From Benchtop to Bedside: Exchanging research lessons learned in an undergraduate program

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Abstract

While there is a rising demand for research and 'evidence based design' in architectural practice, as the Boyer Report [1] and many subsequent critiques of architectural education point out, research is generally not being addressed in design education. Given the innovative and rigorous nature of the extant undergraduate projects in other fields, it is apparent that undergraduate students can contribute much to research about the designed environment. This proposal seeks to develop and test a model which will not only foster a culture of research in undergraduate design education and provide a framework for students to discover new knowledge, but moreover, will promote knowledge transfer between academia and the design profession using the student as a vehicle. The 'Preceptorship Program' pairs a student with 1) an academic mentor from the college, and 2) a practicing design professional, in order to structure a research partnership which is innovative, collaborative, publishable, and carries knowledge from "benchtop to bedside". It is hypothesized that both students and practitioners will become efficient in: accessing useful sources which can provide an evidence base to design, structuring a research project which can inform design, and making connections across disciplines, and between education and practice.

The Preceptorship Program will be qualitatively evaluated by comparing it to others which link research and practice in order to propose a conceptual model for other undergraduate design programs to adopt, and recommendations for promoting research in undergraduate architectural education.

1 Introduction

1.1 Background and scope

This study evaluates undergraduate research in architectural education with specific attention to those opportunities which link education and practice. Over the last ten years, significant transformative efforts have been made in undergraduate education to integrate research. The question arises: 'How is this national initiative appropriate to the early education of architects?'. While many architecture programs across the United States provide undergraduate research opportunities in various forms, the underlying implications of the role of research in the education and career development of an architect have remained largely undocumented. Ultimately, this project probes the question of how architecture research in undergraduate education could be developed through the exploratory testing of a conceptual model based around the mechanism of linking academia and practice to promote a reciprocal knowledge production and exchange. This report summarizes the benefits and challenges of instituting such a model, in the form of the 'Preceptorship Program', by examining data collected from a pilot study semester and comparing it with existing research programs in architectural education, and situating these results in the context of research in practice and in accredited programs in the United States.

1.2 Definitions

1.2.1 Research

Much has been written attempting to define research in architecture, and it is recognized that multiple interpretations and positions exist as appropriate for varying situations and applications. For the purposes of this study, research is defined as the production of new knowledge for the purpose of advancing the field. This definition aligns with the position of the American Institute of Architects (AIA), which describes architectural research, both basic (or pure) and applied, as that which "prompts discovery and leads toward the smarter, more effective practice of architecture" [2, p. 5]. A distinction is made between 'research *for* design', versus 'research *as* design' (or more commonly, 'design as research'), according to three qualifying factors: there exists a systematic process of investigation and rigorous methodology; it is intended to advance knowledge in the discipline; and the results and research process are made public [3]. It is necessary to define research as such in this study, to distinguish the proposed conceptual model from conventional internships and other educational programs which employ collaborative relationships.

1.2.2 Undergraduate research

The following definition of 'undergraduate research' was developed by the Council on Undergraduate Research (CUR) in 1997 [4], and supported by the National Science Foundation's Undergraduate Research Summit in 2003: "Undergraduate research is an inquiry or investigation conducted by an undergraduate that makes an original intellectual or creative contribution to the discipline" [5, p. 9]. Among the characteristics specific to the undergraduate research experience is that, "The student is encouraged to take primary responsibility for the project and to provide substantial input into its direction" [6]. This is an important qualifying characteristic for this study which distinguishes the preceptorship model from research assistantship programs where students perform directed tasks and assignments for their research mentor.

1.2.3 Preceptorship

The preceptorship model is one adapted from medical education which promotes a learning relationship between a practitioner or faculty member (Preceptor) and a student that is framed in a practical milieu. The preceptorship was originally conceived to enhance the learning experience of the student by providing a hands-on, experiential, situated learning opportunity observed and directed by the clinical preceptor in a setting specific to the preceptor's interests and expertise [7]. Recent models have evolved the preceptorship experience to benefit not only the student, but also the clinical preceptor and the faculty mentor. In this Integrative Clinical Preceptor (ICP) model, the learning exchange is reciprocal and interdependent; the student, clinical preceptor, and faculty member collaboratively partner in order to rely on one another as a resource to the mutual benefit of all [8]. Thus, the preceptorship program developed for this study is characterized as being a professionally situated, mutualistic, collaborative relationship between the student, faculty member, and professional preceptor for the purpose of exchanging knowledge.

1.3 Project Objectives and Structure of Paper

The objective of this study is to develop and test a framework for establishing a formal undergraduate research model which produces and exchanges knowledge between academia and practice, and to utilize the results from this study to reflect upon considerations for the evolution and widespread implementation of undergraduate research in architectural education. In examining a model for undergraduate research in architectural education, this paper utilizes a bootstrapping approach by sequentially building upon a series of intermediate goals: 1) to describe the relationship between research and practice by conducting a case study of HKS Architects research department (Dallas, Texas) in order to inform the question of 'How research in education can best benefit practice'; 2) to provide statistical information about the current status of, and opinions about, research in undergraduate programs in architectural education within the United States; 3) to use information gleaned from the above two objectives to structure and test a pilot study of a conceptual model, the 'Preceptorship Program', at the University of Colorado, Boulder; 4) to evaluate the preceptorship program and findings from the pilot study by qualitatively comparing it with three existing research programs in architectural education which link education and practice; and 5) to use the above data points to elucidate structural considerations, best practices, challenges, and recommendations for future study.

1.4 Research Methods

The primary means of obtaining background information occurred through a review of relevant literature on the topics of 'undergraduate research programs' and 'research in architecture'. Data was collected from architecture programs through web-based surveys, publications, and departmental website information. Data was collected from key players in representative case studies through exploratory interviews. Data from the preceptorship program pilot study was obtained through exploratory interviews with students, preceptors, and faculty mentors; direct and recorded observations of and by the students; and an analysis of each student's research products and process documentation.

2 Research in the architecture profession: Case study, HKS Architects

Rather than blindly responding to the call to integrate research into undergraduate architectural education, it is best to situate any programmatic response within the context of how the skills and products resulting from such an experience will meet a current or future need for the profession. As Dr. W. Mike Martin pointed out at the AIA 2007 Research Summit, "One of the things that we thought was really critical when you look at the kind of connection between the academy and practice is that it needs to be more focused on reformatting the curriculum in schools. It was the sense that most of what we do in schools is either not about practice at all or it's all about practice as it was, not about what it's going to be. There is a real need to really think of the nature of what occurs in practice in terms of questions about design and research" [9, p. 26]. A case study visit was made to the HKS Architects Research Department in Dallas, Texas to obtain evidence and expertise on the relationship of research to practice, by inquiring about how research for design is executed and implemented, and what research skills and experience would most benefit the profession.

HKS Architects is one of a handful of architecture firms in the United States with a designated research department. Since the inception in 2006, the research department has produced grant funded studies yielding over 50 publications and presentations in academic and industry forums. HKS was chosen as a case study for this project on the basis of its reputation in conducting rigorous research, and in establishing as a priority the commitment to disseminate and share research results with the profession. Interviews were conducted with four key players at HKS in order to obtain a sampling of perspectives representing different points of view on research including: two senior administrators, the director of research, and a lead designer.

Key findings describing the context of research as it relates to practice are summarized as follows:

- *There exists a current and future need for research.*

There exists a need for research because clients are demanding evidence-based design. Evidence-based practices originated in the medical field in the 1990's and were translated to the architecture realm by healthcare clients asking that similar measures be applied in the design of their own (healthcare) buildings [10]. It has since percolated into the design of other building types including educational, justice, and aging facilities among others. Future scientific research may be limited to larger firms and specialty

firms since most architects will not have the financial resources to perform empirical research [11]; however, "all firms, large and small, could adopt the EBD paradigm by developing design hypotheses, collating available research on the topic and translating findings to design knowledge" [12].

- *Architects do not participate in research.*

Architects do not have the background, skills, or credibility as researchers to engage in scientific research. Even with the necessary skills, practitioners lack the time to participate in research because design studios must uphold business commitments to project profitability and schedules [11]. The HKS research department currently employs mostly clinical experts by virtue of their backgrounds in research, but would welcome the opportunity to consider those with an architecture PhD in this capacity [13].

While the interdisciplinary collaboration with clinicians is valuable, this finding nonetheless makes a case for a projected need of more architecture PhD graduates and PhD programs, assuming the call for evidence based design will continue to increase. Research training at the undergraduate level might more fully prepare and potentially encourage students for graduate study in research.

- *Architects need to integrate research into their designs.*

While architects do not directly participate in research, nonetheless, designers need to be able to make use of research findings to inform their designs in the case of building types such as healthcare design, and potentially many more building types in the future. This implies that designers either need to be able to read and understand research manuscripts and scientific journals, and be able to distinguish between more and less robust studies in research design and implementation [13], or should have relevant findings translated into a format which they can easily access and read, an approach underway by the Stardust Center for Affordable Homes [14] and other topic based or private initiatives. HKS currently translates and disseminates research results to clients and HKS designers in multiple formats such as short 'InfoBytes', research summaries, and full reports [13].

Recognizing that this practice of research translation is not practical or affordable for most firms, architects should be educated in accessing and critically analyzing research literature. This is supported by the United Kingdom's LINK study on research in architecture in higher education, finding 3.42: "A key contribution architectural research makes to the profession is through the output of students with up-to-date skills, now beginning in some cases to include research skills" [15, p. 12].

- *Research is design-based.*

Research is conducted for the purpose of improving design [11]. At HKS, research is never undertaken for the benefit of one design project exclusively; rather, potential research projects are subject to an informal 80% rule such that all research projects must produce results which benefit at least 80% of the projects in practice [11, 13]. In a session on design and research conducted by the Royal Institute of British Architects (RIBA), architect Alejandro Zaera-Polo of Foreign Office Architects similarly states: "those [research projects] of most lasting value are not simply applicable to one design, but contain lessons or solutions transferrable to future projects" [16, p. 18]. It must also be noted that most research requires time and conditions which projects 'on the boards' are not able to permit [11]. As such, research is not directly blended into a project under design, but is conducted after the fact, or in a separate context, to inform future projects. While the typical academic-based research approach is rooted within a discipline's framework and theory (e.g. sociology, psychology, anthropology, building technology, et al), and subsequently brings in the built environment as a controlled or manipulated variable, alternatively, the HKS design-based research process begins with a question from the built environment – often from a designer – and then applies whichever disciplinary methodology and theoretical framework is most appropriate to investigate the particular question [12].

The implications are that undergraduate research experiences which originate in design scenarios provide the most direct benefit to practice, and most closely align with the research process the student will engage in their future careers. By adapting a methodology similar to that of HKS, practitioners can effectively be the source for student research investigations by providing scenarios and topics for improving the built environment.

- *Research is collaborative.*

Research is always conducted with the client's approval. For a research project to be successful, there must be a commitment to the study from the client [13]. When a client champions a research opportunity as a learning experience, this spirit of engagement significantly reduces concerns about liability. HKS collaborates not only with clients, but also with universities and industries to conduct research because these partnerships provide access to additional resources and funding opportunities [11].

The call here is not only to academics to foster research, but also to practitioners. There exists incredible potential for universities to collaborate with firms, clients and industries in the production of knowledge to inform and advance design.

These findings from the case study visit to HKS directly informed the rationale and framework of the preceptorship program model by situating objectives and learning outcomes within the context of how practice currently utilizes research knowledge, and what skills and knowledge future architects should possess to promote evidence-based design.

3 Undergraduate research in architectural education

This section summarizes the current status of undergraduate research in architectural education by representing the positions of the professional and academic organizations, individual faculty, and university programs.

3.1 Professional and Academic Organization efforts

Boyer's 1996 special report, 'Building Community: A new future for architecture education and practice', advised that, "schools of architecture should place greater emphasis on generating new knowledge" citing "both economic and social reasons for schools of architecture to affirm more vigorously a commitment to generating new knowledge. . . for which the profession could provide important support" [1, p. 137]. In the last two years, professional and academic organizations have responded en masse to the call for research in education through a series of initiatives including: the AIA 2007 Research Summit, the 2008 Association of Collegiate Schools of Architecture (ACSA) Teacher's seminar 'Deep Matters: The path to meaningful and provocative architectural research', revisions to the National Architectural Accrediting Board (NAAB) conditions for accreditation, and the 2009 Annual Architectural Research Centers Consortium (ARCC) Research Conference, 'Leadership in Architectural Research: Between Academia and the Profession'.

3.1.1 Research/evidence based design

During the 2008 Accreditation Review, NAAB received input from many sources for recommendations on its 'Conditions and Procedures for Accreditation' (forthcoming 2009) in order to address and adapt to the changing profession. Among the task groups reporting to NAAB to advise upon policy changes, the 'Trends in the Professions' group ranked 'Research/evidence based design' in their top five priorities of issues related to education as viewed from a professional point of view with the justification that, "Future design will be based upon the use of empirical data established through research and testing. Decisions will need to be factually based. This will link knowledge and aesthetics, bridging the gap between the qualitative/quantitative divide" [17, p. 2]. In addition to other gains, upholding research as a priority to be addressed in education will create "a unifying currency between academe (seeking of knowledge) and practice (application of knowledge)" [17, p. 4]. This stance is echoed by NCARB in their 'Position Paper for the 2008 Accreditation Review Conference' which acknowledges that "innovation and responsiveness in design is based upon a solid foundation of empirical knowledge and research in all applicable content areas that influence decision making" [18, p. 4]. Because of their particular relevance to the preceptorship program model, of specific note are the following qualifying considerations determined by the NAAB task group for 'Research/evidence based design':

- "Particular consideration should be given to the pedagogy by which students seeking a first professional degree might interact with research, and might include an externship or internship requirement as well as fundamental skills in research methodologies" [17, p. 4];
- "Research must advance the discipline not just create knowledge"; [17, p. 4]

- "Does the school have a formal research program and how does this program elevate the first professional degree program? How does the research program engage the marketplace?" [17, p. 4]

While it remains to be seen how directly these recommendations will be integrated into the NAAB Accreditation Conditions, the provocations are nonetheless timely and representative of the place for research in the changing professional culture.

3.1.2 Integration of Education and Practice

The strained relationship between education and practice is a recurring theme on issues for drivers of change in education. In response to these issues, NCARB in their 'Position Paper for the 2008 Accreditation Review Conference' recommends: "Architecture curricula should provide a stronger foundation for engagement with the practicing professional" [18, p. 4]. Thus, the preceptorship program model will seek to integrate education and practice through the vehicle of research and mutually beneficial knowledge production.

3.2 'Undergraduate Research in Architectural Education' Faculty Survey

3.2.1 Purpose and Methods

A survey was designed to collect frequency data that would provide information about how many faculty nationally are engaged in undergraduate research projects, what type of research faculty and undergraduates are undertaking, and what faculty identify as benefits and challenges to undergraduate research. This Web-based survey was sent to faculty members of architecture programs in the United States during the fall semester 2008.

3.2.2 Results

Respondents

96 faculty members from over 42 accredited institutions in the United States responded. 27 of those respondents did not include identifying institutional information. 84% of respondents belonged to architecture departments, while the remaining group belonged to various environmental design related departments (planning, landscape architecture, environmental design, interior architecture). The range of respondents included a representative sampling across positions and ranks (Figure 1).

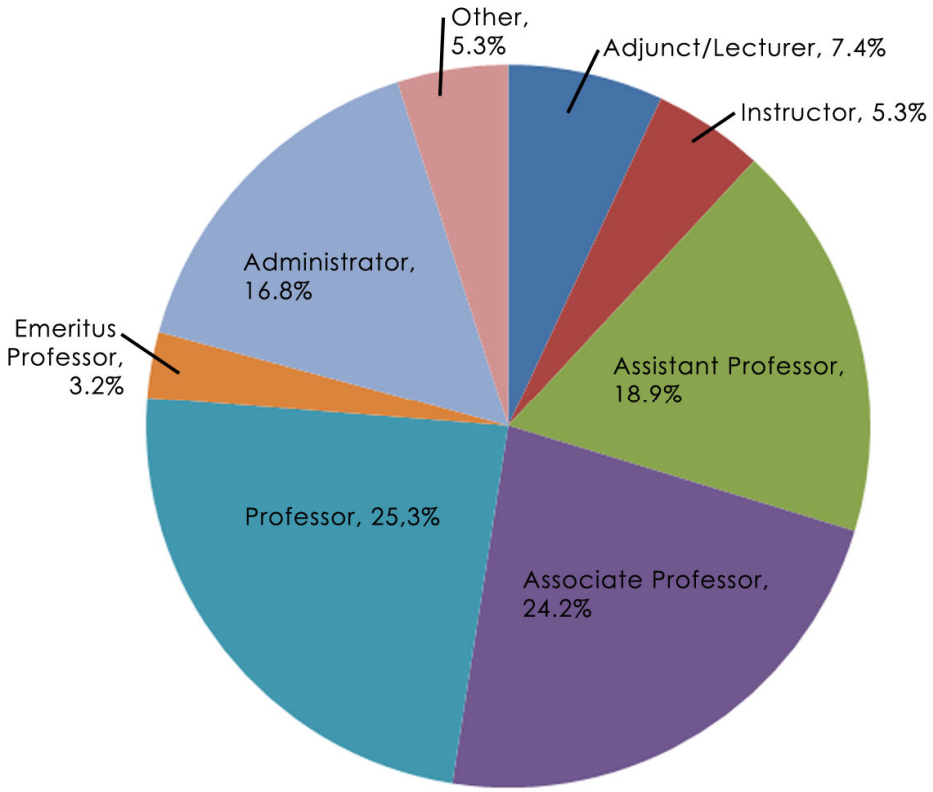


Figure 1: The distribution of survey respondents by faculty position (n=96)

Involvement in Undergraduate Research

A majority of respondents, 82%, indicated that they had mentored some form of undergraduate research related to environmental design, and similarly 82% indicated they were interested in working with undergraduates in the future. Comments submitted from some faculty not currently participating, or intending to participate, in research suggested that "undergraduate students do not have the skills or motivation for research", and that "graduate students, when available, are preferred". In line with the reports made by the professional and academic organizations, 52% of respondents reported research as being 'more integrated/important' in their respective curricula compared to 5 years ago. 37% reported no change, and 11% reported research as 'less integrated/important'.

In terms of student participation, 16% of faculty respondents reported that most (more than 75%) of the undergraduate students participate in research, a statistic which was qualified by some respondents expressing comments that this percentage is the result of a required thesis or course experience. 8% reported estimates between 25% and 75%, 40% reported less than 25% and 35% reported very few or none. As a comparison (Figure 2), the 2002 Boyer Report lists that 16% of research universities report 'most' of their undergraduates participating, 26% report that 'about half' of their undergraduates participate in research, and 48% of research universities have 'about 25%' of undergraduates participating in research across majors [19]. While there appears to be alignment between the Boyer Report and the Undergraduate Research in Architectural Education survey at the high end of the spectrum in statistical reports of programs with undergraduates participating in research, the evidence suggests that fewer programs overall have undergraduate student participation in research compared with other majors. Additional data from universities should be collected to determine if this is indeed a robust statistic, and specifically if this distribution is appropriate to the education of architects, or if the efforts to increase participation should be implemented.

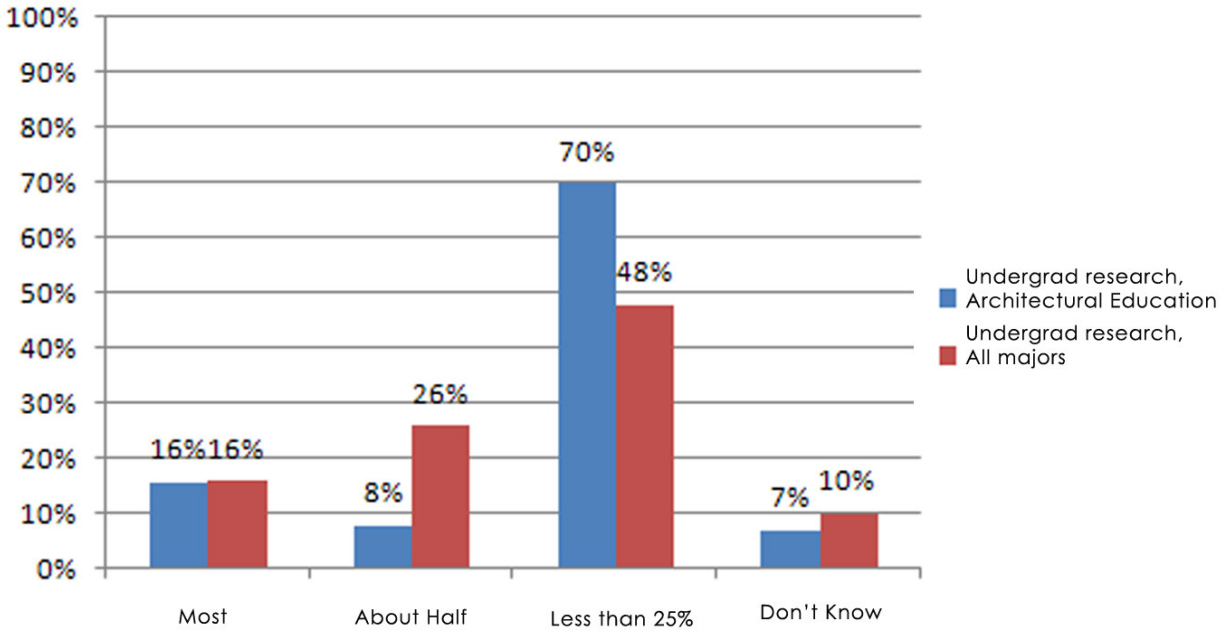


Figure 2: Undergrads participating in research in architectural education compared to all majors (n=96)

Types of Undergraduate Research

With respect to the nature of research projects being conducted at the undergraduate level, respondents were asked to indicate all project types in which they have participated. Figure 3 depicts a significant range in research project types with case study analysis and senior thesis opportunities ranking among the most prevalent. While these topical categories were informed by consulting reports produced from the working groups at the AIA 2007 Research Summit, the 2008 ACSA Teacher's seminar 'Deep Matters', and surveys conducted on undergraduate research in fields outside architectural education, it must be pointed out that there was much discrepancy as reflected in the survey comments about which of the topics listed truly qualify as research. It is the position of the author that as long as the project meets the definition of research (section 1.2.1), all topics listed in the survey are valid considerations as examples of research. Figure 4 lists the breadth of disciplinary specialties of undergraduate research being undertaken with social factors and sustainability ranking among the highest categories. Categories comprising the 'Other' sector (written in the comments section) included: architectural history, theory, air quality, seismic studies, building engineering, ecology, design, housing, disaster recovery, and professional practice. The sheer number of topics reflect not only the breadth but also the depth, diversification, and specificity of the extant research taking place at architectural institutions which undergraduates are being exposed to.

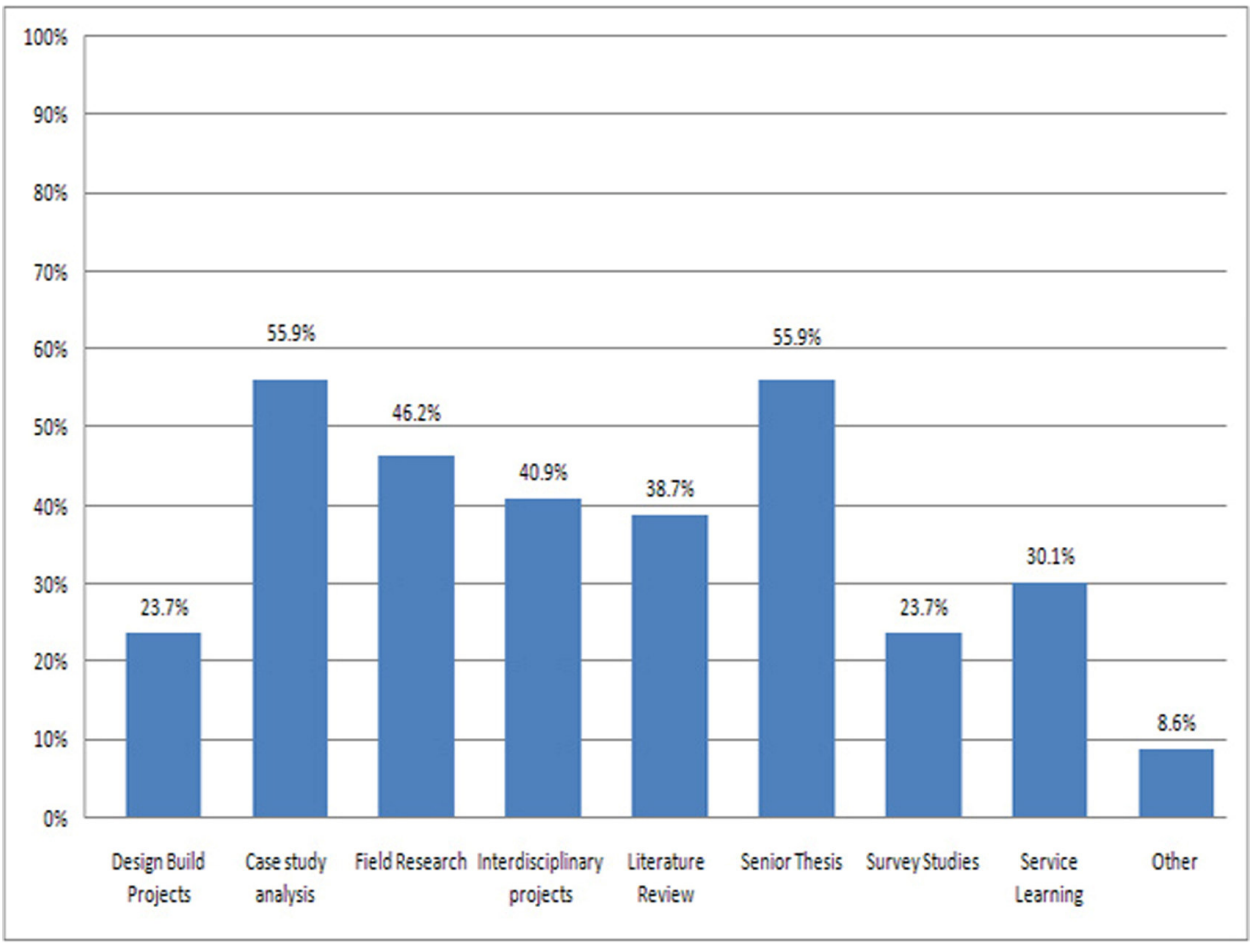


Figure 3: Undergraduate research project types. Data indicates the percent of total respondents (n=96) who selected each response option.

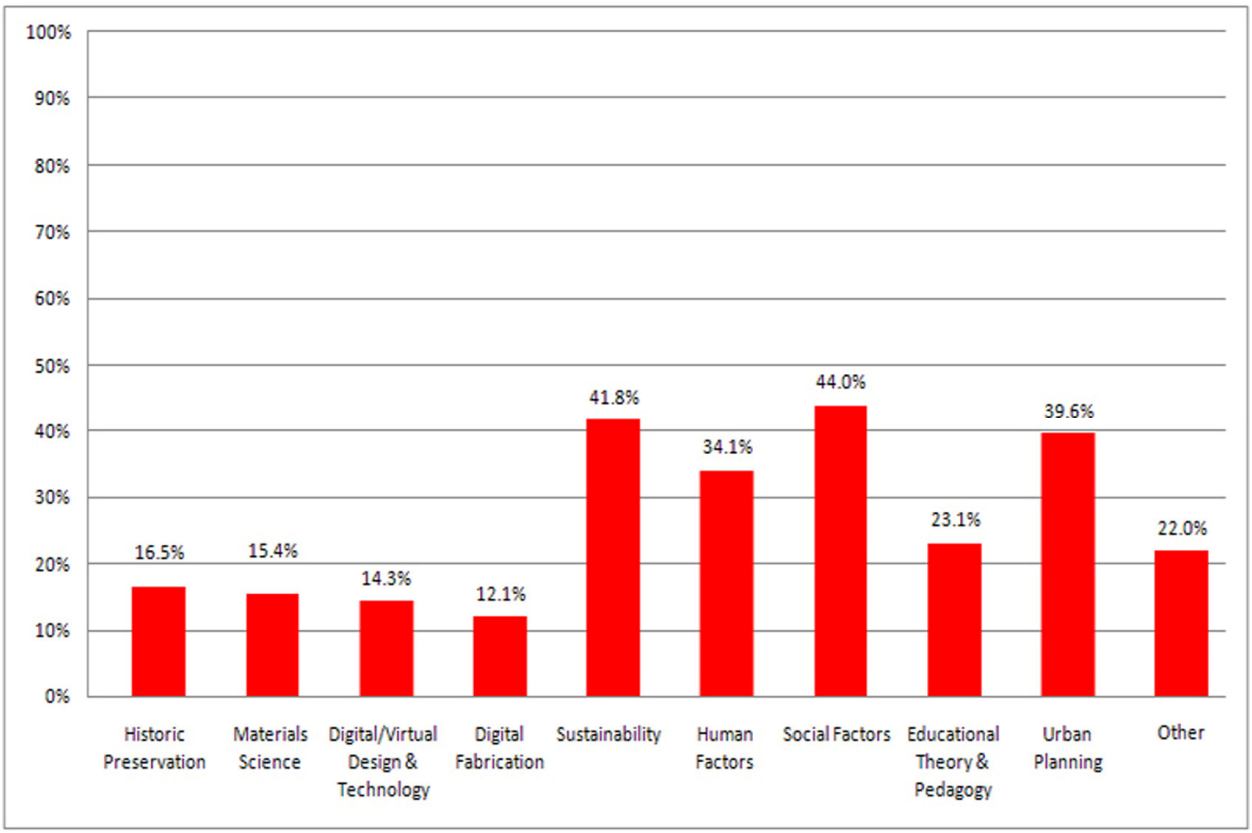


Figure 4: Undergraduate research disciplinary specialties. Data indicates the percent of total respondents (n=96) who selected each response option.

Integration with Practice

69% of respondents indicated that their research involves or integrates practitioners. Given the finding from the HKS case study visit that 'Research is design-based', this statistic suggests that the majority of research is currently being carried out in collaboration with practitioners and contradicts critiques that academic research is too far removed from application or real world relevance.

Benefits and Learning Outcomes

An open-ended investigative question was posed to the survey respondents to list innovative practices and learning outcomes that they employed or witnessed which have enhanced the undergraduate research experience. These responses informed objectives and assessment measures for the preceptorship program. The following are regarded as the most relevant comments to the future of undergraduate research:

Regarding interdisciplinary collaboration:

> "Some experiments of having professional students work directly with research students have worked very well."
>
> "Service learning within the interdisciplinary studio has prepared students for practice with real clients and very real projects."

Regarding connections with the design studio:

> "Preparation of graduate students for research and critical research-based work (can occur) in the studio."

Regarding publication and dissemination:

> "Publication of papers with undergraduate's name on the work." (listed as an innovative practice)
>
> "Publication in the UROP journal once a year encourages students and faculty to continue with the program."

Regarding learning outcomes:

"Enhanced skills in writing and verbal/media presentation; awareness of issues in practice." (listed as learning outcomes)
"Critical thinking, analytical approach to arrive at design solutions. Supporting the argument with evidence, deductive-inductive process" (listed as learning outcomes)
"Understanding of the research methods and how they apply to design and construction." (listed as learning outcomes)
"Students get the advantage of working on research projects. This often leads them to graduate work. We are trying to incorporate more opportunities for this kind of activities in the undergraduate program."
"Students learn sound research methods and apply their research findings in fairly innovative ways."

Obstacles to Research

Respondents were asked to indicate all factors they considered to be primary obstacles to undergraduate research projects (Figure 5). The top three reasons cited include: 1) lack of project funding cited by 62% of respondents, 2) lack of time, and 3) undergraduate students are not able to work independently (due to lack of maturity, experience or knowledge). Several comments mentioned design studio as being a deterrent to undergraduate research because of time requirements and the precedence of design studio within the curriculum. Of particular interest is that few, only 3.3% of the total respondents, indicated ideological impediments as a factor, i.e. 'research projects do not prepare students for professional practice'. Thus, it is a matter of addressing resource, structural and skill-based factors in order to test the reverse hypothesis, that 'research projects *do* prepare students for professional practice'.

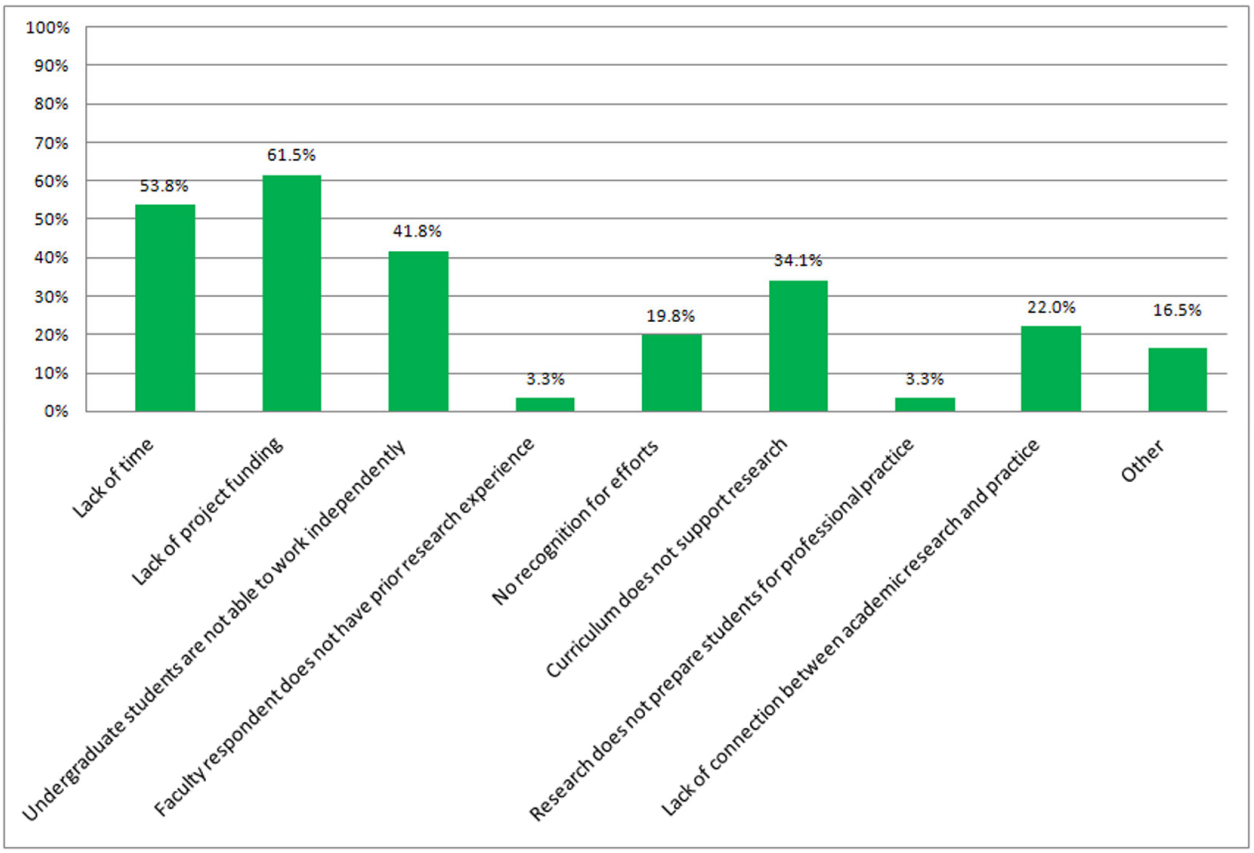


Figure 5: Obstacles to undergraduate research projects. Data indicates the percent of total respondents (n=96) who selected each response option.

Funding

Given that funding was cited as the top obstacle to research, it is important to consider how undergraduate research is currently being supported in architectural education. Respondents were asked to indicate all compensation opportunities currently in place at their respective research institutions to support undergraduate research. Figure 6 represents the frequency of compensation opportunities with elective credit reported as the most available (indicated by 52% of total respondents). Many of those indicating "other" explained that they were not aware of what compensation opportunities were available.

While the AIA's position on not employing unpaid interns is supported [20], when research is structured according the definitions of research (section 1.2.1) and undergraduate research (section 1.2.2), keeping learning and knowledge production as priorities for all constituency groups, it is not unethical to compensate the students with credit, especially early in their learning curve. Students armed with research skills will subsequently have the ability to write their own funding proposals, especially in universities with established undergraduate research offices and funding programs.

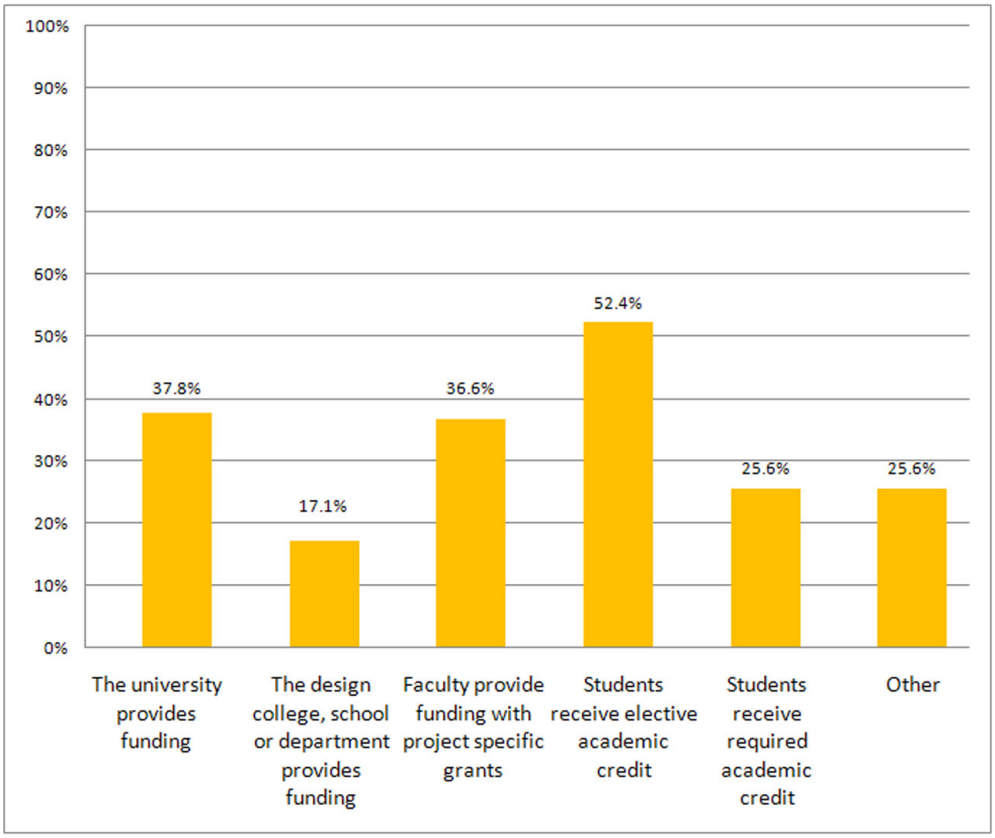


Figure 6: Compensation opportunities to support undergraduate research. Data indicates the percent of total respondents (n=96) who selected each response option.

Conclusions

The frequency data collected on 'Undergraduate Research in Architectural Education' in programs across the United States provides the background for understanding in a broad sense, how many faculty are engaged in undergraduate research projects, what type of research they are engaged in, and what faculty identify as benefits and obstacles to undergraduate research.

In summary,

- Most importantly, the results support the viability of undergraduate research in architectural education given that a significant majority of faculty members currently are or have in the past participated in undergraduate research opportunities, and that most see research as being more integrated into the curriculum compared to 5 years ago.

- Based on the responses and comments submitted, it is apparent that faculty do not agree on what constitutes undergraduate research, and that many, if not most, opportunities are informal faculty-led initiatives versus those outlined within a formal program or underlying curriculum.
- Research should integrate not compete with the design studio experience to maximize learning outcomes, and there is precedent that it can successfully be conducted through collaboration with practitioners.
- Significant obstacles to research exist and administrative structures at the national, university, departmental, and faculty levels should address these issues to make research more accessible to faculty and undergraduate students.

This information helps position and inform future undergraduate research initiatives, and brings to light additional studies which should be undertaken to complement and verify this data. While this study includes a representative sample from among architecture schools in the United States, it is recommended for future studies that a larger population be surveyed with single representation for each of the accredited institutions in order to achieve greater validity in representing the country's institutions as well as to eliminate discrepancies in responses which occurred within institutions.

4 The Preceptorship Program as a Model for Research in Undergraduate Education

The information gleaned through the studies in the preceding two sections provided background from the practitioner's, architectural researcher's, and faculty member's perspectives in order to structure and test a pilot study of a conceptual model for an undergraduate research program, the 'Preceptorship Program', at the University of Colorado, Boulder. The pilot study phase (Fall semester 2008) of the preceptorship program was designed to examine and test a model research program that provides undergraduates an opportunity to participate in research, and that exchanges knowledge with, and transfers research lessons to, practice (such that practice is both the driver and beneficiary of the research).

4.1 Constituency groups

This section defines the roles and outcomes for each constituency in the working model individually as well as collaboratively. Table 1 describes the preceptorship program pilot semester participants and projects.

Table 1: Preceptorship Program: Pilot study participants and projects

Student	Year	Faculty Member	Professional Preceptor	Project Title	Products
1	Senior	PhD student, College of Architecture & Planning	City, Transportation Planner	Geographic and Qualitative Methods for Improving Children's Active Travel Policy	Citation in peer-reviewed publication; invitation to present with mentor at ACSP conference
2	Junior	Faculty, School of Architecture	Architectural firm, Architectural Intern	Examining positive correlations between LEED Middle Schools and extracurricular involvement	Submitted grant proposal to UROP to continue study.
3	Junior	Faculty, School of Architecture	Industry Researcher, Vice President	The Therapeutic Effects of War Memorials on Individuals Suffering from Post-Traumatic Stress Disorder	Acknowledgement in peer-reviewed journal article for efforts on literature search; certificate award from industry partner for Research Assistance
4	Junior	Faculty, School of Architecture	Client, Assistant Director	Tactile mapping: Enhancing campus navigation for blind	Submitted university 'Diversity and Excellence' and UROP

				users	grant proposals to fund project

4.1.1 Practitioner Preceptor
In order to structure the research project around a question from the built environment, a design professional is engaged to provide a real-world design issue, the inquiry of which will benefit not only the design professional but also the profession. When relevant, the preceptor will ensure that the client is supportive of the research project. The preceptor will benefit from this experience by: obtaining new information about a particular project which can also serve as marketing material, collaborating with a university partner and having access to the university's intellectual resources, and having the opportunity to participate in publication and presentation opportunities resulting from the research project which will strengthen the practitioner's credibility as a researcher. It is hypothesized that preceptors with little or no experience in research would gain access to basic research skills and terminology, such as accessing useful sources which can provide an evidence base to design, and helping to structure a robust research question that can inform design, through interactions with the student and faculty member thus promoting the research culture in practice.

In this pilot study, no specific qualifications were imposed on who could participate as a preceptor. On the one hand, it is recognized that senior practitioners have the most experience and knowledge to offer to the student and research project; however, may have less time to engage the student. On the other hand, drawing from the example of the 'Building Stories' case study [21], less experienced professional interns eligible to receive IDP credit for their participation would be incentivized to participate based upon the time they provide. In future iterations, the preceptor might be conceived as more of a collective entity, such as a design team, versus an individual. In this pilot study, in addition to two design professionals, a representative from industry, and a client were engaged as preceptors because they provided real world projects needing research.

4.1.2 Academic faculty member
The role of the academic faculty member is to provide educational support for the student to access the appropriate disciplinary framework and methodology appropriate to the research question. The faculty member benefits from the relationship by collaborating with the student and practitioner on funding and publication opportunities. Ideally, the faculty member is chosen because his/her research interests align with those of the research project. Thus, the faculty member is able to advance his/her own research efforts through this collaboration.

In this study, the academic faculty members included full-time faculty in the architecture department with research experience, and a PhD student in the College of Architecture & Planning.

The academic coordinator of the preceptorship program provided a semester schedule to all constituencies, and regular assignments to the student which were individually tailored by the academic mentor as appropriate to the student's research project. The coordinator held monthly lab meetings with the students to chart individual progress and provide group tutorials on common research topics such as writing literature reviews, and preparing grant proposals.

4.1.3 Student
The student is conceived as the primary vehicle for knowledge exchange between practice and academia. Benefits to the student included: acquisition of skills and experience in research, exposure to issues of practice, networking opportunities, and the potential for collaboration in publication and funding opportunities. It was hypothesized that students would acquire the following learning outcomes as a result of the research experience: time management and communication skills; critical thinking; creative thinking; critical analysis of information; ability to define problems, to acquire information, to frame questions, to apply research methodology, to draw conclusions, and to develop an argument. The student, armed with these skills in research, is him/herself a vehicle for dissemination and change.

Students were expected to meet with the preceptor and faculty mentor once/week. Students were encouraged to seek additional disciplinary expertise as necessary.

Students received academic credit for participation in the preceptorship program. Participants were determined through a competitive application process. 15 students applied for the preceptorship program, and six were selected to participate. Students were selected on the basis of having taken a prior course in research methods, prior research or practice experience, GPA, and year in school. Two of the six students withdrew from the program citing 'lack of time' and 'lack of independent motivation' as reasons.

4.2 Organizational inter-relationships and knowledge transfer among the constituency groups
Given these three constituencies, the student (S), the academic faculty member (A), and the professional preceptor (P), several working relationships among them were probed to more fully characterize the organizational system for the preceptorship program that would best support meaningful research opportunities for undergrad students, and knowledge transfer between education and profession (Table 2).

Table 2: Organizational relationships between the constituency groups

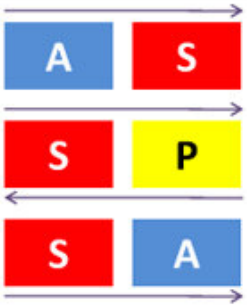
	Working Relationship	Examples	Knowledge Transfer
A		Independent Study, Research Assistantship	Typically unidirectional from academic to student, can be reciprocal.
B		Internship, Apprenticeship	Typically unidirectional from professional to student, can be reciprocal.
C		Case Studies	This model represents the condition where a faculty member seeks out a real world case study for class analysis. While the study makes connections with practice, it can become segregated from practice if the practitioner is not fully engaged in participating for the sake of knowledge production with the result that the feedback loop is not closed.
D		Professional or Research Internship, traditional Preceptoship	Knowledge transfer is built up through a series of phased unilateral transfers which become cyclical when summed.
E		Integrative Preceptorship	Reciprocal knowledge exchange. Collaborative participation in the production of knowledge.

Table 2 demonstrates that knowledge exchange can be unidirectional or reciprocal in nature. Models A and B tend to be the most exclusive in nature. When the relationship is academic-based (Model A),

research may be more rigorous and progressive, but may suffer from being overly theoretical and too narrow. When the relationship is practice-based (Model B), there exists relevance and application, but it may be difficult to maintain a rigorous theoretical framework. While Model C makes connections with practice, in many cases there exists an apparent break in knowledge transfer from academia back to the profession after the initial case study documents have been shared by the practitioner with the academic institution. Model D describes a phased approach, where knowledge is built up through a series of discrete unilateral knowledge transfers which become cyclical when summed. In Model E, all constituency members collaboratively participate in the construction of shared knowledge. Model E attempts to structure an integrative relationship for research between all constituencies. A model similar in ideology was proposed by the 'cultural research' group led by David Brown, University of Illinois Chicago, at the AIA 2007 Research summit:

> "We came up with a model that was more about how – working within practice and in part with architecture schools – we can provide research in terms of broader trends. The goal would be to make that available to practice at the same time to schools in a short cycle of 4-10 years. Students have started to filter into offices. Offices will then have interns with some research background. In addition, over time, you might see the formation of research-based practices. Perhaps continuing into the future, there could be partnerships between schools and practice in which academics serve residencies within offices. This would make another research bridge. The institutional changes most relevant to those ideas involved accreditation and nonproprietary incentives." [22, p. 6]

The preceptorship program was structured according to the knowledge transfer outlined in Model E. Research questions are rooted in and arise from practice, and investigations and methods are conducted using academic resources. The student is the link in the knowledge exchange between the two constituency groups.

4.3 Program structure

With respect to integrating research into the curriculum, a sequential three stage process is proposed in which students first learn skills to access and read scientific manuscripts and understand research findings, then learn quantitative and qualitative research processes and methods, and finally learn about research by engaging in investigative research. It is during this third phase that the student's role is elevated to that of collaborator in knowledge production, and knowledge exchange becomes reciprocal. Keeping with the definition of research (1.2.1), the public sharing and dissemination of results caps the process. The approach should be integrated at both the larger curricular scale (across years), and at the smaller program scale (within a given year). Such preparatory strategy for research is currently not in place, in a formal sense, in the undergraduate curriculum at University of Colorado; however, it is recognized that students participating in the preceptorship program should have prior knowledge of basic research in environmental design and exposure to methods. Should the preceptorship program continue to grow and evolve, it would be necessary to integrate the sequential building of research skills and knowledge throughout the curriculum in order to best prepare students for the research semester.

The preceptorship program is conceived as a two semester (minimum) commitment by the students and preceptors (Table 3). The first semester is devoted to setting up the research project, and the following semesters to executing the research. The pilot study launched in August 2008 was structured as follows: Interested students were selected by a competitive application process. Preceptors were invited to participate in the program by direct invitation on the basis of having previous research experience. As the program evolves, it is intended that a call for participation would be issued to all local practitioners, and a database of interested practitioners and project specialties would be maintained. In the application, students were asked to rank their research preferences and were interviewed in order to determine the best match with mentors. Each research team (student, preceptor and academic) worked to craft a research topic and robust research question which was manageable in scope for the student to complete in one to two semesters and was meaningful for the practitioner. The student was charged with the task of completing a literature review for their mid-term project. Based on the information gleaned in the literature review, an appropriate disciplinary methodology was proposed.

The remainder of the semester consisted of preparing a project proposal. For students electing to continue with their research projects, proposals were submitted to the university's UROP (Undergraduate

Research Opportunities Program) for funding consideration, and in one case, to the university's 'Diversity and Excellence' grant funding program. In the second semester of the program, students were given the choice to apply for funding for their time or receive academic credit. Funding was also solicited for project supplies and travel. Students presented their research proposals in poster format in a public forum, and these posters were also displayed at a special research session at the 2008 AIAS Forum.

Two of the four students have elected to carry out their research proposals next semester. One student decided not to continue because of the time commitment, and one student is choosing to use the next semester to rewrite her project proposal.

Table 3: Semester objectives for Preceptorship Program

Semester A	**Semester B (and following semesters)**
Devise research topic and question	Collect data
Create and maintain digital lab journal	Analyze data
Literature searching on topic	Present results in written and poster format
Compile a literature review	Disseminate results
Propose methods	
Complete a project proposal	
Complete human subjects training (if applicable)	
Submit application for grant funding (if applicable)	

During the course of the semester, students were required to make weekly posts in a digital lab journal (blog) for review and comment by the preceptor and academic mentor, as well as their student research peers. The digital lab journal provided a means of archiving the student's process and ideas, as well as providing a collective space to facilitate communication among the three constituencies. Monthly lab meetings were held with the students and the preceptorship program coordinator to review progress. Students commented that these meetings were helpful to compare and contrast their research processes with the other students and to share ideas and insights. Students requested that meetings be more regular and include special topic seminars on things such as 'Literature Searching', 'Science Writing', and 'Human Subjects Training'.

At the end of the first semester, students, preceptors and faculty members were asked to provide written feedback as a means to evaluate the program in terms of gains and challenges and the hypothesized learning outcomes. Students reported the greatest gains in: confidence, ability to think and work independently, collaboration, expanding knowledge, understanding of research and its applications, restructuring career decisions, and feeling that this experience set them apart from their peers. In terms of challenges, the students reported an overall sense of confusion and insecurity about their research project, specifically in terms of anticipating 'what to do next'. Preceptors reported gains such as: collaboration potential with universities, that the mentoring experience caused them to rethink their own research projects or process by having to teach and explain it to the student, and that the program provided a reason for them to execute research projects, or small parts of larger research projects, that they would not have done otherwise. Preceptors and faculty members observed as challenges to the students: making the shift from creative thinking to critical thinking, and needing more structure in the design of the program. Dr. Upali Nanda, Industry Researcher who participated as a preceptor in the pilot study commented [23]:

> "This is an excellent initiative. Critical thinking, painstaking digging for information, analytical assimilation, and finally cohesive argument formation are skills that design students must learn. Perhaps an undergraduate student does not need to carry out empirical research. But it is vital that he/she learn how to read information that pertains to environmental design, from different fields, in a critical, rigorous and analytical manner. The current ethic in architecture and design is towards greater answerability- issues of perception, environment, health, and so on are central, not peripheral. Architectural success is no longer measured by its photogenic potential. In this climate students need guidance to commit to ethical design solutions. They need to know that creativity must stand on the foundation of good reason- and good reason is developed through conscientious and critical research."

The small number of pilot study participants presents a limitation to support any statistical conclusions about the program. Nonetheless, the reported and observed outcomes, of both process and products, will refine expectations and the programmatic structure of the future preceptorship program semesters specifically to include: a more structured program design, pre-requisite classes for the program, seminars and lectures about aspects of research, and handbooks and classes for preceptors. Additionally, it will be beneficial to follow the participating students over a 5-10 year period to assess long term and professional impacts.

5 Case study comparisons

A sampling of representative research programs in architectural education which link education and practice were analyzed in order to evaluate the preceptorship program model and findings from the pilot study semester through a qualitative comparison of program structure, learning outcomes, benefits, challenges and evaluative criteria. This section seeks to discuss why each individual case study is successful and to synthesize generalizable patterns and trends among the case studies reviewed.

Based upon a review of the literature on research in architectural education, and a survey sampling architecture programs in the United States (Section 3.2), the following three case studies were selected for having an established, published program representative of one or more of the key concepts in this study which merit replication (Table 4). All three case studies respond to a need to connect with practitioners to collaboratively join forces in knowledge production.

Table 4: Case study comparison among four university student research programs in architectural education

Program	Students	Academic	Practitioner	Research method	Year Began	Length	Dissemination of results
Preceptorship Program, University of Colorado	(1) undergrad per team	(1) Faculty member or PhD student	(1) design, or design-related, professional	Experimental; evidence-based	2008	(2) semesters minimum	AIAS forum (2008); project specific publications
Building Stories, Berkeley	(1-2) M.Arch. students per team	Faculty member facilitates course, does not participate on individual teams	(1-2) IDP professionals + (1) project advisor.	Case-based completed by academic-professional teams about design process	2000	(1) semester	Website (public)
AIA Case Studies Initiative	Class participation of students, graduate and undergraduate	Faculty member participation varies by institution	20 hours from firm, 2 hours from principal.	Case study completed by academic teams about design practice and built products	1998	(1) semester	AIA website (public)
University of	(1) Graduate	Faculty	(1) Firm	Case study;	1993	(2)	Presentation

Hawaii	student per team	participation varies by course	Principal/ Practicum Faculty	applied research		practicum semesters + pre/post semesters	and report to firm

5.1 'Building Stories' program, University of California Berkeley, Dr. Mike Martin, FAIA
Similar in scope to the preceptorship program, the 'Building Stories' project was conceived to promote knowledge exchange between practice and academia. The 'Building Stories' program brings together teams of students and professionals to "record and explore the knowledge capital embodied by architectural design practice through storytelling" [24, p. 112]. The program utilizes a case-based, qualitative methodology which dissects the complex interrelationships among the "events, people and circumstances" [24, p. 112] that shape active projects in design and construction in order to share stories of best practices. The research specifically analyzes design practice and process issues. Research teams are composed of MArch students, professional interns, and an advisor who is a seasoned professional in a leadership role of a firm; thus the teams are "heterogenous in terms of the skills and experience people bring to it" [24, p. 115].

Students receive academic credit, and interns and professionals are eligible to receive IDP or CEU credit [25]. Participants benefit from this experience by becoming "familiar with theoretical and methodological issues that guide their work", and by gaining the ability to apply "these concepts, principles and procedures to their own design and construction activities" [21]. Practitioners benefit from having access to the time, energy and resources provided by the academic networks [24]. The course is structured such that all teams attend lectures and discussions about methods and research issues, and individual teams regularly meet to apply those lessons to specific projects [21].

The products resulting from this semester program include: a case report describing the project's background, a team webpage with weekly posted made for review by team members and other interested parties, a written analysis report, and a presentation to the firm [21]. Much effort in developing the 'Building Stories' project has been devoted to creating an effective means of knowledge dissemination to share the results of the research teams with the profession at large. Final team reports are currently available on a public website, and work is underway to devise a web-based "framework to store, organize and access stories" [26] in such a way that is easy for practitioners to access stories of particular relevance to them.

The 'Building Stories' project has invited peer review through evaluation mechanisms such as research undertaken by doctoral students, meeting with past participants of the program (both students and practitioners) and by seeking input from local firms [25]. Evaluation measures indicate that "the initiative seems to provide an inventive methodology for catalyzing knowledge sharing between projects, between individual architects and architecture firms (through the on-line story collection but also through the participation of young professionals) and between practice and academia (equipping design firms to draw on 'that resource on campus' and vice versa)" [25, p. 73].

5.2 The AIA Case Studies Initiative
The Case Study Initiative was conceived in 1998 by members of the AIA Large Firm Roundtable and deans of schools of architecture [27]. This program seeks to "share lessons learned from practice" [28] through a comprehensive review of built projects using a case study analysis methodology. A case study project may be initiated by a practitioner or faculty member, and is open to students at any level based upon the determination of the governing faculty member. The case study analysis is to be completed in one semester by a team of: students, firm member(s) who guide the students' research, and a firm principal [28]. Most of the published case studies were completed by teams of about 5 students, although some were completed by larger classes or by students working independently. In some cases, faculty took an active role in the analysis, and in other cases assumed more of a facilitator role as in the 'Building Stories' project.

Like the 'Building Stories' project, professionals are eligible to receive CEU or IDP credit for their participation [27]. Catherine Roussel, AIA Director of Education, reported that the most successful case

studies are those which have significant commitment and buy-in from the firm [29]. Students benefit from this experience by gaining exposure to issues of practice; faculty benefit by having the opportunity to submit the resulting work for peer-reviewed publication; and practitioners benefit by having the opportunity to reflect on their work through insights from the student work [27].

Teams follow a detailed protocol for analyzing a case study according to several measures such as: client concerns, business issues, design considerations, and project delivery issues [27]. The resulting case study report undergoes a peer reviewed evaluation process before it is published on AIA's public website. Like the 'Building Stories' project, knowledge dissemination to the profession occurs in a Web-based platform on the AIA site.

5.3 University of Hawaii's Practicum Studio, Joyce Noe, FAIA

The University of Hawaii's 'Practicum Studio' began in 1993 in order to "engage practicing architects as teachers to enhance professional practice leaning in an architecture curriculum" [30]. The practicum studio incorporates the AIA Case Study approach, applied research methods, as well as practice competency and community service activities [31]. Most research issues center around practice and process issues. The practicum studio assigns individual graduate students to office in a practitioner's firm for two 12 credit hour semesters. The student is directed by a firm leader who is a licensed architect and who serves as a member of the practicum faculty.

Students benefit from this experience by receiving IDP credit, having situated exposure to the profession, and having the opportunity to work with leaders in the profession resulting in the acquisition of skills in leadership, cultural sensitivity and independent thinking [31]. The reported benefit for practitioners is the long-term investment in the future work force rather than direct, short term benefits produced from the practicum experience. Because students are 'learning, not earning' for the firm, firms incur a significant loss of income [31]. However, the fact that firm leaders continue to support and participate in this experience suggests that the long term value outweighs the costs. To better prepare the students for the practicum studio, a research methods seminar was implemented in 2005: "Prior to 2005, students enrolled in research courses in departments outside of the architecture school which did not cover applied design research issues" [30]. Returning from the practicum studio, students participate in a seminar in which they share and discuss the research performed during their practicum studio. The evolution of this research experience trilogy of courses is strong evidence of the need for support courses in schools of architecture for students to best assimilate research knowledge into their studio or research experiences.

The dissemination of research results occurs in the post-practicum forum, as well as in a written and oral report presentation to the firm [30]. However, the greatest value is the dissemination of skills the participating students will take with them to subsequent professional experiences, and not necessarily in the information generated from this particular experience. The practicum studio employs both internal and external evaluation measures to continually update its framework and optimize the experience for students and practitioners. Internal validity is measured by evidence of critical thinking in writing and design assignments following the practicum studio [30]. Practicum faculty, architecture faculty, students and alumni participate in workshops about the practicum studio in order to provide an external review of the program [30].

The three selected case studies differ from the preceptorship program in that they primarily rely on case study methodology to explore aspects *about* the design process or products, while the preceptorship model promotes experimental research *for* practice. Nonetheless, all three models share in common with the preceptorship program a fundamental goal of forging collaborative relationships between practice and academia which result in knowledge production. The three selected case studies provide valuable evidence about how to structure, assess, and disseminate results from research programs in a way that benefits both the participants involved as well as the profession.

6 Key Findings and Recommendations

This study provides a broad overview of the current status and feasibility of undergraduate research in architectural education in the United States. By relying on several sources for data input into this issue,

the study captures a range of considerations, perspectives and models which can be used to inform initiatives in undergraduate research. The recent changes in the profession support an education that provides opportunities for research and knowledge production, and which forms collaborations with practice. The following recommendations are based upon key findings generated in this study:

Institutional and curricular considerations:

1. Universities should be encouraged to test research programs and opportunities through pilot studies and experimental course offerings. Research programs resulting from experimental versus theoretical models are able to provide more robust data in informing future models. Even a small pilot study (n=4) was able to yield valuable evidence to inform program design.
2. Efforts to standardize definitions of research in architecture education, and learning outcomes which would promote research in the curriculum, should be orchestrated at the national level across all programs, but the appropriate manifestation of an undergraduate research program should vary according to the resources and context of the individual program. It is not intended that the preceptorship model be formally adopted by other university programs, but rather could serve as a conceptual model and process to inform the promotion of research in undergraduate education. Certain learning objectives can be adopted from the Council on Undergraduate Research (CUR), while others will need to be discipline specific based on differences in research definitions and application utilized by the profession.
3. It is recommended that the NAAB or ACSA rigorously track the existing research programs of accredited architecture schools. Providing a common database will facilitate knowledge exchange and program replication among these resources. Having the means to compare programs in a single repository will also shed insight the questions of 'what constitutes research' and 'what constitutes a research program'. In the survey on 'Undergraduate Research in Architectural Education', many faculty members had difficulty in ascertaining whether or not their own home institutions conducted research or had research programs.
4. The success of launching and sustaining a research program is dependent upon a commitment to the initiative and institutional policy changes at the college and university levels. The case studies referenced in this report have been allowed to develop over the course of 10 years because of financial and administrative support from their institutions and professional communities.
5. Successful research will require a significant time commitment from preceptors and faculty members. Undergraduate research programs in the sciences have already issued recommendations to the NSF to "encourage colleges to include serving as a mentor to undergraduates as a factor in tenure and promotion decisions" [32]. Architecture programs should follow suit in this petition.
6. More investigation is needed to determine how research can integrate into the current architectural curricula so that it collaborates, not competes, with other educational requirements such as design studios.
7. Funding opportunities for architectural research should be made available in a single repository which is accessible to both universities and firms, instead of each entity creating their own databases.

Program considerations:

1. Courses are needed on research methods in order to prepare students for undertaking a research experience with a practitioner.
2. The short and long term benefits to students participating in architectural research should be tracked within and across schools. Results from the pilot study on the preceptorship program provide evidence that undergraduate students are able to successfully access useful sources which can provide an evidence base to design and that this ability is valuable for their professional development. Less conclusive is whether students at the undergraduate level are able to structure and carry out a research project which can inform design, and if the knowledge generated from such a project would be directly transferrable to practitioners. This type of experimental research may be more appropriate at the graduate level.
3. It is recommended that Industry partners be invited to participate in research programs. This study only peripherally addressed the role of industry partners. It is recommended that industry partners could also collaborate with practitioners and academics to frame appropriate and timely research questions to advance the profession.

4. Practitioners must overcome obstacles such as litigation fears and claims to proprietary knowledge in order to promote a collaborative culture of knowledge exchange. Bringing clients into discussions about research at the beginning of projects will facilitate a spirit of generating knowledge for the benefit of all. It is difficult to collaborate with practitioners who exhibit a fear that the dissemination of results from a research project are potentially threatening.

Next steps

As a first step, it would be most beneficial to look to the efforts conducted by the United Kingdom (UK) and Europe studying research in architectural schools, not because the answers or issues should be assumed to be the same as programs in the United States, but because these countries have spearheaded elaborate initiatives in attempting to organize a paradigm in which to think about and test the issues. Of particular note, the LINK initiative, Linking Teaching with Research and Consultancy in the Disciplines of Planning, Land and Property Management and Building, funded by the Higher Education Funding Council for England and Wales (HEFCE) conducted three phases of study from 2000 – 2003 "concerned with exploring the understanding held by academic staff about the relationship between teaching and research, and collecting evidence with respect to effective practice in making productive links" [3, p. 712]. A separate study, completed in 2004, examines architectural research in UK schools from an institutional and historic perspective in order to make recommendations for how architecture research might evolve [33]. Such studies have not only documented the issues and status of research in and between practice and academia, but also have resulted in the creation of resources, programs, conferences, committees, and opportunities in general, which promote research in architectural education.

7 Internet Resources on Undergraduate Research and Architectural Research

Agents of Change, University of Oregon
http://aoc.uoregon.edu/

The AIA Case Studies Initiative
http://www.aia.org/ed_casestudies_init

AIA Soloso
http://soloso.aia.org/eknowledge/index.htm

Architectural Research Centers Consortium (ARCC)
www.arccweb.org

Association of American Colleges and Universities conference on "The Student as Scholar: Undergraduate Research and Creative Practice"
http://www.aacu.org/meetings/undergraduate_research/index.cfm

Berkeley Building Stories
http://169.229.137.120/Disclaimer.htm

Center for the Built Environment Industry/Research Collaboration
www.cbe.berkeley.edu

Council on Undergraduate Research (CUR)
www.cur.org

The LINK initiative, UK
http://www.brookes.ac.uk/schools/planning/LTRC/

National Conferences on Undergraduate Research (NCUR)

www.ncur.org

Vital Signs Curriculum Project
http://arch.ced.berkeley.edu/vitalsigns/Default.htm

Web Guide to Research for Undergraduates (WebGURU), Northeastern University
http://www.webguru.neu.edu/

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