TAKING A BUILDING'S VITAL SIGNS: CASE STUDIES

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SUMMARY

This paper describes the Vital Signs Curriculum Materials Project, an endeavor that takes architecture students into existing buildings to examine building performance and design intent. The project began five years ago by developing a set of modular and topical resource materials that contain field evaluation techniques about architectural, lighting, and mechanical systems with attention to energy use, occupant well-being, and architectural space-making. In this process, existing buildings serve as settings for student investigations and offer interesting lessons on the success and failure of various design strategies. The approach has a number of benefits. The personal experience in performing the evaluations in turn contributes to their design-knowledge base at a formative time. The process of developing a clearly stated hypothesis is essential to successfully framing the investigation for collecting data. This research process provides a foundation for understanding the more abstract tools and standards used by designers in practice. This paper describes the resources provided by the Vital Signs Project in support of the development of case studies and how students can receive a hands-on, experiential learning approach designed to develop hypothesis-driven research and teamwork skills.

INTRODUCTION

Most students have limited personal experience in the construction and function of actual buildings, since studio work typically involves hypothetical design projects. With this approach, students come to consider buildings as abstractions, focusing primarily on composition and theory, while overlooking energy use and environmental considerations, the qualitative experience of a space, and the potential effects of design decisions on occupant health and well-being. The Vital Signs Project aims to integrate abstract conceptualization with reflective learning, concrete experience and active experimentation. The premise of the project is that existing buildings hold fascinating lessons on a variety of building performance topics.

Early in undergraduate education, students frequently receive little or no experience in formulating specific research questions, hypotheses, devising a methodology to carry out and test hypotheses or the communication skills to share the knowledge with others. This project integrates research, education and technology by having students compare design intent with the artifact of the design process, hopefully leading to a way of designing buildings that is more responsive to the concerns of occupants and reduces the impact on the natural environment.

PROJECT OVERVIEW

The Vital Signs Curriculum Materials project is a multi-year effort coordinated by the University of California, Berkeley and funded by the Energy Foundation and Pacific Gas and Electric's Energy Center. Vital Signs offers a variety of materials and opportunities for architecture faculty and students to become engaged with investigations of buildings: **Resource Packages** a set of physical performance topics (e.g. whole building energy use, the dynamics of solar shading devices, natural ventilation, and glazing performance) organized as modular materials available over the internet; each package provides protocols for the field evaluation of existing buildings, activities that may in turn lead to written **Building Case Studies** describing student findings; and **Case Study Incentive Grants** supporting faculty and students in their investigations of existing buildings in connection with studio, lecture or seminar classes; **Case Study Competition** challenging students to take a detective's eye to the built environment; **Summer Training Sessions** for faculty to receive direct, hands-on experience with field research as a teaching method; an **Equipment Toolkit Loan Program**, enabling schools to use both handheld and datalogging instrumentation for a semester or a year-long period in the development of case studies; and an extensive website for the dissemination of these resources.

RESOURCE PACKAGES

A Resource Package is a 40- to 60-page document that addresses a single building performance issue. Each package covers relevant primary physical principles, a description of how the topic affects design decision making, a discussion of applicable standards and practices, an annotated bibliography, and a set of field exercises or protocols to guide students through formulating hypotheses, researching literature, conducting informal and formal interviews, and measuring physical aspects of building performance through three general levels of detail.

Level 1: Brief visit, limited instrumentation appropriate for a single day. Involves observations, interviews, and survey techniques.

Level 2: Visits over a few weeks, handheld instruments, building upon Level 1 techniques. Collection of physical measurements and modest simulation exercises.

Level 3: Study over one or more season, data acquisition systems. Adds time-series data collection to procedures in Level 1 and 2.

Vital Signs and architecture faculty at schools across the country have developed these packages to assist instructors and students in framing building investigations. Paper copies of each Resource Package were distributed to faculty members at architecture schools in North America in May 1996, though electronic copies of a package are available to be downloaded at the Vital Signs website.

CASE STUDIES

The project's emphasis on field investigation and the presentation of case studies has several immediate pedagogical objectives. Examining field study data offers insights in the link between architectural intent and actual building performance. The observation and measurement of existing buildings also allows students to compare their data with existing codes and standards. Finally, it promotes experiential familiarity with the physical parameters involved in the design of buildings. This is important because while student work typically involves hypothetical design projects, most students have limited personal experience in the construction, function and operation of actual buildings.

The case study model developed by the Vital Signs Project is not unlike the metaphor of a medical work-up, where doctors chart and diagnose various systems and vital signs of the human body. A typical case study building will offer many interesting paths for investigation that may fall into one of the following categories:

1. Buildings of historical importance such as the Robie House by Frank Lloyd Wright, Crown Hall by Mies van der Rohe, or the Wainright Building by Louis Sullivan.
2. Widely known and influential contemporary buildings such as the High Museum by Richard Meier, the United Airlines Terminal in Chicago by Helmut Jahn or the Portland Building by Michael Graves.
3. Buildings know for energy efficiency and environmental responsiveness such as the Audubon Building in New York City by the Croxton Collaborative, the Real Goods Solar Living Center in Hopland, California by Van Der Ryn Architects, or the Institute for Asian Research at the University of British Columbia by Matsuzaki/Wright Associates.

These categories do not represent an exclusive pool of case study candidates. Each building poses many unique questions for investigation. These questions may stem from curiosity about a particular aspect or quality of a building or even from anecdotal experiences noted from the occupants.

Framing the question

Every designer, historian, scientist, or theorist typically begins their research with a question of inquiry and a guess, hypothesis, or conceptual notion that can be put to a test. For architecture students conducting case study investigations, framing the question and posing the hypothesis is a critical and basic step in constructing a well-bounded, cohesive analysis – often this is a difficult process. The stories held by existing buildings on topics related to occupant well-being, the operations of lighting and HVAC systems and building energy consumption, are not typically seen as design problems by architecture students. This perhaps is attributable to the compartmentalization of architectural practice and curricula, where each designer (engineer, acoustician, lighting designer, etc.) has their own vocabulary and measurement metric.

However, the role of the architect is important as an integrator or overseer of all the professions. One place where the "whole" is realized is in the built artifact. By close examination of building performance and its manifestation on the building as a whole, students will inevitably bring an understanding of their observations and measurements into their designs as they move through school into practice.

Initial building visit

An initial visit to the building may reveal questions and new stories that were not apparent from the literature or the architectural press. Observations and any preliminary measurements might offer an opportunity to pre-test ideas and modify preliminary hunches.

For example, students were interested in a building on university campus because it was known for its indoor air quality problems. Upon visiting the building, walking through making observations and interviewing people in the building discovered that the real story about the building was that the spatial layout and design did not afford the occupants any view or connection to the outside. Hence, they modified their original hypothesis and proceeded to develop an occupant survey about orientation and personal security related to daylight.

From an initial visit, students might find the need to modify their approach and equipment. Logistics of bringing in special equipment or employing specific survey methods could be assessed prior to the next visit. If a large building is selected, a facility manager could be of great assistance.

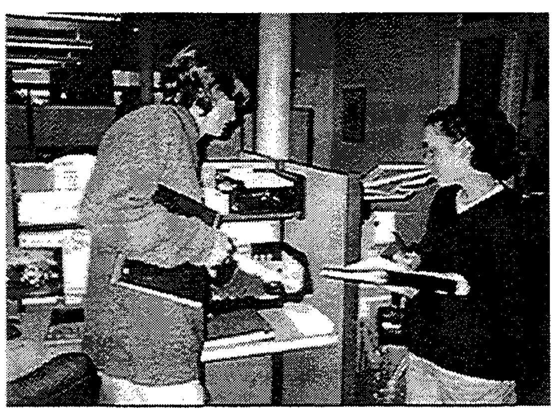

Figure 1. Students taking spot measurements during an initial visit to the National Audubon Society building.

Hypothesis development

After selecting a case study building and building performance topic(s), developing a clearly stated hypothesis is essential to successfully framing the investigation. An hypothesis is a hunch or proposition about the outcome of your question of inquiry. Often we say that it is a testable statement.

For example, a case study could look at a building with a central atrium where ceiling mounted light fixtures had been installed on a 8' X 8' (2.4m x 2.4m) grid throughout much of the building. The topics of investigation would be related to daylight, electric lighting, energy use and occupant perception. The *inquiry questions*: Are the electric lights required at all times to provide the quality of light necessary for the tasks being performed? Do the electric lights play a role in architectural spacemaking?

The *hypothesis*: The electric lights are not needed during many times of day. Furthermore, they create a bland environment that lessens the qualities of the space. If daylight sensors that dimmed or turned off fixtures were installed, energy performance would improve and the quality of light as experienced by the users would increase.

Methods and storyboards

By framing the investigation carefully, the methods can be appropriately planned to collect the information necessary to answer your question, or prove your hypothesis right or wrong.

A useful exercise to do at the beginning of the case study process is to sketch out in storyboard fashion what the case study document might look like. For example a 12-page case study might include an introduction, background information to the building and anecdotal information of what sparked curiosity and inquiry to the topics selected, a statement of the hypothesis and questions of investigation, methods and equipment used, results, conclusions, and design lessons learned from the study.

Successful case studies are those that match hypotheses with methods selected to investigate them, a careful and critical analysis of the information collected, and a clear presentation of the results.

AFFILIATION & FACULTY	CASE STUDY BUILDING
Cornell University Alison Kwok	Audubon House
Florida A&M University Peter Stone, Walter Grondzik	Earth coupled houses, naturally-ventilated houses (Logan House)
North Dakota State University Carol Prafke	"Quick Reads" of cold-climate buildings
Rice University Gordon Wittenberg, Mark Oberholzer	The Menil Museum
University of Cincinnati David Lee Smith, Wolfgang Preiser	Aranoff Center for Design and Art
University of Idaho Bruce Haglund, Sandy Stannard	Northwest Federal Credit Union, St. Ignatius Chapel, Henry Art Museum Addition, Frye Art Museum
University of Virginia Don Dougald, Michael Bednar	4 campus buildings: Campbell Hall, Aquatic Fitness Center, Rotunda, Law School

Table 1: Case Study Incentive Grant recipients

CASE STUDY INCENTIVE GRANTS

With the completion of the Resource Packages, there was a need for case studies that instructors could use as models. In the Fall 1996, Vital Signs awarded eight, $5000 Case Study Incentive Grants to faculty who implemented the Vital Signs approach in a variety of class settings, such as a required first-year design studio, a lecture course on comfort, climate and energy, a fourth year environmental technology class, lecture/lab classes, undergraduate seminars and graduate independent research. This year seven schools received Incentive Grants (Table 1) to develop 20 case studies. Although still under development at this time, excerpts from two of the schools are explained below:

The Logan House. Completed in 1981, the design of the Logan House offers relief from the heat and often unbearable humid conditions of Tampa, Florida (Figure 3). The owners requested an energy-efficient, informal and open living space for entertaining. The design features a raised floor and a belvedere set at the peak of a steeply pitched roof where rising warm air vents through clerestory windows. Students at Florida A&M University formulated a set of hypotheses and questions about air movement and comfort conditions within the house. They believed that the temperature distribution throughout the house is uniform, both horizontally and vertically. They installed a pole, attached with Hobo temperature and humidity loggers, into the central belvedere of the space to measure potential thermal stratification (Figure 2).

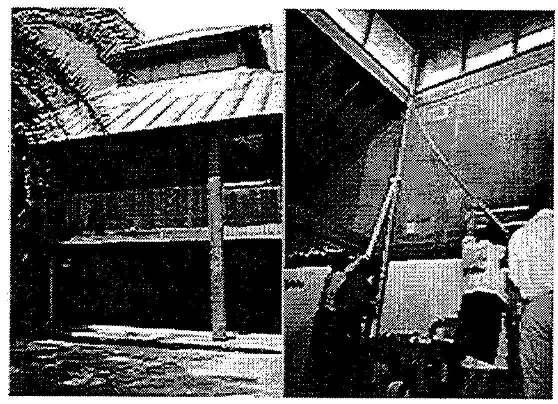

Figure 2. Logan House (left) and students placing equipment (right).

The Audubon House. The National Audubon Society's headquarters building in New York City, completed in 1992, was one of the first models of an energy-efficient and environmentally conscious design (Figure 3). Cornell University students hypothesized that the daylight-following system does not function as intended because it does not respond to variable lighting situations or the occupants' needs and satisfaction. They characterized the physical conditions of the daylight and electric light by taking physical measurements, calculated lighting power density and compared it to the recommended value, surveyed the occupants for their response to the environmental conditions and estimated the amount of energy saved by the daylight-following system (dimming and occupancy sensors).

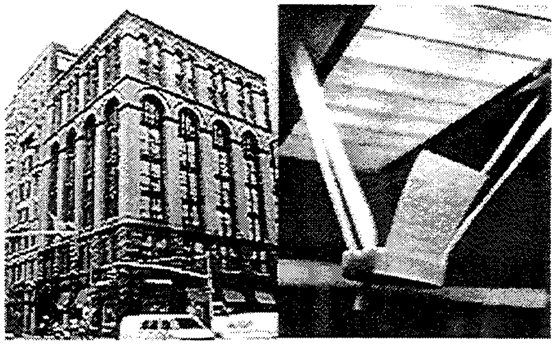

Figure 3. National Audubon Society Headquarters in New York City (left) and a Hobo "sling" (right) hung from fixture to measure lighting use patterns.

CASE STUDY COMPETITION

The Case Study Competition (Figure 4) challenges architecture students to take a detective's eye to the built environment to investigate, measure and report on the physical performance of existing buildings through case studies that would ultimately be shared with the broader architectural community and building professions. The objectives of such a competition are to foster a pedagogic approach where students would:

- demonstrate an understanding of an existing building through the development of inquiry questions and hypotheses about specific building performance topics;
- connect building performance topics to issues of design intent, energy use, occupant well-being, and architectural space-making;
- produce exemplar case studies for widespread distribution to the architectural community.

Unlike typical architectural design competitions where students design a new scheme, the Competition is perhaps the first of its kind in its approach of asking student to investigate buildings around them. In 1996, ninety student teams (280 students) from more than 25 architecture schools submitted 12-page entries consisting of: 1) introduction of the case study building, site and a description of the topics and questions, 2) statement of an hypothesis or "hunch" about a possible outcome to the questions, 3) description of the methods and equipment used to gather and analyze data, 4) presentation of the findings of the fieldwork through a narrative and figures, tables, photographs, or supporting calculations, 5) summary of the investigations and conclusions regarding the topics and hypothesis, 6) case study dossier form listing the detailed artifacts held by the institution, such as reprints, photographs, interview notes, survey data.

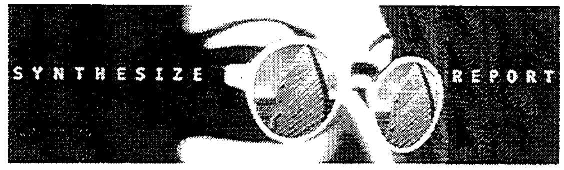

Figure 4. From Case Study Competition poster, submissions deadline on June 15, 1998.

Winning student teams and schools in this year's competition will receive over $10,000 in cash awards. The jury for the 1998 competition:

- *Will Bruder*, Architect, New River, Arizona
- *Nancy Clanton*, Clanton Engineering, Colorado
- *Charles Davis*, Principal, Esherick Homsey Dodge and Davis, San Francisco
- *Gail Lindsey*, Design harmony, Raleigh, NC
- *Nadav Malin*, Editor, Environmental Building News
- *John McRae*, Dean, School of Architecture Mississippi State University

SUMMER TRAINING SESSIONS

The Project has offered summer opportunities for architecture faculty to receive training with the Vital Signs materials, building performance issues, and equipment. In the summer of 1997, the training session assisted educators in incorporating field studies of the performance of existing buildings into their teaching by having the participants experience the case study process for themselves. Faculty teams visited, discussed and evaluated the San Francisco Public Library in terms of lighting, air quality, thermal comfort, HVAC operation, balancing energy flows into and out of the building, and glazing performance.

Participants in the 1998 Summer Training Session will conduct similar investigations at the Real Goods Solar Living Center located in Hopland, California. After presentations from the building's project architects, faculty teams will assemble a list of inquiry questions, develop these questions into testable hypotheses ("hunches," or "notions"), discuss appropriate measurement techniques, and conduct mini-investigations.

Perhaps the most valuable experiences gained from the training session is the opportunity to discuss and share information with colleagues, and to consider how the field investigation approach can be adopted into seminars, studios, lecture classes and independent study classes.

TOOLKIT LOAN PROGRAM

To encourage student investigation and assist in case study development, the National Science Foundation and the Energy Foundation have funded eight equipment tool kits (Figure 5) to be loaned to architecture schools for a semester or year-long period, allowing faculty and students to gain first-hand experience with the Vital Signs field techniques. During the 1997-98 year, 10 schools of architecture received toolkit loans: Cornell University, Mississippi State University, North Dakota State University, Oklahoma State University, University of Waterloo, Texas A&M University, University of Oregon, University of Tennessee, University of Texas at Austin, University of Wisconsin, Milwaukee.

The toolkit contains approximately US$25,000 of handheld and data monitoring equipment, such as miniature dataloggers that are matchbox-sized and can be launched from a personal computer for an hour, week, or longer time period to measure temperature, humidity, light or voltage. Handheld equipment includes light meters for illuminance and luminance, sun angle calculators, clamp-on amprobes, a hot wire anemometer, a clinometer for scaling building heights, a compass, sling psychrometer, infrared temperature gun with a laser siting and a host of meters that might be left in place for longer periods of measurement such as a carbon dioxide meter, VOC (volatile organic compound) and ozone meter. The toolkit equipment is described in further detail on the Vital Signs website, along with approximate prices and vendor names.

The experience gained by participants with the equipment during their loan period is also beneficial for those wishing to make departmental purchases of equipment – we call it, "priming the pump."

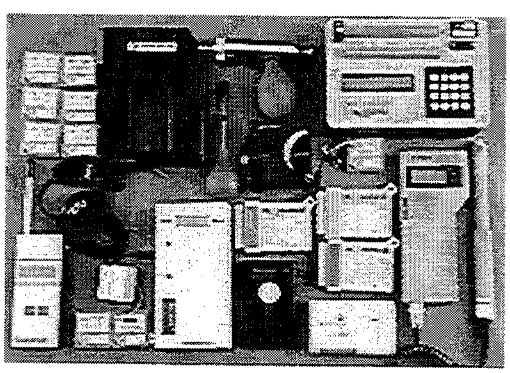

Figure 5. Equipment in traveling toolkit

SUMMARY

The project has grown as more faculty participate in the summer training sessions and students begin investigating, comparing, and reporting on design intent vs. outcome through the development of case studies.

Collectively, the project's flexible and innovative approach to architectural education has sparked the learning process of students in more than 50 schools of architecture across the nation. Clearly, this is just the beginning. Although the funding from the Energy Foundation for the Vital Signs project is specifically intended for schools in North America, the posting of the resource materials and case studies on the web make the project available to everyone. The Vital Signs approach provides the initial opportunities for experiential learning about the successes and shortcomings of design. However, the key to the learning process is the direct experience with existing building, asking questions, testing hypotheses, and ultimately finding answers that will lead students to have a greater awareness and comprehension about the implications that their design actions will unwittingly contribute to the environment.

REFERENCES

1. Benton, Charles C. and Kwok, Alison G. *Vital Signs Project: Work in Progress*. Proceedings of 20th National Passive Solar Conference. Minneapolis, MN. (July 15-20): 274-280, 1995.
2. Benton, Charles C. and Kwok, Alison G. *Field Methods for Architectural Curricula: The Vital Signs Project*. Proceedings of 19th National Passive Solar Conference. San Jose, CA. (June 25-30): 409-414, 1994.
3. Benton, Charles C. et al. *Taking a Building's Vital Signs: A Lending Library of Handheld Instruments*. Proceedings of the ACEEE 1996 Summer Study on Energy Efficiency in Buildings. American Council for an Energy-Efficient Environment, 5 (Summer), 1996.
4. Kwok, Alison G., Benton, Charles C. and Burke, Bill. *Vital Signs Project: Dissemination Activities*. Proceedings of 22nd National Passive Solar Conference. Washington, DC. (April 25-30): 369-374, 1997.
5. Vital Signs website: http://www.ced.berkeley.edu/cedr/vs/