A Model for Professional Inquiry-based Education: Lessons from Construction Management Toward Further Research

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Having implemented new curricula built around inquiry-based coursework, two construction management programs compared their two curricula to establish common challenges. To develop further research, it appeared that a theoretical model was needed to define characteristic problems and potentials of professional inquiry-based education. A model is a conceptual tool that provides a structure of relationships for the development of research designs. This paper describes the development of that model and how it helps define the shared challenges between the two programs. These challenges are then investigated in terms of potential research questions, issues that help focus research plans, and initial ideas about theory and data collection.

Key Words: Inquiry-based learning, construction management education, curriculum design, professional education.

Introduction

The construction management programs at California Polytechnic State University at San Luis Obispo and Mississippi State University have worked over the past decade to implement new curricula built around inquiry-based coursework. These changes reflected what both programs saw as problems in traditional construction education; that the development of integrative, problem-solving, and thinking skills was too difficult in lecture course "silos," and that new pedagogic methods were needed to respond to the unprecedented changes occurring in contemporary construction practice. Supported by the research literature in education, both programs instituted five- and six-credit problem-solving courses around which each new curriculum was structured. In these courses—called "labs" and "studios"—students engage multivariate construction problems through strategies of proposition, reflection, and solution iteration. Students are active learners and develop master-apprentice relationships with faculty. Skills, knowledge, and critical thinking are built through repeated exposure to more difficult and demanding problems. While still rare in construction education, both universities independently arrived at the same conclusion: inquiry-based learning holds tremendous potential for educating twenty-first century construction professionals.

In the continuing work of rebuilding their curriculums, Cal Poly and Mississippi State conducted a comparison of their two programs to establish common challenges that could be addressed by research (Monson & Hauck, 2012). Through that comparison, a set of shared challenges were identified: measuring student learning outcomes, conceptualizing the development of construction content and skill sets, understanding the process of inquiry curricula and curriculum development, building appropriate faculty development, and questions of program accreditation. As these research challenges were identified, it became clear that a model was needed so that potential research questions, plans, and ideas about theory and data collection could be proposed. A model is a conceptual tool that provides a structure of relationships for the development of research designs. The development of this new model—the general model of professional inquiry-based education—will be described, its logic will be applied to the research needs of inquiry construction education, and the methodology of action research will be recommended.

Background

Over the past thirty years, a series of blue-ribbon panels have examined undergraduate education and found significant problems (NIE, 1984; Boyer Commission, 1998; NCPPHE, 2006). While each of these studies had its own focus and agenda, there is a consistent thread running through them; almost every report concluded that students were not developing the thinking skills that would be required of citizens in the twenty-first century. These skills were variously called analytical thinking, problem solving, reflective judgment, applied logic, and practical reasoning, but could be more generally—and accurately—called "critical thinking." The studies were unequivocal in their agreement, and they have been consistent across time. In 1971, McKinnon and Renner found that less than half of undergraduate freshmen were able to think at an appropriately abstract level. Forty years later in 2011, Arum and Roksa found that almost half of their sample of students demonstrated little or no improvement in critical thinking and reasoning skills after two years of undergraduate study.

In his 2006 study titled *Our Underachieving Colleges*, Derek Bok suggests that many of the problems of the traditional lecture course model could be rectified by looking to the example of professional schools where "instructors . . . create a process of active learning by posing problems, challenging student answers, and encouraging members of the class to apply the information and concepts . . . to a variety of new situations" (117). Nearly twenty five years earlier, Donald Schön (1983, 1987) explained what was different between the university lecture course model and professional education; knowledge in a profession can only be demonstrated through practice—by trying something, receiving criticism about one's performance, and then reflecting on that input in the reformulation of a subsequent solution. Schön famously called these activities "reflection-in-action." He said that when students face the uncertain problems characteristic of professional education, they have to learn "beyond stable rules—not only by devising new methods of reasoning . . . but also by constructing and testing new categories of understanding, strategies of action, and ways of framing the problem" (1987, 39).

If epistemology – the way of knowing – in the professions is different than knowledge in academic disciplines, such as history or physics, then education in the professions must, and in fact does, mirror these differences. Thus, case study learning in business management, residencies in medicine, mock trials in the law, and the studio model in architecture have all become standard components of the education of these professionals. Historically, however, most construction management curricula have been modeled more on academic disciplines than on professional ones, dividing knowledge into neat packages to be taught—and mastered—one at a time and rarely transferred to new contexts. If this problematic feature of the lecture course makes it of questionable value to the professions, is continuing this approach appropriate for preparing future generations of professional constructors?

A General Model of Professional Inquiry-based Education and its Shared Challenges

In their initial studies of new models for construction education, both Cal Poly and Mississippi State decided that the lecture course model was not adequate for preparing twenty-first century construction professionals. Both programs found that the inquiry-based learning model of professional education held better promise to realize high-quality student learning outcomes in terms of content knowledge, critical thinking, and the transfer of knowledge and skills

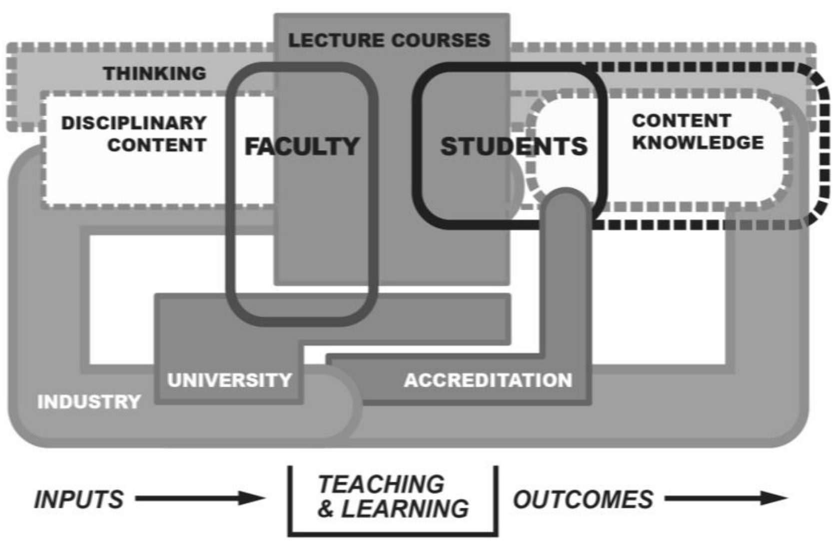

Figure 1: Model of undergraduate education

to new contexts. In the comparison of the two curriculums (Monson & Hauck, 2012), it was recognized that much of what appeared as challenges to both programs was a function of the structure and relationships of the constituent elements of university undergraduate education. For a simple example, the normative lecture course model has particular demands upon facilities and classroom furnishings—seats facing forward, instructor in the front—that are not the same as the inquiry-based learning model—adaptable seating and workspaces, instructor frequently not at the front of the room. A more complex example is how the academic training of faculty tends to reward narrow realms of scholarship and research, whereas inquiry-based instruction requires faculty skills of practice-based application and integrative problem solution. So, a cogent way to build the basis for the development of the research challenges posed by the inquiry-based construction programs at Cal Poly and Mississippi State is to start from a comparison of the constituent elements of normative undergraduate education (Figure 1) as they can be compared to professional inquiry-based education (Figure 2).

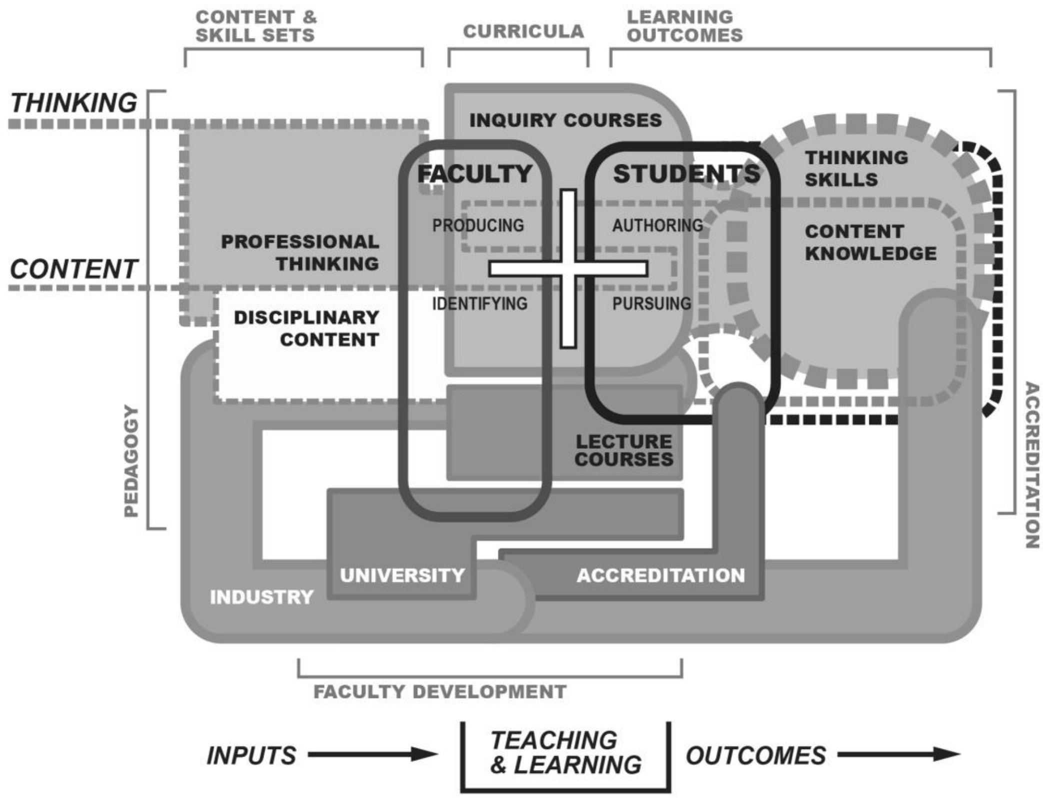

Figure 2: General model of professional inquiry-based education, including shared challenges

The model of undergraduate education in Figure 1 is a set of relationships between disciplinary content, industry, the university and its lecture coursework, the faculty and students at the core of teaching and learning, student learning outcomes, and the process of accreditation. This arc is the familiar system of twentieth century undergraduate construction education. The general model of professional inquiry-based construction education in Figure 2 is conceptualized from the experiences of Cal Poly and Mississippi State and their inquiry-based construction programs. At the bottom is the same system as exists in the normative undergraduate education model. What is different is the substantially larger arc of "thinking" at the top: the emerging set of relationships between professional thinking in contemporary practice, the inquiry courses that engage this thinking, and the outcomes of holistic thinking skills and content knowledge that emerge from the inquiry-based learning instructional environment. The top arc is the path of program development in construction education at both Cal Poly and Mississippi State. It is also the same set of relationships between professional thinking and disciplinary content that typifies professional education. While this top arc of thinking is not wholly absent in the model of undergraduate education, it is the driving feature of the general model of professional inquiry-based education and the location of all of its pedagogic strengths. We believe that, in construction education if not undergraduate education in general, the top arc of higher-order thinking and multivariate problem solving will be of primary importance to twenty-first century teaching and learning.

At the center of the top arc is the organizing element of inquiry coursework. For this model, we have employed the inquiry-based learning framework developed by Phillipa Levy and the Centre for Inquiry-based Learning in the Arts and Social Sciences (CILASS) at the University of Sheffield (2009). The CILASS framework (located around the plus sign in Figure 2) conceptualizes two levels of inquiry. The information frame (the bottom of the plus sign) is characterized by "identifying" when inquiry activities are led by faculty and "pursuing" when led by students. The discovery frame (the top of the plus sign) is "producing" when led by faculty and "authoring" when led by students. The information frame comes directly from normative disciplinary content, while the discovery frame is where the inquiry course creates new disciplinary content that is added to existing knowledge.

Shared Challenges in Inquiry-Based Curriculums

With this general model of professional inquiry-based education (hereafter referred to as the "general model"), we have a construct from which to organize the thematic challenges of inquiry-based learning in construction education as they have been uncovered through the experiences at Cal Poly and Mississippi State. The challenges involve student learning outcomes, the development of construction content and skill sets, curricula and curriculum development, faculty development, and program accreditation. The general model provides a means by which these challenges can be illustrated in the process of defining their characteristic problems and potentials. In the discussion that follows, each of the shared challenges will be investigated in terms of potential research questions, issues that help focus research plans, and ideas about theory and data collection.

Measuring student learning outcomes

Both Cal Poly and Mississippi State pursued inquiry-based curriculums for the primary purpose of educating twenty-first century constructors. So, the first shared challenge between the two programs is the most significant; student learning outcomes from inquiry-based instruction must be properly evaluated for construction education. From this, a number of research questions follow. What are the learning outcomes from inquiry-based instruction? How do such outcomes compare to traditional construction education? Does the inquiry-based classroom realize its potentials to improve learning transfer and professional thinking? Does inquiry practice lead to better professional performance and life-long learning?

Research plans to answer such questions will benefit from the fact that inquiry-based learning is among the few educational pedagogies characterized by rich formative and summative products from which to measure student learning outcomes. Formative assessment is the immediate feedback that provides evidence that objectives have been learned during instruction, and summative assessment is the cumulative evidence that demonstrates achievement of learning outcomes across the course. In the general model, formative and summative assessment exists within the intersection of "students" and "inquiry courses," and summative assessment also exists in the intersection of "students" and post-course "thinking skills" and "content knowledge" that would occur in subsequent coursework and throughout the curriculum. Within inquiry courses, student learning evidence is captured in the production of iteratively developed problem solutions often involving hundreds of artifacts, documents, discussions, critiques, and evaluations. All of these products exist as high-quality formative data for measurement. In the same way, completed projects act as cumulative evidence for summative assessment. As is typical in the inquiry classroom, final solutions are discussed and evaluated in concert with all of the iterative work products that led to the final proposal. This kind of complex student work verifies multiple learning outcomes: content knowledge, application skills, learning transfer to new contexts, and professional thinking through the problem solution process.

Beyond the curriculum, the general model suggests another significant area of learning outcomes research: that of "thinking skills" and "content knowledge" that occur after graduation in professional practice. As life-long learning has become a critical demand upon twenty-first century constructors, the potentials for inquiry-based learning to better prepare students for the evolving nature of practice is an important line of research. It also may be that the foundation of inquiry coursework—as described by "identifying," "pursuing," "producing," and "authoring"—might prove to be one of the essential instructional components of life-long learning development. As these discursive activities represent the fundamental processes of master-apprentice learning, research on the faculty-student instructional processes within the inquiry classroom may lead to a better understanding of how mastery is eventually developed in practice.

Developing the pedagogy of inquiry-based learning

The strategies of teaching in inquiry-based learning—its pedagogy—must be defined, developed, and assessed for construction education. Assuming the CILASS framework as one of the theory bases for inquiry, a number of basic research questions can be formulated. In what way and how well do “identifying,” “pursuing,” “producing,” and “authoring” work in construction inquiry coursework? What are the best practices in inquiry problem making and instructional development? How is faculty/student discourse conceived, formulated, and practiced in the classroom? What is the role and importance of problem solution iteration? How does individual student work intersect with peer and group work? How do textual and graphic representation and the production of artifacts support inquiry-based learning? How do construction professionals and the industry intersect with the methodology of the inquiry classroom?

The general education theory underlying the activities of inquiry-based learning is constructivism (Dewey, 1933; Piaget, 1970; Vygotsky, 1978). The basic characteristic of constructivism—that students build learning out of interaction with the world—is the same foundation for all active, inquiry-based learning. In the general model, the central pedagogical feature is the methodology of faculty/student interaction around the large “plus sign” that bounds the inquiry process. Since the activities of human inquiry and problem solving are so broad, there is a wide body of existing literature upon which research plans can be built. Some pedagogical research will be dependent upon connections to other applications of inquiry-based learning, while others will be found to be unique to the built environment disciplines and construction in particular. Given the importance of integrated practice, research on inquiry in construction education should leverage the discipline’s historic relationship with architecture to provide comparative studies with architectural studio education.

The general model suggests other relationships that could characterize research agendas. There is a natural affinity between “professional thinking” and its relationship to “disciplinary content” which is mirrored as learning outcomes by “thinking skills” and its integration with “content knowledge.” To the extent that this top arc of the general model is defined by the relationships between thinking and content, the realm of industry and practice that induces these aspects then absorbs them back into industry and practice when students leave the university. As in master/apprentice learning, this instructional process is founded within teacher/student discourse. The pedagogical question this provokes is to what extent higher education makes this process any different than apprenticeship. The CILASS framework begins to answer this by establishing the differences between the “information frame” of “identifying” and “pursuing” which is based on normative disciplinary content and the “discovery frame” of “producing” and “authoring” which is based on the discovery of new knowledge. This is a particularly important potential of inquiry research; that a better understanding of how this inventive capacity of inquiry education works to produce new disciplinary knowledge will create a better professional practice environment while it is preparing the next generation of practitioners for an innovative construction industry.

Constructing content and skill sets

Construction subject content and skill sets will be challenged by inquiry-based learning. Given that the emphasis in the inquiry classroom shifts from content delivery to critical thinking, the nature and scope of disciplinary content and its associated skills creates questions for research. What are the requirements for content and skills in the inquiry classroom? How do the learning demands of “thinking” conflict with the learning demands of “content knowledge”? Are the thinking capacities of knowledge and resource management realized in the inquiry classroom?

In the lecture course model, content is provided to students and is assumed to be linear, typological, and static, while skill sets focus on industry standards and vocational capabilities. In inquiry-based learning, content is discovered by students, is seen to be a function of their growing abilities in knowledge and resource management, and is assumed to be multivariate and changing. In the general model, this division in content and skills is represented by the realms of “industry” and “university” below and “professional thinking” and “disciplinary content” above. These realms approximate the split between the lecture course pedagogy dependent upon specified content and skills and the inquiry-based learning pedagogy that engages thinking through content as it occurs in practice. That the construction industry is part of both halves of this divide is a function of its newness within the professions. Unlike law, medicine, or architecture, construction has yet to conceptualize its particular modes of thinking and problem solving even though such ways of thinking are often evident. For example, this issue can be seen where curricula focus on specific industry scheduling software rather than the conceptual complexity of sequences and their management, or where ideas like Lean Construction become systematized into checklist strategies rather than engaging the more basic concept of optimization that underlies virtually every activity in construction. Theorizing, developing, and testing the problem solving concepts that typify construction thinking represent a potentially major contribution by inquiry-based learning research to the entire discipline as a whole. Since inquiry activities are dependent upon problem solving practices, construction education cannot adequately engage inquiry-based learning without necessarily defining what those practices are. As the construction industry enters a period of unprecedented change and redefinition, the question of balance between disciplinary content, skills, and thinking within the inquiry classroom needs to be informed by research.

Developing curricula

From this heightened balance between disciplinary subject content and higher-order thinking, it is clear that the challenge of curricula and curriculum development will be opened up by inquiry research. How might inquiry-based learning coursework organize a curriculum? What subject content is best engaged within inquiry courses? What content should remain taught through lecture courses? How does interdisciplinary and integrated practice affect the potentials of inquiry-based curricula?

Because of their holistic and synthetic nature, inquiry courses appear to be central to professional inquiry-based education and the curricula that support them. This centrality is typical in other forms of professional education that depend on problem solving coursework. However, most professions have content realms that are more successfully engaged outside of the inquiry environment. Frequently, these are subjects that are characterized by forms of internal logic that are symbolic, mathematic, scientific, or fundamentally unique to the discipline; anatomy is an example in medicine, as is calculus in engineering and architectural history in architecture. Even though traditional construction education is characterized by content silos, it is still unclear whether the same types of content divisions exist in construction as a professional discipline. Inquiry-based construction education will have to experiment in finding the proper place for inquiry content and lecture- or support-course content within its curricula.

The inquiry classroom provides especially powerful research potential toward realizing interdisciplinary and integrated practice in undergraduate construction education. This is because the inquiry environment replicates the conditions under which disciplines collaborate to solve problems in practice. Construction curricula that are built around inquiry coursework have ample opportunity to collaborate with the design and engineering disciplines which share the same pedagogy. However, it appears anecdotally that the built environment disciplines in higher education are far behind industry in establishing such collaborative relationships. Given that the structure of the modern university is driven by the division of content rather than its integration, this should probably not be surprising. Curricula inevitably reflect the structures of university organization, its disciplinary divisions, and its dependence upon narrow faculty expertise rather than practical breadth in application. Inquiry-based curriculum development will challenge all of those constraints in its effort to integrate subject content with skills of thinking.

Faculty development

The capacity of faculty members to teach and be productive scholars in the inquiry-based environment is another challenge that will confront construction education. What is the best academic and professional preparation for inquiry teaching? What are the characteristics of high-quality inquiry instructors and an inquiry-based faculty? How do the requirements for research output intersect with inquiry-based learning?

Since the activities of problem solving in the inquiry environment are so connected to the applied practice of subject content, each inquiry faculty member must be prepared to be a “teacher-master as a problem solver, a design thinker, and a knowledge builder” (Monson, 2011). Outside of long-standing professional education contexts, this kind of classroom practice is rarely seen in construction. So, few construction faculty are prepared for inquiry coursework through their own educations. However, inquiry-based learning applies abilities that can be built through experiences in professional practice. Such observations challenge the accepted notions of faculty teaching credentials. Research into student outcomes will offer opportunities for analysis between classroom instructional practices and faculty background in disciplinary problem solving. While there are substantial differences between practical application of problem solving skills and classroom inquiry teaching, the potential links between them is a necessary research line so that construction education can increase the number of faculty capable of inquiry coursework. Faculty development is also an issue that demands substantive pedagogical research into inquiry problem making and development, classroom facilitation and discourse, and the potentials of team teaching.

Since the inquiry environment is often very demanding on faculty time, the relationship between scholarly research and course teaching loads is an important question for inquiry-based learning and the curricula that support it. An inquiry curriculum that is structured by performance outcomes allows faculty to pull projects from their current research agenda to use in their inquiry coursework. The authentic nature of the faculty member's interest and commitment to such classroom projects may have an important developmental effect. When the problem engaged in the classroom is of academic research value, it might prove that faculty employ their expertise in a more practice-based manner—an effect that eases the transition to inquiry-based learning for faculty with little experience. Research that establishes potential relationships between scholarly interests and its dependency on practical content mastery may suggest other ways in which inquiry coursework can be accelerated in construction education.

Program accreditation

Lastly, the issue of program accreditation is a challenge that must be engaged as a substantive—and potentially generative—issue in inquiry-based construction education. The research question is a direct one; how does construction program accreditation address inquiry-based learning?

As accreditation structures have arisen in response to the existing lecture course paradigm of undergraduate education, the ways in which inquiry-based learning challenges that paradigm will have to be considered by accreditation schemes. Currently, neither ACCE, ABET, nor ATMAE mandates integrated synthetic problem-solving activities through the length of a curriculum. So, the struggle to incorporate four years of inquiry activities within the confines of a 124-credit-hour degree program is very problematic. As well, the accreditation restrictions on faculty credentials and specifications of course titling and syllabi content—which are all generated by the lecture course model—work in direct opposition to inquiry curricula. However, the move to outcomes-based accreditation could be a cogent way of supporting inquiry-based learning if the structure of accreditation requirements evolved toward performance and away from prescription. Inquiry-based learning generally supports performance evaluation very well because of its dependence on iterative student problem solving and the copious production of learning evidence that such coursework entails. Innovations in accreditation will be a necessary component to the research on inquiry-based construction education for the simple fact that it is almost unrecognized by the current structures of accreditation. If research proves inquiry to be valuable—if not vital—to twenty-first century construction practice, accreditation will have to evolve to help guide its adoption in construction education.

Conclusions: The Structure of Future Research into Inquiry-Based Curricula

Though research of inquiry-based construction curricula will eventually require traditional types of descriptive and experimental research, we suggest that the immediate need for further theorizing, conceptualization, data collection, and development will be best met with exploratory action research. This assertion is built on two related observations: that the challenges posed to twenty-first century construction education are real, pressing, and largely unmet; and that the current lack of inquiry-based curriculums across construction education limits the opportunity for traditional research designs across larger population sets. An action research agenda encourages wider adoption of the methods of inquiry-based learning because it depends upon the participation in, collaboration though, and dissemination of research activities while it builds a larger base of practitioners in the pedagogy. Exploratory studies allow the feasibility of the research questions outlined in this paper to be tested and developed. So, this type of research model offers construction faculty and programs that are interested in curriculum change the opportunity to share in the development of better and more widespread inquiry-based learning.

This is not to suggest that these research lines will not have to be rigorous, well-designed, and comprehensive. Through its directorates in education, NSF is demanding increased evidence of strong research evaluation through its ongoing efforts to improve the impacts and usefulness of its education projects and programs—the Promoting Research and Innovations in Methodologies of Evaluation (PRIME) was specifically created to meet these demands for improved research quality. As well, there is a strong move among many grant funding organizations to promote interdisciplinary research. Inquiry-based learning in construction education can be connected in directly productive ways to the long history of the pedagogy in the design disciplines—architecture, landscape architecture, planning, and interior design—as well as many of the newer problem-focused curriculums in engineering. These cross disciplinary opportunities promise substantive lines of research that both encourage further investment in integrated practice as well as allow construction education to build upon the long standing lessons to be learned by the experiences of other professional disciplines in the built environment.

While these potentials awaits further study and development, the general model of professional inquiry-based education is a first step in describing the common ground shared in the larger realm of inquiry-based professional curricula. In establishing this structure for the definition of further research, the promises of inquiry-based learning in construction education—and perhaps undergraduate education in general—have a much better chance of being realized.

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