supported and keep a strong focus on the organizing principle. Hands-on activities are used to check comprehension before leaving a key topic area; an emphasis is placed on maintaining a positive and supportive learning environment.

The workshop is led by expert instructors with professional experience implementing integrated design strategies and whose work focuses on energy efficient, low environmental impact design. The presentation mimics a Thought Map, a concept taught in the course, to convey the interrelation of human, environmental and building infrastructure systems. An accompanying workbook provides the participant with definitions, graphics, case studies and in-class exercises. The workbook facilitates group discussion during the presentation and becomes a reference resource for participants later.

For the professional charrettes, interactive communication is emphasized by rewarding group discussion and knowledge sharing with “play money,” which is used to purchase or sell project ideas and expertise. For both the professional and student workshops, multiple exercises enable participants to practice team dynamics and cooperation. Individuals are assigned roles (e.g. owner, architect, engineer, contractor) to play on their mock project. Hands-on activities using tracing paper, colorful drawing implements and netbooks teach habitual documentation and recording of the design process, a vital concept to evaluate the success and repeatability of design approaches on projects. Without a record of processes explored on a project, achievements would be difficult to replicate, and ineffective ideas may make it back onto the drawing board without modification.

The curriculum is grouped by concepts and definitions in order to be easily adapted to accommodate participants with varying degrees of design and professional experience. The intent is for the next generation of designers to use integrated design customarily rather than as an innovative practice, as well as to provide an opportunity for practiced professionals to refine their expertise by gaining integrated design skills. Reaching both students and professionals aims to expedite the shift in design approach, thereby increasing energy efficiency and working toward ZNE design.

2.2 Curriculum Components
The curriculum is organized into modules addressing:

- Components of integrated design including definitions and overview
- Team dynamics
- Project management and delivery
- The charrette process
- Simulation tools

2.2.1 Components of Integrated Design
Participants learn that integrated design concepts and definitions include both an impetus for shifting the design approach and an interconnection of systems as parts relating to the whole. Collaboration among disciplines and open communication are shown to positively affect project success. Project roles and educational backgrounds that may seem non-traditional to building design are discussed to shed light on the many sources of input that go into a project.

Core principles are introduced to evaluate and respond to project context. Considerations such as cultural setting, existing site conditions and interaction with current infrastructure, materials and microclimate are explored.

2.2.2 Team Dynamics
To reinforce the interdisciplinary imperative, participants engage in exercises to practice and understand team dynamics. Games that encourage creative thinking and help identify right- or left-brain dominance promote understanding of how different types of thinkers contribute to group-based problem solving. An important element of integrated design is bringing together logic-, linear-based personalities with creative, innovative types so that visionary ideas can be brought to life through pragmatic solutions. For instance, in one workshop event, a student team conceptualized a seaside school design with an innovative roof system that
visually imitates a wave pattern, which works synergistically with the wind and incorporates cutting edge technologies – all while enhancing the whimsical nature of design.

As mentioned, participants explore thought mapping, following a diagram style to outline information with branches of concepts and ideas. The processes for thought mapping are then applied in an exercise (Fig. 2) with the group.

2.2.3 Project Management and Delivery
The team dynamics module is followed by project management approaches pertinent to integrated design. Project roles and responsibilities are defined and then organized to illustrate connections between project team members. Lean construction principles are incorporated to raise awareness of materials sourcing and efficient installation to reduce waste.

The AIA Integrated Project Delivery (IPD) guidelines for contractual structures are presented to clarify how documentation, accountability and risk are distributed across the project team in various structures. Case studies of projects that successfully followed the IPD process are presented to both reinforce the concepts defined in the workshop and elicit ideas for application in participants’ mock project work.

A key aspect of IPD is the ability to better manage risk for the owner, architect, engineers, and contractor. By aligning the goals of these parties to be focused on the best outcome for the project and making each party responsible for the behavior of the others, everyone gains more control of the overall process. Thus, increased certainty among the principal parties mitigates risk.

In some projects, performance-based incentives built into the principal parties’ contracts also help align project design and construction goals and their achievement.

2.2.4 The Charrette Process
The practice of design charretting is essential to gathering group requirements, goals and ideas effectively. The method of conducting this group brainstorming exercise is defined both historically and in common contemporary usage. The Pyramid Approach (Fig. 3) was developed as part of DesignShift to guide project teams along a logical trajectory of design development that utilizes resources most effectively.

The approach begins at the base of the pyramid, with an assessment of climate conditions as well as considerations for available wind, sun and water resources. Cultural and community factors are also assessed. Enclosure or building envelope design plays a key role in the second stage of pyramid building, as do site interaction and site topography.

The discussion then flows into minimizing building loads and optimizing building elements. Participants move through successively narrower stages until specific products and technologies appropriate to the project are identified at the last stage of the charrette process.
2.2.5 Simulation Tools

The next section of the curriculum presents a suite of open source tools to help project teams create synergistic, efficient and sustainable designs from the outset. For optimized results, participants are encouraged to utilize these tools in preparation for the design charrette stage. Entering a design charrette with site and other key characteristics pre-identified will help guide the project team to ascertain which ideas will enhance synergies and optimize project results.

Instructors provide a tutorial on tools that provide participants with new skills immediately applicable to projects. Two tools focused on in the integrated design process were developed by the DesignShift creators to convey methods and concepts unique to the program. These tools, the DesignShift Project Delivery Creator and the Integrated Design Checklist, simplify integrated design tasks and reinforce a successful process. Other quantitative tools demonstrated include:

- NREL MapSearch to consolidate renewable energy source information based on location.
- Climate Consultant to display climate data, psychrometric chart and wind rose analysis by location.
- eQuest® for building energy simulation and analysis.
- Sensor Placement + Optimization Tool (SPOT™), for quick rendering of an interior space to evaluate lighting and daylighting options.
- NREL’s In My Back Yard (IMBY) to calculate energy produced by wind turbines and photovoltaic panels.
- ATHENA® EcoCalculator to assess life cycle for common building assemblies.

2.3 Design Competition

Participants in the student version of DesignShift apply their learning through a team competition. At the end of the first workshop day, students divide into teams and receive specifications and requirements for a mock building project. On the second day, teams provide physical sketches of their designs and develop a PowerPoint presentation that shows analytical results from the suite of tools introduced above.

Student teams are given time on their own after the workshop to finalize their designs (Fig. 4) and submit them online. Judging is based on the best combination of integrated design, energy efficiency and sustainability. Winning teams are recognized on the EDR website and awarded a prize. The competition gives students the opportunity to apply the concepts, test drive the tools and seek feedback from instructors.

For professionals, the workshops are one-day events with participants divided into teams that focus on a specific building system (e.g. cooling, heating, lighting/daylighting). The teams use play money to buy and sell their expertise. At the end of the session, teams present their work, and the winning team is recognized.

3. IMPLEMENTATION

The student program has reached participants from multiple universities in California, and the professional program has been presented at California investor-owned utilities’ training centers. Response from participants has been positive overall with regular course refinements to enhance participants’ experience based on real world feedback. Now that the program has a well-developed course agenda and class structure, the emphasis has shifted to creating a scalable andrepeatable educational training process.

Efforts to affect greater market transformation and reach an expanded audience include outreach to design and construction industry groups, possible continuing education credits to professionals, and successive, smaller workshops that focus on portions of the curriculum. Topics may focus on building enclosures, contract mechanisms, cost...
evaluation, renewables, lighting and daylighting strategies or charrette facilitation.

Feedback from student and professional workshop classes (Fig. 5) has created tremendous opportunity for the program to evolve. Each time the course is taught, participants complete surveys online, including open-ended questions that generate meaningful commentary. When asked about beneficial aspects of the course, participants responded:

- “...the fact that we got to work with professionals and other majors not relating to us. It was a great lesson in communication and team work.”
- “I believe that the program was organized and structured perfectly. We had enough time to do everything we needed and most importantly everything was fun. This was a great educational experience that will influence every participant’s professional careers.”
- “This was a fun workshop that integrated seamlessly across all stakeholder disciplines and should be experienced by others.”

4. CONCLUSION

The DesignShift Integrated Design Process and Charrette Delivery System transforms traditional design thought, breaks through independent silos and drives a new methodology into common practice. Using process-based and quantitative tools, case studies of successful projects and guidelines developed across disciplines, this effective, repeatable training approach has been successfully developed for both university students and professionals. Its versatile, scalable curriculum can be customized for different audiences and has evolved into a tool with realized project energy savings and sustainable benefits.

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6. REFERENCES

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