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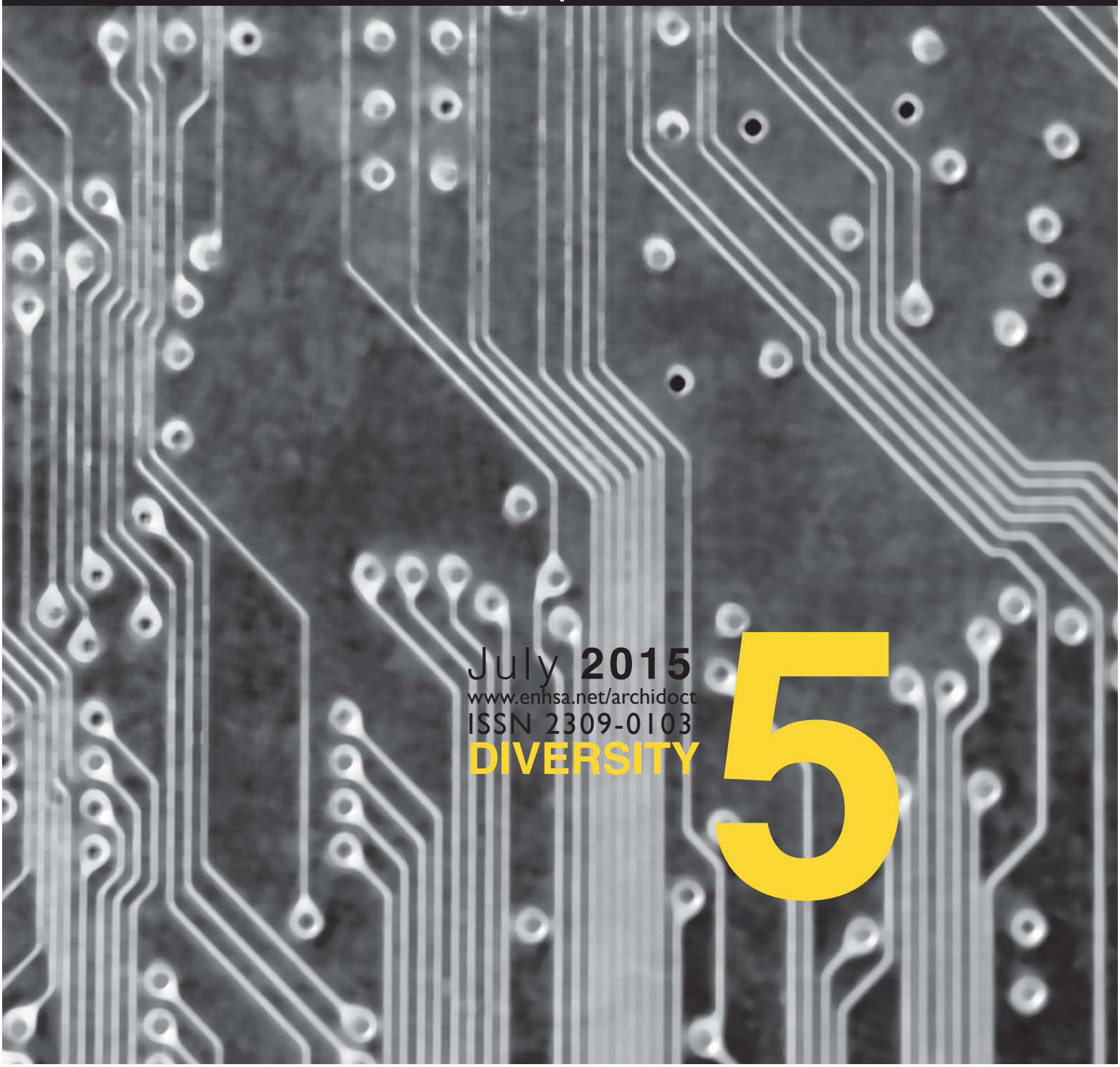

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A Good Practice Example

Interdisciplinary Technology-Driven Design Processes in Architecture

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Abstract

Architectural design operates traditionally on project based processes of development, whereas related social, cultural, visual and technological knowledge is collected, analyzed, evaluated and transformed into design. In parallel recent technological advances are paving the way to achieve 'integrated interdisciplinary design', a type of practice based on collaboration, cross-disciplinary communication, experimentation, visualization and research at all stages of the design process in order to achieve efficiency, sustainability and technological innovation in architecture. In considering the influence of technology in design, the holistic architectural design approach that enables design optimization through an integrative nonlinear development of form, functions and technical system parameters is increasingly complemented with performance based open-loop design approaches driven by means of contemporary digital technology. Respective nonlinear design developments provide through interdisciplinary experimentation and design-driven research, innovation and advances that constitute significant initial stages for further research in architecture. The paper discusses the influencing modes of technology-driven design and their implications towards a framework of related research.

Keywords

Technology-driven design, Design-driven research, Interdisciplinary integrated design.

Note

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Introduction

Design has undoubtedly been at the core of architectural education since its inception in the 19th Century. Especially the project based design educational model adopted at the Bauhaus workshops at the beginning of the 20th Century aimed at simulating, albeit in a simplified and directed way, the actual processes of professional action, by requiring students to apply their accumulated knowledge and skills in primarily linear and integrated way to a design problem. In the frame of this 'practice informs teaching' model, an integrated environment of theoretical and practice related artistic creativity and research was created for a comprehensive project development. Walter Gropius propagated collaborative work, aiming at the cooperation of architectural related arts at a multidisciplinary level and the search for form within an integrative environment in the studio (Lampugnani, et al., 2004).

The significance given to architectural design as the main activity for creative exploration, interaction and assimilation remains a common characteristic in architectural education. In parallel, the academic environment has been significantly altered as a result of the implementation of the European policies on higher education, mainly represented by the Bologna Process and Lisbon Strategy on one hand, and globalization and the fast growing internationalization of economies and markets on the other. In this frame, architectural education is acknowledged to be interactive and comprehensive, consisting of an equal integration of both theory and practice oriented knowledge within the core activity of architectural design. The interactive and interrelated nature of the individual components is mostly significant for a comprehensive architectural education (Spiridonides, 2005).

At the same time, contemporary design approaches gradually acknowledge the fact that architecture encompasses a number of disciplines, bringing together a number of distinct modes of research and types of knowledge. Research into architecture is becoming conscious of these interactions and of the particular need for architectural knowledge and practice to be further nonlinear and integrative across disciplinary boundaries. Design provides possibilities for interdisciplinary research, through an integrative approach to education and practice, while also crossing traditional research areas. Rationale for this change is based on widely recognized transitions from industrial societies and their linear, hierarchical thinking to the emerging post-industrial era of deeply interrelated types of knowledge and complex system thinking. Recent advances of disciplines, specialization, materials, system science and digital data driven computation have brought a radical change in the contextual frameworks in which architectural design and production are normally placed. Such advances have been paving the way to achieve 'integrated inter-, multi- or even transdisciplinary design', in all cases a type of practice that covers a mindset of collaboration and cross-disciplinary communication and experimentation, visualization and research at all or possibly at different stages of the design process. Respective modes of thematic integration may refer at areas of contents and scales of development, as well as at the design process followed on the basis of contemporary digital technology platforms of operation. Especially the latter comes into fore by considering recent technological advances and architecture as interactive processes. Along these lines the syntax of architectural design, technology and any implicated interdisciplinary developments from the conceptual design to the realization are of major significance. Such integrated activities promise to generate substantially new, innovative and transformative solutions to buildings, their designs, as well as their habitation and usage, last but not least, to the associations, the industry and methods employed in practice to realize them.

Given the interrelation and necessity for integration of architectural design and technological as-

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pects, two operational modes of technology-driven architectural design processes of different and supplemental aims may be applied to associate the complexity levels of design articulation and evolution. The first operational mode follows an integrative nonlinear design development through a rather rigorous development and integration of related technological aspects concerned within the architectural design process. Such a methodology aims at holistic integrated design results that, even if following closed-loop processes of development, may be strongly influenced by the integrative development or even transfer of technology to shape the final proposal. A second approach that utilizes advances in digital technology towards interdisciplinary experimentation and research by design, follows primarily performance based open-loop processes of developments. The results obtained herefrom are representative of an architecture of homogenization of the discipline areas concerned. In this frame, complex system developments may be considered for the final design outcome, in a performance based internal and external field of influences.

Integrative Nonlinear Design

Design has undoubtedly been at the core of architectural education since its inception in the 19th Century. Especially the project based design educational model adopted at the Bauhaus workshops at the beginning of the 20th Century aimed at simulating, albeit in a simplified and directed way, the actual processes of professional action, by requiring students to apply their accumulated knowledge and skills in primarily linear and integrated way to a design problem. In the frame of this 'practice informs teaching' model, an integrated environment of theoretical and practice related artistic creativity and research was created for a comprehensive project development. Walter Gropius propagated collaborative work, aiming at the cooperation of architectural related arts at a multidisciplinary level and the search for form within an integrative environment in the studio (Lampugnani, et al., 2004).

Holistic architectural design provides possibilities for an integrated approach from early stages, facilitating merging of individual knowledge and interdisciplinary research based knowledge, while enabling new knowledge inquiry and acquisition at various design stages that form closed-loops of the development process. In this frame the term 'integration' within the holistic design process gains significance. Pedagogically the concept of integration may be applied at different levels: Integration of knowledge, skills and attitudes by emphasizing learning competencies, as opposed to their quantified and fragmented use; integration of analysis (analytical thinking) and synthesis (creative thinking), perceived as parallel processes interrogated within the design process; integration of learning and valuation with emphasis on the learning process instead of the learning result; integration of architecture as cultural phenomenon (aesthetic) and as a technical phenomenon through designing; integration of research, investigating and designing by implementing platforms of digital technology with knowledge management and valuation systems. Such integrative development objectives tend to implement respective knowledge about architecture into processes of research based design. In architectural designs that follow this approach in their pedagogy, faculty members try to give students an integrated experience in design, while also giving them the opportunity to work outside of their normal areas of knowledge and experience for applying relevant results within the actual design process. The approach has also repercussions in the way that architectural graduates are expected to influence and inform professional practice as a result of their training. Collaborations among faculty, students and corporate partners aim at exploring the potential for genuine cross-functional communication and cooperation, while highlighting strategies fundamental to the success of the integration approach (Malecha, 2008).

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In terms of the design process per se, digital technology is in capacity to link conceptual design to analysis, production and fabrication. In following rather closed loops of linear design developments supported by technology transfer and material advancements, complex architectural forms become possible. Along these lines architectural design often still prioritizes predominantly form over its subsequent materialization, construction and manufacture, nevertheless leading to 'top-down' engineered, often non-optimized solutions. Kenneth Frampton among others expressed this concern in his studies in tectonic culture (Frampton, 1995). Dissociation between geometrical design and tectonics may be evident in complex surfaces of form and structure, or geometry and manufacture disintegration. In other cases, early phases of digital technology integration provide possibilities for a shift from mass-production to mass-customization, while relating the principles of the former with the advantages of individual fabrication. Related processes are based on the coupling for example of architectural computer-aided design, structural design, manufacturing and rapid prototyping.

Besides any technological advances, the design process itself can not be considered as a linear problem-solving activity, whereas sequential activities are carried out in a linear order, as for example problem definition, analysis, synthesis and evaluation, as there is no direct flow from one activity to another (Alexander, 1964). In this frame, an open structure in the synthetic process that forms the core of the design process has been proposed, in which phases are grouped in a circular arrangement, yet the process itself does not develop in a linear manner (Moggridge, 2007). Given that digital design is in capacity to provide information and complexity at every level of the design, there is no fixed scale at which design processes are essentially to be developed, while at the same time each intermediate process result may influence part or the whole of the design outcome (Picon, 2003). Along these lines, digital design may be applied throughout the different stages of the entire design process shaping individual iterative operational circles that are linearly linked to previous and subsequent ones. In this way, an integrative nonlinear design process emerges throughout the development, whereas, knowledge is employed from research and new knowledge is generated throughout the design process that develops new hypotheses and visions.

Furthermore, recent developments prove that numerically controlled devices are in position to shift architectural preoccupations beyond mono variables, such as geometry, to the integration with materiality and construction in favour of performance. Nonlinear design processes based on interdisciplinary performance optimization criteria are considered to be crucial for the future of architecture. At the same time, standardization would still mean more efficient use of raw- and new materials and energy. Such an approach shapes performance based architecture following more or less interactive, iterative closed loop research based design processes. Also in practice, given the escalating complexity of design criteria and tools to manage any implicated multi variable design criteria, new interdisciplinary and collaborative design research practices of architects and specialists consultants have become increasingly essential, while these are also collectively credited with the success of their projects.

An interrelation of technology with architecture from early design stages aims at the advancement of individual, or multiple architectural parameters within the holistic design context (Phocas and Michael, 2010). In this frame, design system components may be integrated to form the architectural design syntax, possibly by further providing design-driven technological developments. Advanced interdisciplinary research activities in individual interrelated closed-loop areas may thus be initiated through the synergy of technology with design. Alternatively, integrated design may be based on technology transfer and further influenced by new systems and materials applied within. In this way an interactive architectural design process is followed through innovative material and system based

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technological applications, resulting to technological developments driven design. Any intermediate research requirements derived by design, or research results obtained from other discipline areas from outside the design field, support the integrated context of design. In both cases additional advanced research may be required for the realization of the technology-driven design proposals, that would lead to further interdisciplinary design processes and technological innovations.

Interdisciplinary Research by Design

Common backbone for architectural skills acquisition and related research processes with regard to the advancement of the field is the argument that "architecture encompasses several disciplines and uniquely brings together modes of research that are often kept apart and so provides possibilities for multi- and interdisciplinary research" (Rendell, 2004). In this frame it has often been suggested that instead of trying to conform an architectural praxis to a scientific paradigm, architecture should provide a new model for research practice in all disciplines, which carries academic and social mandates and is intellectually coherent, capacious and integrative (Wortham, 2007). Since the connection between research and design gradually becomes established, the question how to construct knowledge and understanding out of a design or a design process increases in significance (Salomon, 2011).

Several recent works suggest that we are today in the process of defining and refining the idea of architectural research as a mode of scholarship and inquiry that is special to architecture and is not adequately described in terms of the 'scientific' method. Few years ago the European Association for Architectural Education developed a framework stating "Architectural research is original investigation undertaken in order to generate knowledge, insights and understanding based on competencies, methods or tools proper to the discipline of architecture. It has its own particular knowledge base, mode, scope, tactics and strategies. Any kind of inquiry in which design is a substantial part of the research process is referred to as research by design. In research by design, the architectural design process forms a pathway through which new insights, knowledge, practices, or products come into being. It generates critical inquiry through design work that may include realized projects, proposals, possible realities, or alternatives" (EAAE, 2011). Research by design offers indeed a promising perspective for the field, requiring an instrumental and rigorous approach in the supporting and driving modes of the design process. In this sense, research by design also requires an overarching theoretical framework to ground the experimentation and to give it purpose and direction in relation to the production of a relevant architectural discourse and equally relevant improvements in practice and, by extension, the development of the built environment in terms of a performative architecture.

The interdisciplinary aspect in research by design activities constitutes in broader sense an academic and professional field of growing complexity. The following distinctions of discipline interrelations are considered in the present argumentation (Jantsch, 1970):

- Multidisciplinarity: A variety of disciplines occurring simultaneously without making explicit possible relationships or cooperation between them.
- Pluridisciplinarity: Various disciplines grouped in such a way as to enhance the cooperative relationships between them.
- Crossdisciplinarity: Various disciplines where the concepts or goals of one are imposed upon other disciplines, thereby creating a rigid control from one disciplinary goal.
- Interdisciplinarity: A group of related disciplines having a set of common purposes and coordinated from a higher purposive level.

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• Transdisciplinarity: The coordination of disciplines and interdisciplines with a set of common goals towards a common system purpose.

Given the particular characteristics of architecture as an explorative and transformative knowledge field that inherently relates to the humanities, empirical, interdisciplinary, applied and formal sciences, it may be argued that architecture is intrinsically transdisciplinary and in extend multireferential and multidimensional (Hensel, 2012). In this context the requirement for reintegration of various types of knowledge, as stated in article 3 of the 'Charter of Transdisciplinarity', is of particular significance (CIRET, 1994): "Transdisciplinarity complements disciplinary approaches. It occasions the emergence of new data and new interactions from out of the encounter between disciplines. It offers us a new vision of nature and reality. Transdisciplinarity does not strive for mastery of several disciplines but aims to open all disciplines to that which they share and to that which lies beyond them." In parallel, transdisciplinary platforms of operation may support interdisciplinay design processes on the basis of latest advancements in digital design technology through the introduction of computing facilities and numerical methods of analysis (Hayhurst, Kedward, Soh and Turner, 2012). Digital design enables designers to collaborate, visualize, research and modify building performance with relatively high accuracy. At the same time, this mode of operation requires designers to rethink alternative strategies in order to establish a robust connective link between disciplines and specializations. Thus an aptitude for open-loop developments in multi-variable systems may be achieved from early conceptual design stages until the production phase. This implies rethinking buildings as integral systems rather than the juxtaposition of optimized and mono-functional layers.

In support of the afore mentioned, is the process of complex problem analysis and solution mechanisms within the research by design process, whereas the design domain depends on the culture of collaboration. Teams may be continually formed and reformed and new technologies employed to assemble the expertise and perspectives arising from the members and disciplines. Collective intelligence supports actions of sharing, cycling and innovation, as well as the interpretation of design into intermediate research results. Underlying such interdisciplinary mode of operation is a sense of disciplined architectural specific interactions among the diverse teams. Thus the success of the methodology rests on an integrative approach to research in architectural design, which also examines the increased complexity and quality of building systems in producing sustainable forms in physical context. In this frame integration succeeds in a double way: integrating knowledge in the design process and integrating architectural design in learning disciplinary knowledge.

Open-Loop Performance based Design

The roles of digital design and computation have played in the conceptualization and design development up to date is indicative for a new syntax of architectural design emerging. Though not new to other design industries, computational platforms of operation and real-time performance simulators provide meanwhile robust visualization and feedback features that can be associated with geometrical digital design models. Design developments at various stages encompass further parametric investigations with regard to form, material and structure. Initial examples comprise among others the stainless-steel roof over the courtyard for the Deutsche Bank in Berlin, Pariser Platz 3 by Gehry Partners and Schlaich, Bergermann and Partners, and the roof for the courtyard of the British museum in London, by Foster and Partners and Buro Happold. In this respect it may well be stated that the computer needs to redefine materiality rather than abandoning it in favor of the seduction of pure images (Menges, 2012). This means also a redefinition of design objectives and procedures.

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In an open-loop performance based design, comprising a cyclical nonlinear process that moves repeatedly from 'synthesis' to 'evaluation', continuous design iterations dealing with creativity and accuracy represent respectively different phases of the design process, including a conceptual outer loop design phase and a detailed inner loop phase (Phocas, Kontovourkis and Ioannou, 2013). Throughout the development, a number of in-between loops represent the process of iterative design refinement. In this frame of operation, any design process may be repeated until a desirable solution is achieved. This implies that any development from concept to detail may be re-evaluated within a performative context in a nonlinear way, i.e. by moving from the conceptual to the detailed design phase and vice versa. In parallel to such a nonlinear design approach realized through certain cyclic interdisciplinary design steps, also interactivity within the decisions making processes may provide promising modes of operation for a bottom-up approach. Such iterative analysis steps of design verification and optimization shift the focus of the design teams to developing processes, from which specific results then come about through the definition of and emphasis on influencing values and parameters. In this frame architecture is effectively bridged with respective performance disciplines concerned (Gibson, 2013); designing thereby becomes interdisciplinary towards a form-generating process. Architectural design provides such possibilities, in terms of such an open-loop interdisciplinary approach from early stages of the design process, facilitating merging of individual knowledge and cross- disciplinary research based knowledge.

Conclusions

Architectural design implies that different types of knowledge need to be an inherent part of any related decision making process, which includes individual, rational and design driven ways of thinking and knowledge production. Within an integrated context of cross-disciplinary collaborations this mode of inquiry can address the challenges of bringing together the various aspects of the built environment on one hand and articulating a paradigm design process driven by the increasing influence of digital technology on the other. Such a holistic design approach is undoubtedly acknowledged in education and practice, due to its potential to apply a heterogeneous set of discourses, types of knowledge and disciplines, through comprehensive iterative closed-loop cyclical processes of development. In addition, it enables further interdisciplinary advancements in terms of advanced performance based research or technology transfer within architecture.

In the search for successful models of integrated interdisciplinary design, architecture benefits not only from the directive of understanding and implementing transformative design knowledge, but also from the possibility that collaboration will trigger the ability to envision, investigate, create and discover through research from a systems thinking perspective. Progressive performance based practices go beyond incremental improvements to standard responses, but instead work on fundamental questions throughout the architectural design scales, identify the forces to innovate and achieve compelling solutions. They do so by understanding key domains of architectural designs as influenced for example by the human subject, the environment and the structural and material organization complex. As the complexity and sophistication of the built environment grow, technology employed should increasingly commit to realizing an integration of considerations, coupling science, design and imagination to advance the field of architecture towards a more compelling next generation.

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