ABSTRACT
Despite many advances in design education, architectural educators are struggling to prepare students to meet the profound ecological challenges of our day. To embrace more effective ecological processes and methods, design educators must be challenged to reconsider and clarify the goals, approaches, and outcomes of sustainable design education. This paper explores how the emerging concept of “regenerative design” might inform the next generation of architectural education. Three architectural design courses taught over the past several years are used to illustrate potential pedagogical approaches and lessons for the integration of regenerative approaches to sustainable design in architectural design curricula.

Key words: architectural education, regenerative design, sustainable design.

1. THE SHIFT TO REGENERATIVE DESIGN
During the past decade significant educational transformations have taken place within architectural design education and practice. We have seen the inception and widespread adoption of the U.S. Green Building Council’s LEED certification system, the emergence of Building Integrated Modeling (BIM) and the integrated design process, the goal of carbon-neutrality established by the Architecture 2030 Challenge, and the development of a myriad of sustainable design guidelines, performance standards, technological systems, and evaluative tools and methods. While practical guidelines and rating systems are useful tools for students, they often lack a larger holistic and systemic ecological perspective. In his essay “Shifting our Mental Model – ‘Sustainability’ to Regeneration,” architect Bill Reed from the Integrated Design Collaborative, argues that we need a new and more ecologically robust model for design: “Sustainability, as currently practiced, is primarily an exercise in efficiency. In other words, through the use of BREEAM, LEED, and other rating systems we are attempting to slow down the damage caused by excessive resource use. We must do better...Our role, as designers and stakeholders is to shift our relationship to one that creates a whole system of mutually beneficial relationships. By doing so, the potential for green design moves us beyond sustaining the environment to one that can regenerate its health – as well as our own.” (1) Reed uses the following definitions to distinguish the transitions from “sustainable” to “restorative” and ultimately “regenerative design” (2, 3):

1. Sustainable Design – “Green Design” with an emphasis on reaching a point of being able to sustain the health of the planet's organisms and systems over time. Sustainability is an inflection point from degenerating to regenerating health.
2. Restorative Design – Approaching design in terms of using the activities of design and building to restore the capability of local natural systems to an entry state of self-organization and continual evolution.
3. Regenerative Design – This design process acknowledges that humans are an integral part of nature. Human and natural systems – currently disparate systems in Western culture – need to be in alignment in order to achieve a state of continual and healthy evolution. The design process can and should catalyze this alignment.

With aspirations to extend sustainable design thinking and practices to embody the next generation of ecological design education, a small cohort of faculty at the School of Architecture at the University of Minnesota have
brought the concept of a “regenerative trajectory” into the classroom. During the past three years, the integrative, restorative, and relational principles of “regenerative design” have been incorporated in several courses, including a graduate-level seminar on the “theory and practice of sustainable design,” a required first-year graduate studio on “zero-energy carbon-neutral design,” and a one-week intensive workshop on “video as an ecological design tool”. This paper explores three approaches to integrating regenerative design into architectural design curricula. It will explore the course objectives, content, projects, assessment methods and tools, and lessons gleaned from the courses during the past three years which might inform a more regenerative approach to the next generation of design education. For detailed information on the courses, including syllabi, project statements, and student work, see the “Zero+ Campus Design Project” website at: http://zeropluscampus.umn.edu/courses/. (4)

2. THEORY AND PRACTICE OF SUSTAINABLE DESIGN SEMINAR
During the past three years, students in the graduate-level “Theory and Practice of Sustainable Design” seminar have been asked to extend their understanding of sustainability to consider the ecological relationships, connections, complexity, and whole systems thinking inherent to a “regenerative approach” to sustainable design. As Bill Reed emphasizes in his essay “The Trajectory of Environmental Design,” the key is to move from designing “objects” to designing “relationships: “There is really no such thing as a ‘regenerative project’ – nor can there be – an object by itself cannot be regenerative – it’s about the relationship between the objects and how they are continually evolving that makes them regenerative. Regeneration is a process of engagements with the purpose of healing living systems.” (2) The two projects are designed to emphasize the assessment and design of ecological “relationships” within a local and bioregional context.

2.1 Regenerative Assessment and Design Intervention
Working in small teams, students are assigned a real client with a local project and site to work with throughout the semester. This two-phase project includes: 1) a regenerative design assessment and 2) a regenerative design proposal. In Project One, the regenerative assessment phase, students explore ecological relationships and whole systems thinking by assessing an organization, its facility, and context. The understanding developed in Project One is used as the foundation for Project Two in which each team proposes regenerative design interventions for the organizational mission, its facility, and its ecological context. Students are asked to work within the framework of the client’s ecological vision as well as tangible qualitative and quantitative design and performance goals. Teams develop a project assessment and regenerative design proposal using:

- In-person interviews with the organizations contact person and other interested individuals.
- On-site observations and field visit to the site and facility (a minimum of two visits is required).
- Library, internet, and case study research.
- Assessment and application of design guidelines and performance metrics.
- Brief written summaries, photographs, and diagrams.

Fig. 1: Regenerative Design Education (Doug Pierce after Bill Reed et al.)

The assessment and design phases are both organized according to three topics, the first of which focuses on the “Organizational Mission, Values, and Goals” which involves background research, in-person interviews, and a thorough site and building audit. The first topic encourages the team to approach ecological design within the context of
Next Generation Design Lessons

Working directly with organizations and businesses that embrace sustainability as part of their goals and mission provides a real-world context for students to critically explore the relationships between social values, economics, ecological issues, and design. Students are asked to grapple with the large “messy whole” while balancing and integrating the complexity of real client goals, existing site and project conditions and constraints, qualitative and experiential considerations, and early performance metrics and goals appropriate at the level of schematic design. The course challenges the assumption that complex projects need to be introduced incrementally, but rather purports that the “next generation” of design education must teach in ways that foster a more synthetic, concurrent, and dynamic integration of ecological goals, design issues, and scales.

3. ZERO-ENERGY AND CARBON-NEUTRAL DESIGN STUDIO

In contrast to the proceeding course, the “Zero-energy Carbon-neutral Design Studio” is a required six-week spring studio for all first year graduate students. The course has a narrow focus on the regenerative design opportunities of daylighting and thermal design as vehicles to reduce building energy consumption and carbon emissions. Students work in teams to consider how architectural design can respond to the growing challenges of global warming and climate change. The course project uses a proposed “Minnesota Zero-Emission Zero-Energy Design Lab” as a third-floor addition to the existing Rapson Hall for the College of Design at the University of Minnesota (a potential project for the University). Students are asked to investigate how the building – through its site design, massing, section, envelope, materials, systems integration, and details – could significantly harvest solar and renewable energy to reduce and meet energy demands while also addressing design excellence and creating meaningful architectural experiences. The educational challenge is to design a curriculum that captures the complex design processes, methods, and integrated thinking necessary to promote a regenerative and next generation approach to zero-energy and carbon-neutral sustainable design and practice.

3.1 Zero-Energy Carbon-Neutral Assessment and Design

In contrast to the typical design studio, this six-credit hybrid design/technology studio is scheduled for only 6.5 weeks, meeting essentially all-day on three days per week. The course is taught by a team of design educators in collaboration with visiting practitioners (including three educators in environmental technology, sustainable design, and computer methods and four visiting design critics who provide additional studio critiques). Forty-five to fifty students worked in teams of four.

The content of the course is organized as a series of iterative projects with six topical modules related to zero-energy carbon-neutral design: 1) bioclimatic response,
2) daylighting integration, 3) thermal optimization, 4) ecological envelope, 5) experiencing sustainability (lightscapes) and 6) whole building and systems integration. Students address the design of the “whole” and the design of the “parts” by alternately focusing on the integration of daylight and thermal design issues at the scales of the building massing, section, rooms, envelope details, and systems integration. Working as a team, students develop, refine, and evaluate design proposals using iterative processes and methods.

3.2 Bioclimatic Design
In Project One, students participate in a design charrette to evaluate Rapson Hall at the site and building scales and to develop preliminary design proposals that explore the bioclimatic “story” or “narrative” of their site and program for the “Zero-Emission/Zero-Energy Design Lab”. This project immediately elevates the regenerative concept of shifting from designing “objects” to designing “relationships.” Teams are asked to develop a presentation capturing the experiential and physical forces on the site that could shape architectural design from a bioclimatic perspective. This includes an ecological inventory and development of four design proposals at the scales of the site and building massing. The “bioclimatic inventory” uses photography, graphics, and diagrams to investigate varied conditions, including: site and bioclimatic forces and features; luminous and thermal phenomena; indoor environmental quality; the journey through the site/building; construction and enclosure conditions; materials and details; and the experiential and poetic design opportunities. Conceptual design proposals include physical and computer models at the site and massing scales, time sequence studies of the models, Ecotect solar studies at the site/building massing scale, and a written and graphic critique on critical bioclimatic issues and lessons.

3.3 Daylighting Design
In Project Two, teams move into a series of qualitative and quantitative daylighting investigations. This enables the instructors to elevate the integration of design excellence, spatial quality, and human experience while simultaneously considering quantitative luminous performance. While daylighting is the primary lens used in the second project, the related issues of place, thermal comfort, heating, and cooling remain present in the investigation.

In Project Two, students evaluate the daylighting design from their bioclimatic design proposals in Project One. They considered how to use the daylighting design to capture and celebrate the bioregional qualities of light in place and to harvest energy from the sun and wind. Emphasis is on ecological and human relationships and the potential of passive design strategies to reduce energy consumption and carbon emissions while creating beauty. The evaluative process includes development of a comprehensive daylighting program based on activities (written and photographic qualities of light); physical site and massing models; plans and sections; diurnal and seasonal photographs of the physical models; an Ecotect quantitative analysis on a diurnal and seasonal basis (illuminance studies for 9 a.m., noon, and 3 p.m. for the equinoxes and solstices); and a written and graphic critique of critical daylighting issues and lessons. The daylighting studies elevate the intersection between poetic and pragmatic ecological design considerations, site and contextual relationships, and the potential design and experiential opportunities of daylighting as well as the energy and performance considerations. The early daylighting studies are carried forward into the next project to evaluate the effectiveness of the proposed thermal and passive design strategies.

3.4 Optimizing Thermal Performance and Building Loads
In Project Three students establish energy and thermal performance goals and seek to achieve thermal design optimization through the application of passive strategies and systems integration using an iterative parametric analysis method. This involves the initial assessment of the daylighting proposals from a passive solar perspective. The passive assessment is followed by development of several hypotheses to reduce energy
consumption and carbon emissions that are tested through parametric isolation, iterative simulation, and comparative evaluation. Students continued to improve upon their earlier design proposal though incremental refinements and testing toward the goal of thermal design optimization for a passive design approach.

The evaluative processes for Project Three focuses on the use of Ecotect computer modeling to test their hypotheses and examine the resulting impacts on building heating and cooling loads as well as other performance metrics such as internal temperature, passive gains, and thermal comfort. Each team is asked to prepare a presentation illustrating their research data, hypotheses, methods, findings, and conclusions. A written and graphic critique is required to consider critical thermal lessons and intersections with earlier studies on bioclimatic and daylighting design.

The evaluative process includes development of large scale physical models and building sections to explore the integration of ecological concepts with building materials and detailing. The large scale physical models encourage students to integrate ecological issues seasonally and diurnally and to gain an understanding of construction methods and details.

3.5 Ecological Envelopes
In Project Four, students revise their initial design proposal to explore the integration of ecological concepts and passive and active approaches to lighting, heating, and ventilation at the scale of the building envelope. The challenge is to consider the opportunities of the building skin as an ecologically responsive envelope. They are asked to consider the concept of “fivefold functionality” by exploring how the envelope might address multiple issues such as the integration of passive and active systems for heating and cooling as well as additional ecological concerns such as harvesting water, generating electrical energy, creating habitat, responding to health and well-being, creating beauty, connecting to place, etc.

The evaluative process includes development of large scale physical models and building sections to explore the integration of ecological concepts with building materials and detailing. The large scale physical models encourage students to integrate ecological issues seasonally and diurnally and to gain an understanding of construction methods and details.

3.6 Lightscapes: Experiencing Sustainability
Prior to moving into the whole building systems integration, students are asked to step back and look at the quality and detailing of one significant space within the proposed building addition. This enables the students to more deeply explore materials, construction, and systems integration at the scale of a room. Students develop and test both poetic and pragmatic design intentions through parametric studies using large scale physical and computer models. These studies enable students to gain a better sense of the experience of sustainability in their project while also further exploring the material and detail opportunities of their design proposals.

The evaluative process includes photo-documentation of the quality of space and sun penetration studies; Ecotect illuminance studies on a diurnal and seasonal basis; and Ecotect thermal studies to evaluate hourly temperatures and passive gains. DAYSIM and Radiance studies are optional. While time consuming, this project results in great insight into the quality of the space and further resolution of daylighting and thermal integration within a bioregional and site context. At this point in the semester, students had gained sufficient experience with the qualitative and quantitative methods of testing and analysis to successfully evaluate and modify their design proposals. The qualitative daylighting studies of the large-scale physical models are invaluable in enabling the students to experience the character of the space in time and to successfully assess both design excellence and design performance. In the final project, students are asked to use this study to inform systems integration at the scale of the whole.

3.7 Whole Building and Systems Integration
The final project focuses on the integration of the architectural design with lighting, thermal, and renewable energy systems. Emphasis is on the creation of a meaningful whole that aspires towards broader regenerative design goals while addressing human comfort and design excellence. In the Project Six, teams...
present a final evolution and evaluation of their project. They develop an integrated design solution for the proposed addition and compared the performance to a “baseline case,” which is their initial concept presented in Project One and analyzed in Project Two. Teams are required to meet the daylighting, thermal, ventilation, energy, greenhouse gas emissions, and other relevant design and ecological goals set by the team. They analyze the final design and compare the results to the original “baseline case” showing the estimated improvements in energy use, carbon dioxide emissions, thermal comfort, daylighting performance, and other ecological metrics of student’s choice. The evaluative process for Project Six includes physical models at the site, room, and envelope scales; daylighting studies (qualitative time sequence photographs and Ecotect, DAYSIM, Radiance studies on a diurnal and seasonal basis); thermal studies using Ecotect to assess passive solar and system integration; carbon calculations; graphical systems integration studies; and a final written conclusion.

3.8 Next Generation Design Lessons

This model of integrating ecological design education and related technological considerations into the design studio enables students to meaningfully integrate zero-energy and carbon-neutral design thinking into their personal design and decision-making processes. After three-years of teaching the hybrid “technology-studio,” the instructors witness a profound change over the course of the 6.5 weeks in the students’ abilities, confidence, and skill in framing design questions and then investigating and weighing both poetic and pragmatic ecological design considerations. The direct application of ecological and technological issues into the early design studio provides a solid foundation that positively supports the students’ ability to address ecological design in their on-going education and practice. The benefits of direct design application and synthesis within a studio-context outweighs the loss of additional time for reflection and processing found in a traditional lecture course. As an ecological design “emersion experience” students have responded positively to the studio. Each first-year graduate student is introduced to “zero-energy carbon-neutral design” as a foundation to a regenerative and next generation approach to sustainable architecture.

4. VIDEO AS AN ECOLOGICAL DESIGN TOOL WORKSHOP

The final course that has been considered within the context of regenerative design is a 1-credit 1-week workshop on “Video as an Ecological Design Tool.” It uses off-the-shelf digital video and editing software to envision the inter-relationships between energy, waste, water and carbon emissions across the building and site scales on the University of Minnesota Campus. The primary goal of the workshop was to explore the creative design potential and opportunities of video as a temporal and spatial ecological design tool. Students worked in small teams to investigate ecological design opportunities and interventions that could inspire the University of Minnesota towards becoming a zero emissions, zero-energy, zero water, zero runoff, and zero-waste campus.

4.1 Workshop Provocation and Design Assessment

Working with film producer and guest instructor Jeff Sylvestre and multi-media librarians Scott Spicer and Jenny Veille, students worked in small teams to produce a video “provocation” to inspire the administration, students, faculty, and the public to imagine the regenerative and sustainable design opportunities of the University of Minnesota Campus. Video and multi-media were used to assess existing ecological conditions at an assigned site on the campus; to visualize energy, water, and/or resource flows and integrated ecological opportunities on campus; and to present design concepts and interventions to reduce ecological impacts. The emphasis of the exploration was on process and exploration rather than the final video outcome.

4.2 Workshop Procedure

Working as a team, students quickly defined an ecological design “provocation” focusing on the question “What if the University of Minnesota campus...” The ecological design “provocation” (question, hypothesis, or design challenge) was used to explore one or more ecological issues related to energy, water, carbon, habitat, and/or biodiversity. The teams then developed an “ecological design intervention” for a specific site/district on the campus. Video and multi-media were used to develop a 60-90 second video proposal exploring the team’s chosen question and ecological design intervention on the site. During the one-week period, filmmaker Jeff Sylvestre incrementally introduced the students to the fundamentals of storyboarding, scripting, film production, and editing. Video critiques were conducted throughout the week. Extensive case studies of video clips were critiqued throughout the
week. The learning curve on the video and multi-media software was surprisingly fast, with students gaining confidence and comfort within a 24-hour period. The final day of the workshop was used for video screening and discussion on the role of video and multi-media in ecological design.

4.3 Next Generation Design Lessons
This one-week workshop on video and multi-media introduced students to a new way of thinking about ecological issues and design. Video is unique in allowing designers to concurrently layer multiple messages and communication techniques through visual imagery, sound/silence, text, and narration. As Jeff Sylvestre explained to the students: “Video can present aspects of a subject as a unified presentation with many different parts - patching together elements of a subject into a quilt-like whole. Video allows for presenting information in many modes - visually, aurally, narratively, graphically, experientially, emotionally. They tend to be better at reaching different types of learners. Videos are fun to watch. They go beyond lecture, PowerPoint, or the printed page. They can engage the heart as well as the mind, combining visuals, text, music, testimonial, narrative, and emotional response as well as intellectual. They peak curiosity on many levels.” (6) Video is an exceptional ecological design tool for exploring varied types of relationships, whether they are conceptual, contextual, or physical.

The exercise of developing a 60-90 second video encouraged students to focus, edit, and simplify their design concepts and messages. Students were able to step outside of the traditional modes of architectural representation. Video enabled them to juxtapose ecological images, messages, and sounds to deliver a design concept in a compelling ways that can reach a broader audience. It enabled the students to deliver an ecological design message in a way that was inspiring, hopeful, and compelling. Video and multi-media provide a unique means of communicating the complexity and interconnection of regenerative and sustainable design issues. Video is an excellent complement to more traditional means of architectural representation and communication.

5. LESSONS FOR A REGENERATIVE DESIGN TRAJECTORY
During the past three years of teaching a series of lessons related to the “regenerative trajectory” have emerged from the preceding courses, including:
• Grappling with the Messy Whole: Educators need to encourage students to explore the inter-relationship between ecological issues, scales, and design goals. Working across topics and scales helps students to shift from designing “objects” to designing “relationships”. Students need to be introduced to the complexity and “messiness” of ecological design thinking early in their education.
• **Why Real Clients and Sites Matter:** Introduction to real sites and real clients (even in the earliest of design studios and courses) enables students to gain first-hand understanding of ecological relationships and contexts. A real site can be touched, felt, observed, revisited, and experienced through time. Real clients enable students to engage in a dialogue with the clients and design issues and to explore solutions to real world problems. Reconnecting design to the natural and built world with ecological, cultural, and contextual relationships may be the single most important lessons students learn from a regenerative approach to sustainable design.

• **When “Simple” Analyses is Good Enough:** Schematic design and assessment tools still lag far behind educators’, students’, and the profession’s desires to quantitatively evaluate design decisions. Despite the limitations of existing tools, it is important to introduce quantitative and qualitative analyses early in the design process. Schematic design tools can be used to strengthen students’ intuitive design skills and to test the strengths and limitation of existing tools.

• **The Value of Diagrams and Visual Communication:** Students and the profession need new ways of exploring and visually and graphically communicating the complex inter-relationships inherent to regenerative design. It is essential to introduce diagramming and representational methods to help students explore design thinking and communicate to their clients, including integration diagrams, strategy matrices, feedback loops, video and multi-media, among other techniques.

• **The Undivided Life:** Educators can encourage students to explore and challenge their own values, personal habits, and lifestyles within the context of design practice. Tools such as “ecological footprint calculators,” journals, photo-documentation, and reflection exercises can be used to explore regenerative design principles and the inter-connection between personal and professional values and actions.

• **Inspiration from Outside the Profession:** Students should be encouraged to look outside the design professions to consider how other disciplines and professions might inspire the next generation of design thinking and practice. Consider integrating ecological theories such as bioregionalism, deep ecology, eco-feminism, environmental justice, and biomimicry into the curricula. Collaborate with local individuals and organizations outside of architecture to extend ecological thinking and to create new partnerships and alliances.

• **Creating the Path Together:** A regenerative approach to sustainability is an emerging approach to architectural design. Create opportunities, however modest, to test new ecological design ideas in the classroom. Invite students, local practitioners, and other disciplines and organizations to be partners in defining and creating the next generation of regenerative sustainable design. Share work with other educators and practitioners.

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7. **REFERENCES**


(4) Zero+ Campus Design Project, University of Minnesota, http://zeropluscampus.umn.edu/courses/
