Performance-Based Directives in Architectural Studio-Based Education: Methods and Studio Project Outcomes in Sustainable Architecture and Design[1]

DANIEL FAORO
Lawrence Technological University

JANICE MEANS
Lawrence Technological University

> *But I am convinced by the poignant observation of a famous architect and revered teacher of architecture: he needs to teach, he says, because with his students he can propose the ideal solutions of problems, rather than the routine compromises that he must submit to in the world as it is.* –Paul Goodman, *The Community of Scholars*, 1962.
>
> *A great building must begin with the unmeasurable, must go through measurable means when it is being designed and in the end must be unmeasurable.* –Louis Kahn.

The implication in these quotes is that the position of an architectural educator in the design studio belongs to a unique, if not rarified, group of individuals who are by nature idealistic and who focus on what might be called transcendent truths. When the architect co-author of this paper referred to the Louis Kahn quote at a university assessment event, he was told by the engineering faculty member speaker, that if this was true, then perhaps design studio courses should be graded. A physical science based faculty member added, 'If something cannot be measured then it does not exist'. In conclusion, the speaker suggested that if you cannot measure the cognitive skill or ability you attempt to evaluate, then you should not attempt to teach it. When attending my first jury as a young architecture faculty member 20 years ago, I asked what aspects I should focus on in my comments and was told, "Just consider if it is architecture or isn't".

Both Louis Kahn and Paul Goodman identify two ever present issues in architectural education today: the need for *relevancy* and *accountability.* Administrators, accrediting agencies and students want to know how architectural studies relate to the world of practice and how students and their projects are evaluated. This paper addresses these issues and proposes a methodology which has proven to be successful, as evidenced by five years of consecutive student awards at the international level.

Donald Schön considers design and engineering problems to contain both the issues of rigor (technical process of how we build a road) and relevance (political/social value-based problems of where the road will go). In the design studio, the goal is often a delicate balance between the two. Schön, in his attempt to clarify the outcomes in architectural design, identified twelve "design domains": program/use, siting, building elements, organization of space, form, structure/technology, scale, cost, building character, precedent, representation, and explanation.[2] The authors have used these identified design domains as criteria on project evaluation forms to serve as feedback to students during design reviews. This is done in an effort to shift to measurable learning outcomes by focusing on course work and viewing it as a knowledge-based learning experience relative to a student's abilities and skills in architectural design.[3] As a result, the methods of instruction become prescriptive to mea-

sure and expand the student's knowledge base of place-making, design methodology, building systems and design strategies and the focus is on those skills which are both measurable and transferable.

ARCHITECTURAL STUDIO-BASED EDUCATION AND THE SCIENTIFIC METHOD

An assertion is often made by architectural faculty that 'design is research' or that 'design is solution seeking'. The understanding of the design process must come from how traditional researchers view the process and the validity of their work. Universities are primarily concerned with three activities: preservation of knowledge, where a body of facts about the world are organized and accepted as truth (scholarship); transmission of knowledge where the concern is with how students learn (teaching); and development of new knowledge concerned with revealing, displacing, or expanding of truth (research). In the applied professions, these activities are conducted in the pursuit of service with benefits for the 'common good', with such activities supporting the public/nonprofit status of institutions of higher learning. Pure researchers utilize the scientific method employing the following processes to identify 'truth' as the crux of their work.

1. *A hypothesis is formed* attempting to relate select parameters to an outcome. By definition, it narrows the scope of study by addressing a singular issue which is measurable and germane to the researcher's field of knowledge. It should also be based on background studies of existing research in the researcher's field, i.e. the hypothesis and methodology should advance the field of study and its pursuit may build upon or expand, but not replicate, the work of others (unless substantiating others' findings).

2. *A methodology is developed* (experiment) to measure the impact of specific parameters in a process and to isolate their unique characteristics from other parameters that are present in the experiment. The measurement methods (data collection) should be well documented and be able to be replicated by others. Research parameters must be understood as generic and in turn, results of processes predictable. The philosopher, Thomas Aquinas, asserted that knowledge that is able to be replicated, or which forms a general rule, is the most perfect form of knowledge.

3. *Results are tabulated* and presented in a format such that observations can be made, conclusions can be formulated (analysis), and the results can be replicated.

4. *A summary of the results are made* and one of the following outcomes result: the original hypothesis is upheld, failed to be proven, or the experimental methodology is compromised or proves to be inconclusive. In the last case, researchers are expected to offer suggestions as to how the methodology can be improved.

5. *References and acknowledgments are cited* to any works which inspired or informed the study.[4]

In studio based projects, it is difficult to provide the format for the inquiry described above for the following reasons:

- **Architects are not as concerned with 'absolute truth' as they are with compliance of 'standards of care and competence'.** How these criteria are derived often varies, but they are usually based on accepted practices and the consequence of not following them is problematic.

- **The design process is viewed, and often described as an art—individualistic and not able to be generalized.** This is problematic since the 1970's U.S. Supreme Court ruling regarding supplanting and setting of fee schedules essentially redefined architectural practice as a commercial enterprise rather than a professional service. Still, practitioners often market themselves claiming to have specialized knowledge and practice unique to their individual genius and use this claim as a marketing tool. The concept of sharing it with the rest of the profession so the world can benefit while altruistic, diminishes the firm's position of market dominance. The 'star system' in selecting studio instructors reinforces the idea that a student's knowledge is linked to the lineage of a unique master under which the student studied. Only the most respected and established professionals are allowed the ability to pass on their specialized views of methodology. In turn, their values are not challenged. They need not defend their pedagogy on the basis of educational assessment norms and their courses are often classified as 'electives' which are not subject to scrutiny by accreditation agencies.

- **The basis of research methodology in design studies involves multiple variables, is very complex, and is often described as 'systems based'.** Isolating key, singular, parameters and concentrating on their impact during the process of design is not the objective in design methodology. The design process is viewed as a 'holistic' activity which is multi-disciplinary and often both iterative and integrative in nature. Knowledge in architecture is related to the 'phenomenological' branch of philosophy. In this regard, knowledge is considered only partial and imperfect, as we uncover only some of the many complex series of interrelationships. Architecture is not reproducible to standardized solutions since the final solution is dependent upon the context of the site conditions and varying client needs. These render architecture as different from the mass production models in 'product design'. Neither is it comprised of the singular focused tasks often found in engineering.[5] In the words of the late structural engineer Mario Salvadori, an architect at the end of his/her career finds they know a little about many subjects, whereas, in context, the engineer knows much about his/her specialty, but has little broad-based knowledge on other subjects.

- **Design studio outcomes rarely result in physical, science–based, tangible, or measurable, physical evidenced-based results leading to verification of a hypothesis.** However, design build studio projects can afford the opportunity for measuring physical parameters and, thus, the process can involve aspects of the scientific method. Case studies, as post occupancy evaluations, e.g., as shown in the "Vital Signs" and "Cool Tools" projects, can serve as measurable research outcomes as well.

In the next section, the example of work describes performance- based methods in the design studio with a strong emphasis on sustainable design outcomes.[6]

NORMATIVE DEFINITIONS IN EDUCATION OF COGNITIVE DEVELOPMENT LEVELS

Historically, architecture design instruction was thought to be primarily integrative in nature, or the bringing together of knowledge from supporting lecture courses. Although this is still true to some extent for our institution, the authors' efforts are based on both the transmission and application of architectural knowledge. In the fourth year of the curriculum, when the course described in the following sections is offered, students at most architectural institutions are making a transition from the traditional lecture course as part of their course work in the liberal arts and sciences, to the architecture studio and department-based courses. For the subject example studio, assignments in reading and writing provide a transition from the traditional liberal arts and science course work to the more uniquely skilled architecture courses. Course projects involve not only design projects but preparations of reports on site analysis, local history, climate, vernacular traditions, and answering questions based on selected readings. Students provide written design statements with each project. The very act of writing can change the atmosphere of the class from casual to serious.

The course is designed to foster the development of cognitive skills; the listing is based on a synthesis of Bloom's Cognitive Skills Inventory (1956), and Boyer/Mitgang recommendation for architectural education in Building Community (1996).

a) Discovery of Knowledge--the ability to learn and recall key concepts.

b) Integration of Knowledge:

1. *Comprehension of concepts*--the ability to recognize the meaning of concepts.

2. *Analysis skills*--the ability to isolate and identify significant parameters or factors that help explain how a conceptual framework or model was developed.

3. *Synthesis skills--the ability to apply the differing subject areas into a coherent 'whole' concept.*

c) Application of Knowledge--the ability to generalize or find new applications for the concepts either literal or abstract.

1. *Sharing of Knowledge*--the develop-ment of communication-based skills (See notes below.)

d) Evaluation of Concepts--the ethical and moral basis of valuing, choosing or deciding on what de-

sign is most appropriate to respond to public interest issues such as health, safety, general welfare, and ecological impacts.

THE DEFINITION OF CREATIVITY AND THE STUDIO EXPERIENCE:

> *...the creative process is that in the emergence in action of a novel relational product, growing out of the uniqueness of the individual on the one hand, and the materials, events, people, or circumstances of his life on the other.*[7]
>
> *--Carl Rogers*

> *I had a pretty good experience in school after I realized I wasn't supposed to be creative. Instead I was supposed to learn what they were teaching me and give it back to them.*[8] *--Carol Ross Barney, FAIA*

> *"Creativity is arrived at not through intuition but through science." --Lev Zetlin, PE*

In the performance-based design studio process, the authors establish a set of principles and methods to encourage studies based on establishing clarity in how creative studies are evaluated. Students appear to find the studio experience rewarding in the therapeutic sense of satisfying a need for self expression rather than as an intellectual process of generating alternatives and evaluating them. The difficulty in evaluating creative works is problematic, as Carol Ross-Barney's quote above suggests.

In a learning environment, with an emphasis on evidence and measurable results, a shift away from the creative process can take place. In his work, *The Theory of Creativity,* the educator and psychotherapist Carl Rogers notes that evaluators need to examine the *process* rather than the *product*.

The process for this studio involves the study of metrics including codes, energy standards and the USGBC criteria for LEED® certification to define the parameters for the students' designs. For the authors, creativity is measured in a student's work with regard to process, while students alone judge the product. The instructors' responsibilities are twofold: *evaluating the areas of cognitive and architectural knowledge/skills*; and *the ability to engage in a creative process*.

Rogers identifies the following conditions as necessary for creative actions.

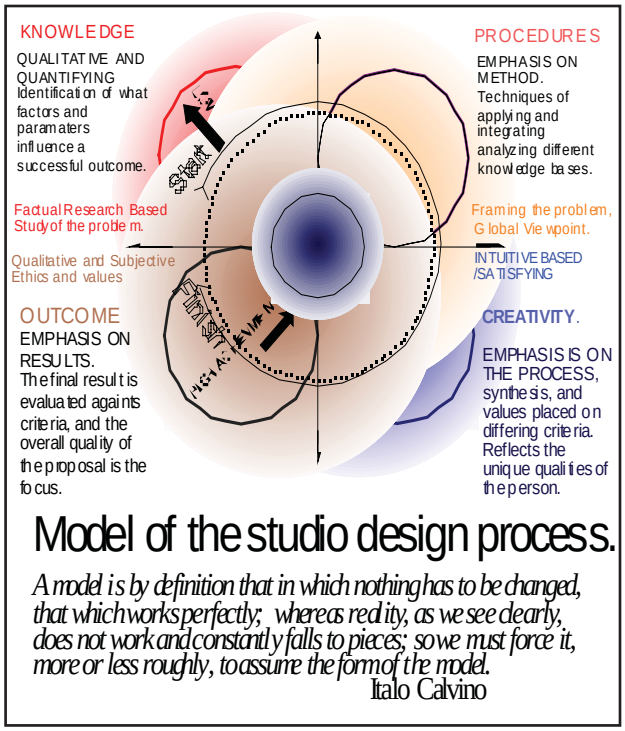

Figure 1. Model of the Studio Design Process

A. *Openness to experience or "Extensionality".* A person must be open to experiences, not defensive, and avoiding predetermined reactions or perceptions.

B. *An Internal Locus of Evaluation*. The value of the creative product is held by the individual not an external evaluator. It must be satisfying and an expression of the individual.

C. *The ability to Toy or Play with Elements*. The philosopher Emmanuel Kant would refer to this as *purposiveness, without purpose* or *the free play of imagination.* This is the ability to play spontaneously with ideas, shapes, colors, or relationships. Excessive play, however, can lead to a lack of focus and not be productive. Not all individuals are comfortable with creative actions. Instructors should respect that point of view and try to help students become comfortable to take these risks.

Dr. Arthur Winter, M.D., believes that you can enhance the creative process by engaging your preconscious by the following actions:

A. Talk about yourself and your past and remove yourself of inhibitions caused by people and circumstances of the past.

B. Do not select a defined role for yourself. This inhibits alternative approaches to problem solving.

C. Enjoy the pursuits of wonder, curiosity, playfulness, and imagination like a child.

D. Do not prejudge your ideas. Let them flow. Verbalize or write down your ideas.

E. Write or tape your frustrations and record what is bothering you.

F. Change your environment if you are having problems with generating ideas.

G. Review and analyze only after you have removed any restraints to your flow of ideas.

H. Do not be afraid to make mistakes. Write your ideas down in detail. Look at the flaws and then reinvestigate them again.

I. Do not make excuses.

J. Associate yourself with people who are encouraging rather than discouraging.

These conditions and enhancements touted by Carl Rogers and Dr. Winter are consistent with those of the late engineer, Dr. Paul B. MacCready. Dr. MacCready inventions include the Gossamer Condor, the first human-powered vehicle to fly over the English Channel. In a 1980's lecture at Oakland University in Rochester, Michigan, Dr. MacCready shared that there must be a desire to achieve for creativity to flourish. In his case, it was a desire to pay off a debt. Combining studio with a competition which promises monetary reward and wide personal recognition contributes to the motivation and creativity of students.

PARALLEL THEORIES: COGNITIVE ORIENTATION AND ARCHITECTURAL DESIGN THEORY / METHODOLOGY

Performance-based design should be linked to knowledge and cognitive studies to guide informed decision making. Experts in cognitive and learning theory state that individuals have a variety of cognitive orientations. The authors attempt to allow students to approach design problems in a manner that parallels the four intellectual tendencies which theorists have identified as: rational/analytic; intuitive/global; principle-centered; or factual.

The authors further propose that parallel architectural-based intellectual approaches to the learning modes of the Myers-Briggs personality profiles can be found in the model by Robert Oxman.[9] These approaches are compared below.

Architectural Strategy / Theory (Robert Oxman)	**Learning Modes / Cognitive Equivalent** *(Meyers-Briggs)*
*Canonic: an existing parti is emulated. (*e.g., an architectural precedent is adopted as a model)	*Factual:* Truths are revealed by accepted facts and form the basis for decisions, knowledge or prece-dent based.
Metaphoric: a form or Gestalt Emerges (e.g. contextualism, geology, cultural or clients' personal influence establishes directives)	*Intuitive /Global:* Solutions are derived from experience or observation arrived from broad goals.
Systematic: a modular, or geometric, pattern is imposed upon the problem (e.g., a cellular or modular approach in design)	*Analytic:* Solutions are derived from the fit between the problems objectives and the physical requirements.
Syntactic: a formal language or some structural pattern is established. This structure and its generative rules form the basis for a process or fit. (e.g., Pattern language/New urbanism)	*Principle centered:* A rule based approach is followed. Compositional or other system based rules.

SENIOR YEAR SUSTAINABILITY STUDIO COURSE

The sustainability Studio is an elective allied studio course available to senior architecture students who have completed four integrated design studios, at least two structures courses, and two environmental systems courses (sometimes one concurrently). The integrated design studio (IDS) concept is unique to our university. It fosters an interdisciplinary approach to architecture studio education.

In the initial phase of this studio, students study fact-based data gathering on microclimate, sunlight and wind affects, codes and standards, sustainability guidelines, sustainable technologies, improved methods of assembly, vernacular architecture informing new designs, low-embodied construction materials, programmatic functional relationships, context and site influences, and constraints. They then employ normative analytical methods for interpreting the relevance of their findings to initial design decision making for site placement, orientation, disposition of space, and form generation. For multi-building projects, creating a sense of place based on critical regionalism and climate is emphasized. The project scope involves the development of a site master plan, specific design of building sites, HVAC, structure, and construction system development, primary wall sections, and selection of environmentally responsive design materials and systems

EXPANDED FORMAT OF THE SENIOR LEVEL SUSTAINABILITY STUDIO, LAWRENCE TECHNOLOGICAL UNIVERSITY 2002-2007

The studio course has a pedagogical basis as cited above with an emphasis on the "integrated studio" model. The projects are based on entries to an international sus-tainable architecture competition sponsored by the American Society of Heating, Refrige-rating, and Air-Conditioning Engineers (ASHRAE). Lawrence Tech projects have been selected as first, second or third place awards for the last five consecutive years.

The course is developed with four phases:

I. Documentation of Background Data and Relevant Key Project Conditions

II. Integration of Knowledge and Alternative Development Based on Divergent Thinking

III. Design Development Phase

IV. Final Documentation/Presentation

Phase I (3 weeks): Documentation of Background Data and Relevant Key Project Conditions

This is a team-based study of: relevant background information; site analysis; historical/cultural context; climate; passive control strategies and analysis; spatial/functional analysis; building code/ standards search (IBC and ASHRAE); energy-conserving mechanical and electrical systems; LEED® criteria; and the developing of digital models for site conditions. Parallel to this is a individual investigations of case studies and examples of sustainable projects of the same building type as the design problem (precedent examples).

The studies are generated with results that have direct design implications and can be used to make informed design decisions. Students are expected to develop effective strategies for: functional user-based space planning; climate responsiveness; building code solutions for exiting and system selections; viable passive and active alternative energy systems; site planning strategies to solve issues of access, massing, form and solar shading; and information on potential LEED® credits. Student utilize computer programs for this work including: Sketch-up®, for site models and shadow studies; Climate Consultant® for climatic analysis and climate responsive design strategies; Google Earth® for physical context models; and municipal database information and social/economic profiles. This work is presented, made available to all, and considered as common or shared research in a digital format.

Phase II (4 weeks): Integration of Knowledge and Alternative Development Based on Divergent Thinking

The class is divided into two-person teams who proceed as follows. Preliminary designs of 3-4 alternatives are made based on the areas of emphasis listed below this paragraph. Students are directed to develop 3-6 clear written goals or objectives for each alternative. One half of the

objectives are primary-related to the central design issue described below. The others are secondary. Primary objectives are not to be common between the various alternatives. If the objectives are common, then the result tends to be options of one design not a true alternative. This activity is often evident in practice rather than in academic course work. Prominent architects, when displaying their firms work, i.e. Norman Foster, typically display many alternative designs for a project as well as variations of a dominant design concept. Consequently, the design process is developed from a broad and divergent perspective.

ALTERNATIVE 1: Establish a design based on **functional / spatial relationships and response to user needs**. Use the class program analysis and case studies to base this alternative on functional spatial planning issues as primary. Adjacency and proximity issues, circulation relationships, room dimensions/proportions and how the design responds to user needs are central. *This study demonstrates a student' knowledge of program and functional planning* issues.

Figure 2. Conceptual Design Alternatives

ALTERNATIVE 2: Establish a design based on **site and context**. Contextually designed projects derive architectural design inspiration in form and character from the existing built environment and surroundings. Students are to consider sustainable issues in the site plan as well as the site features' impact on design decisions. This is to become a generating motivator in the scheme. Solutions should address a balance between functional site constraints and inspiration on an abstract basis deriving forms and geometries from natural or manmade orders or geometry. *This study allows students to demonstrate knowledge of the site and context issues.*

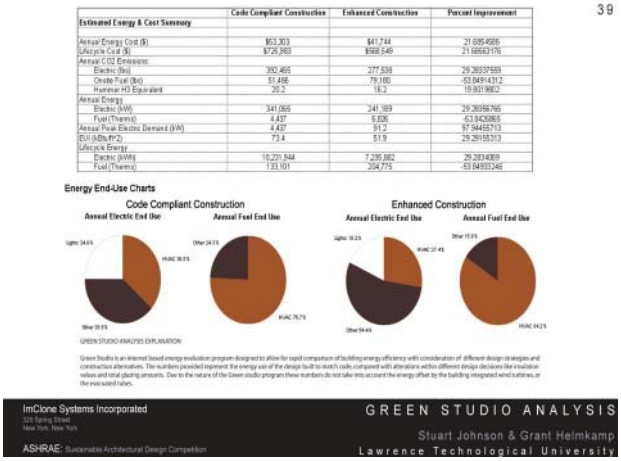

Figure 3. Sustainable Design Analysis

ALTERNATIVE 3: Establish a design based on **sustainable design and technical issues.** Establish as a primary consideration a technical issue in your project which considers the passive climate design, energy efficient active systems, materials and resource conservation measures. Sustainable issues should dominant and have a clear impact on material choices and form. *This study allows students to demonstrate knowledge of system selection criteria, LEED® objectives , and climate responsiveness* issues.

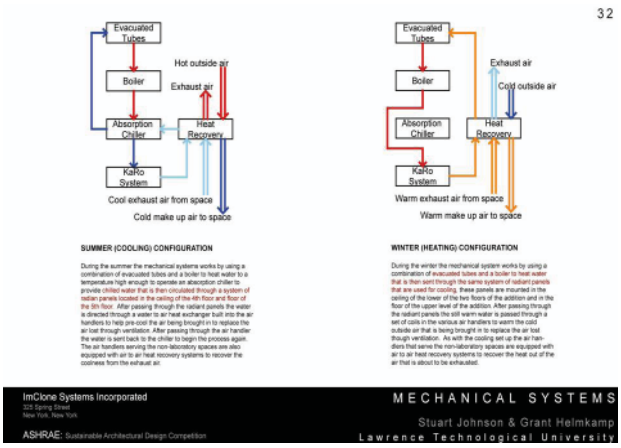

Figure 4. Documentation of HVAC Systems

ALTERNATIVE 4: Establish a priority for design based on **spatial order, proportion, and aesthetic concepts**. Consider influences based on place-making or critical regionalism. Both theories often cite the vernacular and local building traditions, where materials and response to climate conditions are generators of a design concept. *This study allows students to demonstrate knowledge of issues of form and composition, proportion, and visual spatial concepts.*

Phase III (4-weeks): Design Development Phase (Refinement of Dominant Alternative)

In this phase, the final design proposal is developed from the alternatives and project systems, and materials. Detail development is emphasized.

The first step is to solidify the final design, second is to develop the HVAC systems, select alternative energy sources, and define the structural and envelope systems. The primary metric to measure sustainability is LEED® 2.2 New Construction criteria and material from life cycle analysis, (LCA), type software, either BEES or ATHENA. Whole building energy analysis using Green Building Studio® software is completed to measure the energy performance and model the performance of the structure.

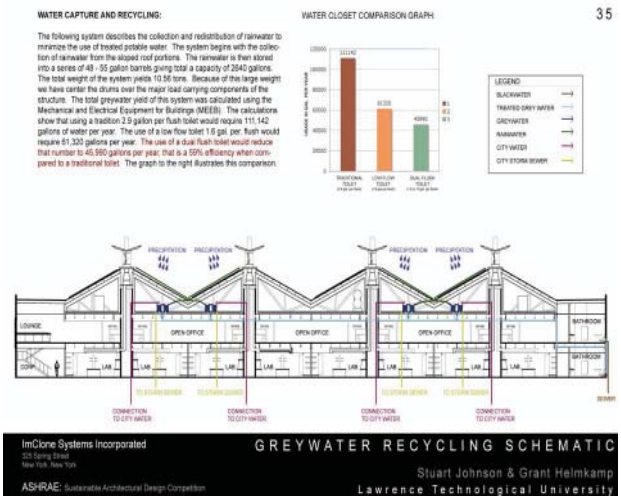

Figure 5. Documentation of Sustainable Processes (The recycling of rainwater is diagramed here.)

Phase IV (4-weeks): Final Documentation and Presentation

Work continues in documenting materials, measuring alternative energy generated, tallying LEED® points and design development of the building. Presentation documents are completed. Interdisciplinary reviews are done by architects and engineers.

CONCLUDING REMARKS

Sustainable design studio studies can provide an opportunity for performance-based design measures to be integrated into academic coursework. The various metrics to assess sustainable characteristics support efforts to develop research skills, strengthen background work in project development, and employ physical and ecologically based scientific facts in evaluating and promoting ecological literacy in the design of carbon neutral buildings.

The authors' assertion is that sustainable design with a knowledge base rooted in the biological and physical sciences with national support for 'performance based' carbon neutral design in an interdisciplinary team model could renew the architecture professions' research interest in building systems and technology. According to Abraham Flexner, the medical field ethicist and reformer, research is an intrinsic part of a profession's self definition. Sustainable design has awakened a new ethical dimension in architecture regarding resource conservation for future generations. The integrated sustainability studio serves as a model for meeting these goals.

Acknowledgments: *This work is based in part on experiences gained from teaching the Architecture design courses at Kansas State University. Co-author, Dan Faoro, therefore thank s professors: Robert Burnham, William Miller, Donald Watts, and Dale Bryant for mentoring and sharing their work and approach to design education with him. In addition, his personal experiences as a student of John Macsai at the University of Illinois-Chicago played a role in shaping his approach to studio design education in architecture. Author, Dan Faoro, further thanks faculty from Lawrence Technological University including: Edward Orlowski, Joe Savin, Will Allen, Celeste Novak, and co-author, Janice Means, all whom have been reviewers for the Sustainability Studio, and partici-pated in numerous reviews to*

share their insights and experience. Co-author, Janice Means, thanks professors Dan Faoro, Edward Orlowski and Celeste Novak for their reviews of her Passive Solar Design Strategies Course, of which a portion of the students have taken in conjunction with Professor Faoro's Sustainability Studio and the late Dr. Joseph Olivieri, who mentored her in HVAC design, solar design, and university teaching. Together, we thank the administration, Dean Glen LeRoy and Joe Veryser for their support, and the students of Lawrence Technological University who have been dedicated to the studies and receptive of these instruction methods, and the supportive faculty.

ENDNOTES

1. *Performative Architecture, Beyond Instrumentality*, Branko Kolarevi**c** and Ali Malkawi, eds. (Routledge Press, 2004) "The book addresses the emergence of a new kind of architecture, in which building performance is a guiding design principle, adopting new performance-based priorities for the design of cities, buildings, landscape and infrastructures. This emerging architecture places broadly defined performance above form making; it uses digital technologies of quantitative and qualitative performance-based simulation to offer a comprehensive approach to the design of the built environment. The emphasis on building performance is now redefining expectations of the building design, its process and practice."

2. D. A. Schön, *Educating the Reflective Practitioner*. (San Francisco, CA: Jossey-Bass Publishers, 1987)

3. Necdet Teymur, "Architectural History as 'Educational Object*' ", Architectural History and the Studio*, Adam Hardy and Necdet Teymur, eds. (Question Press, London: 1996). "The author contrasts the goals of 'educational projects' as inspired by '*epistemological maximalism*'. "This epistemological mode is characteristic of the traditional university disciplines that see the increased quality and production of knowledge and exposure to truth and wisdom as ideals of education and research…with that of '*professional minimalism*' that is characteristic of professional practices that try to attain professionally prescribed levels of competence through training.", p. 34.

4. See the Case Study outlined in, "Cool Tools for Building Performance" by A. Kwok and W. Grondzik which provides an excellent summary of the methodology and rigor in scientific investigations. (Atlanta: ASHRAE Publications, 2008)

5. Stephen Kieran, "Research in Design: Planning Doing Monitoring Learning". Journal of Architectural Education, 61 no. 1 (Sept. 2007), 27.

6. For a similar methodology see, "Performance-Based Design for Environmentally Responsible Architecture in Hong Kong's Hyper Dense Urban Context", by Jin Yeu Tso, Lawrence Berkley Labs sponsored lecture, 10-15-2001. The work describes a "multidisciplinary research project team for Environmentally Responsible Architecture and Urban Context (ERAU) was formed to coordinate the knowledge and efforts of its research partners, to provide both the setting and the resources to study environmental technology and building performance. The project is comprised of five major components: (a) urban visual sustainability; (b) urban wind environment and natural ventilation; (c) acoustic quality for urban planning and building design; (d) thermal comfort and building energy efficiency; and (e) natural lighting for urban space and architecture."

7. Carl Rogers, *On Becoming a Person*, (Houghton: Mifflin, 1970), 350. Gender reference per original author.

8. Kathryn H. Anthony, *Design Juries on Trial: The Renaissance of the Design Studio. (New York:* Van Nostrand Reinhold, 1991), 172.

9. Robert Oxman, "Towards a New Pedagogy", *Journal of Architectural Education*, 39 no. 4 (Summer, 1986), 24. Oxman refers to the advantages of "parsing a project" or breaking it down into phases. Also see Stefani Ledwitz, "Models of Design in Studio Teaching", *Journal of Architectural Education*, 38 no. 2 (Winter 1985), 24. The author points out that the difficulty in the "one time distribution of project information" is typical in most architecture studios.