

# What would Vitruvius Do? Re-Thinking Architecture Education for the 21<sup>st</sup> Century University

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**ABSTRACT:** In the 1996 AIA Convention in Minneapolis, the governing bodies in the education and professionalization of architects; namely, the AIA, AIAS, NCARB, NAAB and the ACSI released the Boyer Report, subsequently published as *Building Community: A New Future for Architecture Education and Practice*. The report was named in honor of Ernest Boyer, an educational theorist who also participated in writing the text. Less comprehensive than the canonical texts by Vitruvius and his interlocutors, it is nonetheless a mirror of our current assumptions about the education of the architect. This paper looks at the epistemology inherited from Vitruvius as it shapes pedagogy up and through the Boyer Report and into the twenty-first century. The basis of our argument is that historical divisions between professional or applied knowledge and liberal, or theoretical knowledge inherited from the past limit our capacity within architecture education to integrate new strategies for knowledge creation and dissemination. We conclude that considering architecture education also means reconsidering the basis of architecture knowledge. What of the (persistent) Vitruvian model is relevant in our post-modern condition? What do we learn from the image of our profession projected through the lens of the Boyer Report and it's like? In other words, what would Vitruvius do?

**KEYWORDS:** Architecture epistemology, pedagogy, education, design thinking

## INTRODUCTION

Our purpose in this study is to look at issues in the epistemology and pedagogy of architectural education in the twenty-first century. Our starting point is a broad analysis of the canonical texts in architecture education originating with the Roman military engineer and architect Marcus Vitruvius Pollio's first century text, *De Architectura* or *The Ten Book on Architecture*, that arguably still informs the underlying intellectual structure of the education of the architect. The educational context of Vitruvius' text was a post-Eleatic, pre-Scholastic discourse without institutional bearings. Universities as such didn't exist in Augustinian Rome. In contrast, recent texts such as the 1996 Boyer Report are a product of the modern research university whose origin in Germany in the early 1800s is indebted to the *liberal artes* or 'free arts' model divided between 1) knowledge for knowledge sake and 2) knowledge about how things are made. The clarity of the modern academic structure where liberal arts are separate from technical schools was contaminated in the mid-1900s with the advent of interdisciplinary and hybrid degrees like bioengineering, but architecture schools and the profession still labor under an older epistemological paradigm. It is not clear if the Boyer Report helps or hinders us in the search for a new paradigm, but search we should as the contours of our disciplinary landscape are shifting. What of the (persistent) Vitruvian model is relevant in our post-modern condition? What do we learn from the image of our profession projected through the lens of the Boyer Report and it's like? In other words, what would Vitruvius do?

The basis of our argument is that historical divisions between professional or applied knowledge and liberal, or theoretical knowledge, limit our capacity within architecture education to integrate new strategies for knowledge creation and dissemination. Another way of framing this is to say that the current pedagogical structure is awry to an epistemology of architecture.

### 1.0. Pedagogy

From its rediscovery, translation by Daniele Barbaro, and publication at the start of the Italian Renaissance in the fifteenth century Vitruvius' Ten Books stakes its claim as the foundational

text in the education of the architect. Daniele Barbaro's 1556 commentary on Vitruvius (second edition 1567), written and illustrated in part by Andrea Palladio secured its place in history some 1200 years after the original publication. Palladio writes his own *Quattro Libri dell' Architettura* (1570), clearly echoing and expanding the Vitruvian model.

Arguably, every movement in architecture since the Beaux-Arts has to discredit, support or supplant the Vitruvian model. One explanation for its endurance is its simplicity. Ten Books is first and foremost an argument for architecture knowledge as practice with some theory. Architects who rely solely on theory and scholarship without manual skill are 'hunting the shadow, not the substance.' Second, it outlines an ecumenical approach to the kind of knowledge architect's need – astronomy, medicine, economics, and so forth. Although this argument is often decontextualized and used as a basis for the interdisciplinary of architecture knowledge, it's a bit of a red herring as in Vitruvius's time these are not institutional nor discrete areas of study, but part and parcel of the generalized topics any well-educated Roman would understand. It helps to remember that Vitruvius himself was not an aristocrat and could not even afford to visit the Greek architecture that is his touchstone (Dripps, 1987). Finally, the Ten Books outlines a social and ethical role for architecture as a civic project and the architect as the arbitrator of the good in what is built. Architects are more skilled in theory than craftsmen, as they must negotiate custom, use, and the nature of the setting, the appropriate expression of the social status of the occupants through correct use of the orders, and the eurythmic adjustments to the canonic *symmetriae* in order to evoke a greater appearance of beauty—in short, the suitability of the form to the purpose (Vitruvius and Morgan, 1960; Semes, 2004). The argument was critical in an Aristotelian intellectual context where only general principles not knowledge about making things registered as wisdom or understanding. Vitruvius' argument is a general call to acknowledge the role of the architect in a social and intellectual hierarchy that would otherwise reduce it to carpentry or poetry, not science. The point here is that outside of its intellectual context, the Ten Books are only minimally useful even as they have been so difficult to shake loose.

Broadly defined, the difference between early Vitruvius—that is the Renaissance re-reading of him—and his resuscitation in the French Beaux-Arts tradition through Claude Perrault is an emphasis on art and the role of human culture in the first, and geometry and the role of Cartesian abstraction in the second. Vitruvius didn't change, but his interlocutors did. In either case, what is really at issue is whether or not architecture in an Aristotelian sense is more than merely practical art in which case it would not be located in the university system, but taught by craftsmen in the guilds. We find echoes of this argument in Christian Norberg-Schultz 1966 book, *Intentions in Architecture*, the Boyer Report, Richard Sennett's *The Craftsman*, and others. The twin arguments about what constitutes knowledge of general principles or theory, and the value of the hand, artisanal, or the practical arts bogs us down in an intellectual mud from which it has proven impossible to extricate ourselves. For the classically defined disciplines that fall clearly into a liberal arts education in the humanities, this is problematic, but not impossible. They can justify their existence in a modern university as necessary foundational education. Architecture knowledge does not immediately pertain as 'foundational' and even if the classical model is potentially flawed, architecture is a professional school education, not really a part of the humanities.

### 1.1. History of the School

The modern architecture school begins with the Académie Royal d'Architecture (1671–1793). It is the precursor to the Académie des Beaux-Arts, later École des Beaux Arts in Paris, and based on the structure of apprenticeship. Learning models in France and Britain vary in the details, but share a similar overall attitude that architecture is an artisanal practice learned through the practice of making drawings of buildings. The French system is a state-certification structure with a strong built-in hierarchy where the eight directors of the Académie determined everything from the winner of the Rome Prize, the awarding of commissions, who received government employment. Similarly, the British system was built around articulated pupillage where students apprenticed to master architects but in addition students were expected to participate in professional associations. Students in professional training in Britain did not attend university but were educated by practitioners outside of academic institutions. The Architectural Association is representative. Founded in 1847 by architectural assistants it

remains to this day unattached to a university. As late as the 1958 Oxford conference, 63% of architecture students in the United Kingdom were trained in art schools or polytechnics, not at university. In both cases, the alignment between what architects did— even if based on conflicting notions of whether it's formal order was derived from natural law or abstract geometry—the pedagogy outlines a program of making artifacts that were pleasing, durable, based on basic laws of statics, and socially responsive.

Research is introduced into the university in the 1800s in Prussia starting with the University of Berlin. Based on the educational theories of Christian Wolff that linked the university teacher with scholarly research to be disseminated to various audiences. Interestingly, these new research professors were equally divided between the general faculties providing the German tradition of *bildung* or a civilizing education and those directed to the few occupations requiring university-level training: law, theology, medicine, and secondary school education. German universities were communities of scholars organized around as colleges of professors who determined the direction of research, funding for assistants and generally participated in faculty governed campus life. The modern research university's roots vary to the degree that they adhere to the Germanic tradition whereby most professors saw themselves as academics first and only secondarily connected to their professional discipline. Most other professions (engineering, architecture, accounting) were trained as in the British system through associations of practitioners organized in private institutions or polytechnics and arts and crafts schools. These were not research driven and did not bear the burden of being knowledge producing.

The condition of architecture education in the United States was a hybrid from the beginning. Universities in the US synthesized the French state-dominated system and professional practitioner dominated English system in an uneasy mix that has proven especially unstable for architecture education. Compounding this are recent developments toward research-based universities that demand more applied science and less architecture-as-art from faculty little prepared for scholarly production based on a professional school education. The American condition did not have the historically entrenched professional associations of the English – compared to their British counterpart the AIA is a significantly weaker political body than the RIBA. Well over half of all registered architects in England (66%) are member of the RIBA, whereas 53% of their American counterparts belong to the AIA. The RIBA exerted direct control over university education from its inception in 1834 and continues to do so today. The US National Architecture Accrediting Board (NAAB) that oversees professional programs in architecture only began its work after 1945. William Robert Ware, founder of MIT's (1865) and Columbia University's (1871) architecture programs instrumentalize and adapted the French system into American schools that had largely been directed toward the education of gentleman architects who most often studied abroad in the Beaux-Arts system before returning home to spend a few years at university. Given the weakness of the professional organizations it is not surprising that universities saw an opportunity after the Civil War to provide a standardized education for a growing middle class. The first architecture schools in the US are founded after the war in such schools as MIT, Cornell and Illinois. Professional education in the US is university-based rather than professional-based. It is also not research- oriented, as the advent of the research university is not until the late-1800s with the creation the Johns Hopkins (1876), University of Chicago (1892) and others.

The American research university model differs in several important ways from its German predecessor. These differences are especially trenchant for architecture curricula. First, the department structure is organized around a chair with semi-independent faculty pursuing autonomous research projects unlike the more autocratic German structure where a single scholar leads a department and determines the coherence of the research agenda. Secondly, the American universities include applied research in addition to theoretical research whereas applied research is left to the technical schools in Germany. Lastly, teachers in American professional schools tend to see themselves as practitioners first and academics second. When combined with their historic affiliation to the Beaux-Arts apprenticeship model, American architecture schools put greater emphasis on the studio-as-learning environment where a practicing architect conveys practical knowledge about buildings based on their individual temperament and intellectual orientation. William Ware's mid-nineteenth century precepts for

the modern architecture school reflect the Beaux-Arts model and reverberate with tensions that we hear in today's university environment: details of a practical nature are best postponed until after formal education, architectural design should be conducted by a competitive method with judgments by jury, the study of design should be continuous through school and design problems should not be overly practical, the study of construction should be stressed, and the architecture curriculum should include as broad a cultural background as time permits. One can hear strains of the applied research demands of the American university (the study of construction, structures) and the overarching tones of the artistry of the Beaux-Arts model.

## 1.2. Epistemology

This brings us to the current milieu: the twentieth century and its conflicting pedagogical structures that foster additional confusion about the kind of knowledge, if any, that architecture schools produce. This is not to be glib—it is not clear in the current professional architecture school whether it should be an art academy, or a research unit. Schools of architecture are caught between the scholarly demands of the research university and a crisis of confidence in professional knowledge and education grounded in our own hybridity (Schön, 1988). As Donald Schön reminds us, architecture as an occupation is concerned with the "design of usable structures and an art based on the forms of buildings and the experience of passage through their spaces" (Schön, 1988), however; the structure of architecture knowledge may be otherwise.

As early as 1932 the ACSA *Study of Architectural Schools* noted the 'scarcity of real research in architecture schools' and the difficulty of architecture programs fitting into the university model. The problem is little diminished by 1954 when the AIA *Architect at Mid-Century* reports that there 'needs to be more support for research in architecture schools,' "study institutes" for faculty, and schools need to maintain a closer relationship with practice. Repeatedly from the 1930s onward, reports by the AIA, ACSA and independent studies sponsored by universities underscore 1) the importance of applied research, 2) the need for basic competencies in technical issues, 3) increased relevance between practice and formal education, and 4) a need to connect architecture programs and departments to other academic units through faculty and student engagement (AIA, 1967, 2009; Arch Education Study, 1981; Moore, 1965; Gutman, 1988; Cuff, 1991; Boyer, 1997; Schön, 1988, NAAB, 2008-12; McGrath and Navin, 1992; Jann, 2010). While the reports are good at outlining the problems, they are often confused—in the same way the American university system tends to mix the apples of applied research with the oranges of practice, so too recommendations about how to 'fix' the problems outlined above in architecture schools mix pedagogy with epistemology, how to teach with what is being taught. To give the Boyer Report, *Building Community, A New Future for Architecture Education and Practice* (1997) its due the recommendations reach back to the Vitruvian model of theory and practice to resuscitate and revive the architecture educational system. Interestingly, it is Robert Gutman's *Architectural Practice: A Critical View* (1988) that highlights a general misconception: if schools are having difficulties, then so must the profession. While architecture schools may not be doing well in their academic setting, the demands for professional architects only continues to increase. There are more architects working on more diverse projects today than at mid-century (Gutman, 1988).

## 1.2. Doing and/or Thinking

The Boyer Report, named in honor of the sociologist Ernest Boyer, an educational theorist who also participated in writing the text, outlines seven 'essential' goals: 1) training practitioners dedicated to promoting beauty in our society, the rebirth and preservation of our cities, including building for human needs and happiness, and the creation of a healthier, more environmentally sustainable architecture, 2) diversity with dignity where we would continue to promote variety amongst schools and program diversity in the curriculum, 3) standards without standardization to establish a coherent set of expectations for all schools without diminishing individual schools capacity to tailor curricula, 4) better integration between schools and practice, and architecture department and other units in the university, 5) schools would create a 'climate for learning' between faculty and students, 6) support of productive partnerships between school and the profession such as internship programs that build ties with practitioners but also include extended learning throughout professional life, and 7) encourage architects to participate in civic engagement through service to the nation and their

communities adhering to the highest and best practices and ethical standards.

While this all seems reasonable, the Boyer Report confuses theory and practice much the same way the introduction of Vitruvius did in the foreign intellectual soil of the Renaissance. The problem with architecture knowledge is systemic and emerges from the particular soils of the modern condition. This argument should be especially apparent after reviewing the historically determined categories of pedagogy outlined above. It will be improbable, if not impossible for a new approach in architecture education to flower from the ground laid by Vitruvius or his interlocutors, even their most recent incarnations in the twentieth century, regardless of how well meaning and sincere the humanist tendencies are. The classical education divided knowledge into theoretical and applied science, which architecture, in Vitruvian terms, aspired to emulate. Our failure to thrive is one of kind, not degree: architecture knowledge may not be about types of knowledge, but a way of thinking. As Linda Groat suggests:

“In academic circles, the gradual emergence over the last twenty years of architectural research as a recognized avenue for generating new knowledge seems to affirm the stature of architecture as a discipline. However, the tendency of architectural research to be defined (and to define itself) in terms of the traditions of apparently discreet, and allied disciplines suggests instead that the focus of the architectural discipline remains elusive.” (Groat, 1992)

Groat goes on to explain that although many contemporary theorists “have attempted to post various philosophical positions (i.e., structuralism, phenomenology, or deconstruction) as viable alternatives to the now discredited positivist assumptions of modern thought, these apparent alternatives do not in fact extricate us from the theoretical cul-de-sac in which we now find ourselves.” In her example, the intellectual conditions in both practice and research involve the “philosophical and ideological failure of modern thought to sustain a sufficiently robust conceptualization of cultural phenomena in general and architecture in particular.” In other words, as much as we want Vitruvius to help, discussions resonant with classical definitions promoting beauty and sensitization to cultural relevancy (like sustainability) are doomed to fail if we use this to define an architecture epistemology.

One alternative is to reconsider how we constitute architecture knowledge. If architecture is established as an either/or proposition where artistry and applied science, Vitruvian beauty and firmness respectively, are instantiated as separate categories much as the original dictum in classical philosophy that separated the applied arts or poetics from the natural or philosophical sciences, we stand to repeat the failures of our predecessors, while hoping for different outcomes. However, reconsidering architecture as a *set of cognitive practices that enable artifact making* may offer new possibilities, will certainly require restricting the curricula and, after reflection, are not especially new.

Donald Schön argued in the mid-80s at MIT for the introduction of a cognitive orientation to design reasoning as a foundation of design learning (Schön, 1992). He observed that regardless of how current pedagogy was modeled, the education focus was on the representation of the design artifact, rather than an explicit articulation of knowledge. Schön calls this latent knowledge “design reasoning.” His prescription is a workable marriage of artistry and applied science, reflective practicum and classroom teaching centered around the idea of ‘design reasoning’ where design-as-cognition relies heavily on visual reasoning. Architects use representations to think through the problems of design and this kind of cognitive structure is the real focus of the knowledge environment of studio, not the artifact produced at the end.

Beyond the utility of representation in design thinking, Schön argued firstly that studio-based projects should mirror the complexities of real-life problems from the professional world, and secondly; learning would proceed through reflection-in-action and reflection-on-action such that the design student’s thinking would eventually mirror the ‘expert’ thinking of their tutors. Schön substitutes ‘reflective practice’ for design artistry, but retains the emphasis on the idea that a student is to be coached by a knowing tutor, ideally a trained practitioner with expert

knowledge of the field who would model, correct, and guide the habits of reflective practice.

The success of Schön's learning program should not be underestimated or ignored – it has proven a trenchant theory of cognitive or 'reflective learning' in professional education (Brockbank and McGill, 2007). However, critiques of Schön identify several key factors, one of which is of particular interest, namely that he demonstrates a limited understanding of the domain of cognitive learning (Webster, 2004b). Additionally, Schön's model ignores many devices formal education uses to direct student learning, presents a narrow notion of how learning takes place (master to student only), under conceptualizes the notion of 'reflection,' uses research methods of dubious validity, and does not recognize the structure/agency dialectic widely recognized in learning theory as an important component of the relationships of power inherent in the master-student model (Webster, 2008; Webster, 2004b; Foucault, 1990; Giddens, 1984; Dutton, 1991; Stevens, 2002). In the final analysis, Schön is a reflective-turn on the traditional Beaux-Arts apprenticeship model where a master teacher/practitioner inculcates an unknowing student into the cognitive habits of the professional. Schön's epistemology is based on the critical reflection of expert others as the primary means of transformative reflection in the student. Reflection is undeniably important, however; it is only one part of the design process. As Helena Webster notes, architectural educators may be better served to consult theories of innovation and creativity if this is the primary issue as there provide better and more nuanced models of the design process (Webster, 2008).

More recently Rivka Oxman and others propose that a more reasonable cognitively formulated approach is through the phenomena of visual reasoning in design as opposed to the product-making orientation of professional traditions (Oxman, 1999, 1992; Finke, Ward, and Smith, 1992; Papert, 1991). In *Educating the Designerly Thinker*, Oxman proposes that the goal of design education should be defined as the acquisition of the cognitive ability to manipulate the representations of design knowledge and to acquire basic schema in design thinking. Making the design process visible – where it is coded and cataloged – is the first step in training students in 'designerly thinking,' that, while not an ability to design *per se*, is part of design awareness. The Issue-Concept-Form strategy used by Oxman is presented to students through a computer-based program that offers a series of interconnected choices such as Issue=phenomenological content, concept=use of traditional elements, form=inner court. Students navigate an increasingly more abstract set of relations as they work out the knowledge structure of elements in an architectural schema. This kind of think-map makes possible a visualization of the process, albeit a process wholly pre-determined by knowledge schema from within a codified architectural cannon. What is not previously known cannot be encountered from within the program.

What is most promising with the Oxman approach is that results are measured and learning outcomes evaluated. The most significant qualitative results were in the area of the development of concepts and knowledge structures measured by evaluating the student's ability to model, and the coherence and complexity of student models. Students worked individually and in teams in the computer environment to generate their schema. Even though the models students generated primarily represent their ability to navigate a series of choices based on pre-determined options, the value of the method is that it shifts the focus away from the apprenticeship model toward a new learning environment: a computational environment where students worked together using a shared set of learning tools. While this is not intended to replace studio-based learning, it may be a potential test-bed for understanding the cognitive structures of design thinking not only in architecture, but in other disciplines as well.

## CONCLUSION

Much as hybrid disciplines in the sciences that challenge traditionally constructed divisions between theory and practice, natural and artificial, architecture education needs to be reconsidered at the epistemological level in order for us to re-think our pedagogical strategies. Bioengineering, human-computer interaction science, biophysics and so forth are not the sum of separate disciplinary parts. These are new disciplines not because Frankenstein-like they are built from familiar parts; their newness is in the very fabric from which they are cut, requiring new language, new tools, new learning environments and new cognitive structures to contain the particular kind of knowledge they produce. It may not matter which comes first,

chicken or egg-like – if we develop new learning environments, new epistemologies may emerge. Conversely, new ways of describing what an architect needs to know may engender new learning environments. As with most paradigms, it is our perception of the learning schema that constitute architecture education that determine not only how, but what an architect thinks.

One alternative offered in this paper outlines how we might re-think the structure of knowledge in architecture by focusing on the cognitive phenomena of design thinking. This would entail being attentive to the cognitive schema we use in our visual representations in architecture, developing more complex visual schema that encode and fuse complex information sets, and formalizing through research and dissemination the processes of design. That means taking design out of the 'black-box' and exploring its' cognitive contours – not an easy task, but one that could re-draw the learning landscape of architecture in preparation for the challenges of the twenty-first century city, just as Vitruvius attempted so many years ago for his Roman inheritors.

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## REFERENCES

- ACSA. (1932) A study of architectural schools.
- AIA (2009). The business of architecture: An aia survey report on firm characteristics. Technical report, American Institute of Architects, Washington, DC.
- AIA (1967) Study of education for environmental design. Princeton.
- Angelil, M. M. (1990). On architecture, the city, and technology. Association of Collegiate Schools of Architecture, Washington, DC.
- Boyer, E. L. and Mitgang, L. D. (1996). Building community: a new future for architecture education and practice : a special report. Carnegie Foundation for the Advancement of Teaching, Princeton, N.J.
- Brockbank, A. and McGill, I. (2012). *Facilitating reflective learning: coaching, mentoring and supervision*. Kogan Page, London, 2nd ed edition.
- Bunch, M. A. (1993). Core curriculum in architectural education. Mellen Research University Press, San Francisco. Cuff, D. *Architecture: the story of practice*. MIT Press, Cambridge, Mass., 1991.
- Dripps, R. D. (1987). Rethinking vitruvius. *Journal of Architecture Education*, 40(2):19–20. Dutton, T. A. (1991). *Voices in architectural education: cultural politics and pedagogy*. Bergin & Garvey, New York.
- Finke, R. A., Ward, T. B., and Smith, S. M. (1992). Kinds of seeing and their functions in designing. *Design Studies*, 13(2):135–153. Foucault, M. (1995). *Discipline and punish: the birth of the prison*. Vintage Books, New York, 2nd vintage books ed edition.
- Giddens, A. (1984). *The constitution of society: outline of the theory of structuration*. Polity Press, Cambridge.
- Groat, L. N. (1992). Rescuing architecture from the cul-de-sac. *Journal of Architecture Education*, 45(3):138–146.
- Gutman, R. (1988). *Architectural practice: a critical view*. Princeton Architectural Press, New York, N.Y. Jann, M. (2010). Revamping architectural education: Ethics, social service, and innovation. *International Journal of Arts and Sciences*, 3(8):45–89. McGrath, B. and Navin, T. (1992). Architecture as conciliator: Toward a unifying principle in architectural education. *Journal of Architecture Education*, 45(3):171–181.
- MIT (1981) Architecture education study. Study
- Moore, C. (1965). Architecture: Art and science. *Journal of Architecture Education*, 19(4):53–56.
- Morgan, F. and Pohlman, R. W. (1993). *Education and practice: the critical interface*. ACADIA.

- NAAB. 2008 report on accreditation in architecture education. Tech. rep., National Architectural Accrediting Board, Inc., Washington, D.C., February 2009.
- NAAB. 2009 report on accreditation in architecture education. Tech. rep., National Architectural Accrediting Board, Inc., Washington, D.C., February 2010.
- NAAB. 2010 report on accreditation in architecture education. Tech. rep., National Architectural Accrediting Board, Inc., Washington, D.C., 2011.
- NAAB. 2012 report on accreditation in architecture education. Tech. rep., National Architectural Accrediting Board, Inc., Washington, D.C., 2012.
- NAAB. Highlights from the 2012 visiting team reports. Tech. rep., National Architectural Accrediting Board, May 2013.
- Nicol, D. and Pilling, S. (2000). *Changing architectural education: towards a new professionalism*. E and FN Spon, London.
- Norberg-Schulz, C. (1965). *Intentions in architecture*. M.I.T. Press, Cambridge, Mass.
- Oxman, R. (1999). Educating the designerly thinker. *Design Studies*, 20(2):105–122.
- Oxman, R. (2004). Think-maps: teaching design thinking in design education. *Design Studies*, 25(1):63–91.
- Oxman, R. (2008). Digital architecture as a challenge for design pedagogy: theory, knowledge, models and medium. *Design Studies*, 29(2):99–120.
- Oxman, R. E. and Oxman, R. M. (1992). Refinement and adaptation in design cognition. *Design Studies*, 13(2):117–134.
- Papert, S. (1991) "Situated Constructionism" in Harel, I and Papert, S (eds) *Constructionism*, Ablex Publishing Corporation, Norwood, NJ.
- Pollio, V. and Morgan, M. H. (1960). *Vitruvius: the ten books on architecture*. Dover Publications, New York.
- Quintrell, M. (1989). Reinventing reality: Reconstructing architecture. *Journal of Architecture Education*, 43(1):45–50.
- Schon, D. (1988). Towards a marriage of artistry and applied science in the architectural design studio. *Journal of Architecture Education*, 41(4).
- Schon, D. and Wiggins, G. (1992). Kinds of seeing and their functions in designing. *Design Studies*, 13(2):135–153.
- Semes, S. W. (Summer 2004) Vitruvius on architecture. *American Arts Quarterly* 21, 4.
- Sennett, R. (2008). *The craftsman*. Yale University Press, New Haven.
- Snodgrass, A. and Coyne, R. (2006). *Interpretation in architecture: design as way of thinking*. Routledge, New York, 1st ed edition.
- Stevens, G. (1998). *The favored circle: the social foundations of architectural distinction*. MIT Press, Cambridge, Mass.
- Webster, H. (2004b). Facilitating reflective learning: Excavating the role of the design tutor. *Journal of Art, Design and Communication in Higher Education*, 4(3):265–282.
- Webster, H. (2008). Architectural education after schön: Cracks, blurs, boundaries and beyond. *Journal for Education in the Built Environment*, 3(2):3–72.