Transformer:
The Work of the Architect between Idea and Object

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Architecture is a process for transforming an idea into a built object. Architects transform ideas into information, construction managers convert that information into a plan of action, and contractors transform the plan into a completed object. Typically, idea, information, action and object are seen as sequentially dependent – the architect must complete construction documents before the construction manager can develop a workplan, and construction can only begin once these preceding activities are complete. In this sequential model of architectural practice, action and object are made to conform to the architectural idea as represented in the construction documents. The foundations on which the sequential model is built, however, are being shaken by recent changes in project delivery. Design-build and fast-track production, for example, require a reconfiguring of project teams and project tasks. Is the sequential model of architectural process appropriate for the dynamic, collaborative project environment we face today? This paper explores critical inaccuracies and implications of the sequential model, and describes an alternative model emphasizing integration of project teams and project tasks. This integrated model acknowledges the reciprocal dependencies between idea, information, action and object. In contrast to the sequential model in which the finished building is the result of conformation to detailed, preexisting construction documents, the integrative model examines the possibility that idea, information, action and object may evolve iteratively in a process of continuous transformation.

INACCURACIES OF THE CURRENT MODEL

The American Institute of Architects' *Handbook of Professional Practice* can serve as a reference model of the sequential process as operationalized in practice. It offers architects a straightforward method for scheduling their services under the familiar categories of schematic design, design development, construction documentation and construction administration. It is the accepted norm for defining architectural process, and it is the model that architects, their clients and consultants expect will be used when they enter into a project. While this sequential model offers many benefits, it also contains critical inaccuracies.

First, its sequential structure – the notion that each step is built on the completion of the last - assumes that design is complete before construction begins. This is less and less the case in practice however, as fast track production becomes the norm. Today we are more likely to see construction begin well before design is complete, and the sequential design-then-build model fails to account for the simultaneous unfolding of design and construction activities.

Second, the sequential model implies a rigid separation of disciplines. The contracts based on this model such as the AIA A-201 and B-141 reinforce this separation by prescribing separate owner-architect and owner-contractor contracts, low-bid awarding of construction contracts that limit early communication between designer and constructor, and the relegation of the architect to "observer" of construction. In practice, however, collaboration is becoming commonplace. Design-build contracts uniting architect and contractor under a single contract with the owner, are now used for over one-third of all projects in the US (HBE Blueprint 1999). Negotiated bidding on construction contracts, also on the rise, encourages early communication between designer and constructor.

IMPLICATIONS OF THE CURRENT MODEL

In addition to its inaccuracies, the sequential model also suggests several implications that may create inefficiencies and obstacles to practice. One such negative implication is waste. Consensus estimates show that poor project management wastes up to 30% of project costs every year (Puddicombe 1997). Part of this waste may be due to the mismatch between our inaccurate, sequential model of the transformation process and the dynamic, collaborative reality of architecture as practiced today. Second, the linear process is slow. More and more owners are looking to put design and construction on a fast track, and this requires an overlap of design and construction phases. In the sequential process model, however, design and construction are sequentially dependent – construction cannot begin until design is complete.

Third, the linear model is hostile to change. When it is assumed that design is complete before construction begins, design change (and therefore design improvement) during construction is strongly resisted. As the transformation process is currently structured, change costs an estimated $60 billion per year (Ibbs 1997). A more flexible model that recognizes the need for change could reduce its cost and open the door to innovation and continuous design improvement during construction. Innovation is also inhibited by the separation of disciplines inherent in the sequential model. Early project team formation, collocation and common goal definition are regularly cited as the primary contributors to project success, and the organizational and contractual structures implied by the sequential model restrict these kinds of interdisciplinary and cross-phase cooperation (de la Garza et al 1994).

AN ALTERNATIVE

An alternative process model intended to be more efficient, faster, more flexible and open to innovation is proposed here. Its main distinction from the sequential model is its circular structure. Rather than assume that each step (idea, information, action and object) must be complete before the next can begin, this model breaks the process of transformation down into a series of smaller sub-steps (Figure 1). The second key distinction it makes is to do away with the traditional discipline- and phase-specific labels of design and construction and adopt terms that better reflect the dynamic reality of architectural practice by acknowledging and encouraging interdisciplinary collaboration and design-construction phase integration. These sub-steps or "fundamental processes" focus on the relationships between the traditional categorizations of design and construction.

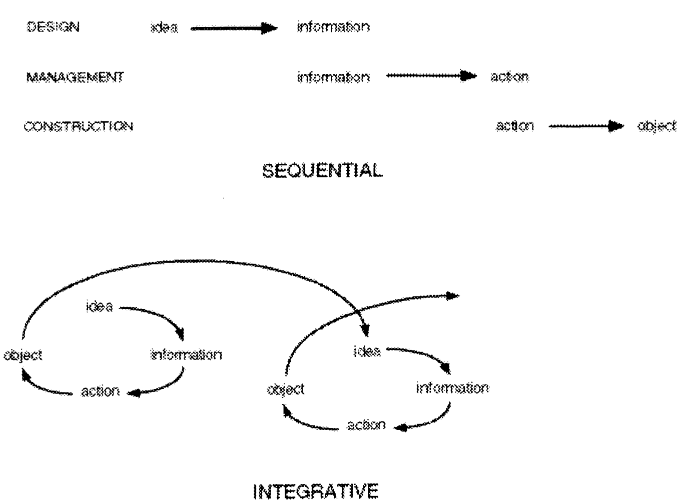

Figure 1. In a sequential architectural process, the built object is made to conform to design information completed prior to the start of construction: in an integrated alternative, feedback from incremental steps in the construction process can form the basis of continuous design improvement.

These processes form repeating feedback loops or cycles in which the act of transformation that concludes one step in the process becomes the subject of observation in the next (Figure 2). For example, a specific construction activity such as framing a wall could lead to observations by the architect that suggest improvements to the design of the windows within that wall. While lead times for product manufacture, inspections, workflow scheduling and a variety of other factors make it necessary to define some design elements far in advance of construction, certain design decisions may remain open to respond to the emerging reality of the building on site.

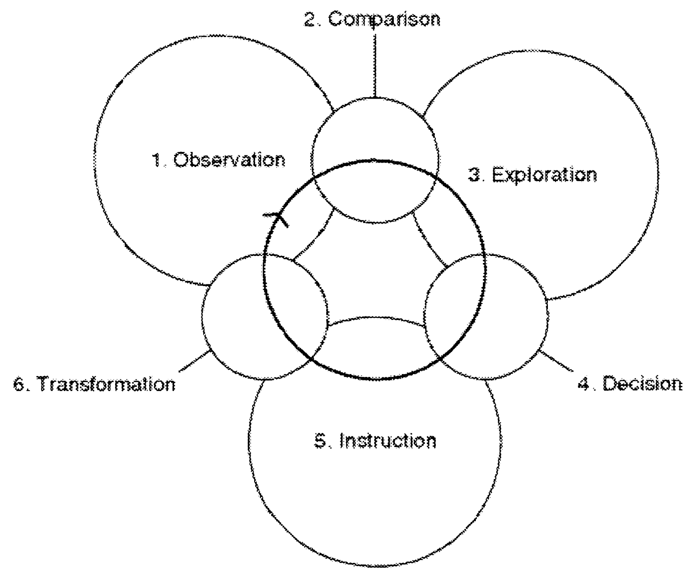

Figure 2. Fundamental processes in the transformation process.

These cycles repeat throughout the life of the project without distinction between traditional project phases. They occur in the planning stages, design stages and construction stages, each cycle building on the results of the one before. Repeating cycles can be found in Jones' principle of circularity (1980), Simon's locally well-structured problem-solving approach (1984), and Alexander's step-by-step process (1995). These authors, however, do not externalize the design process to include critical considerations of collaboration, communication and coordination.

To grasp the concept of the design-construction process as a series of repeating feedback loops or cycles it is necessary to abandon the idea of sequential dependency. While, for clarity, figure 2 shows the six fundamental processes occurring in sequence as we follow them clockwise around the loop diagram, in operation they form a complex network full of gaps and shortcuts rather than a linear sequence. They provide an alternative framework for conceptualizing and improving the dynamic process of transformation in architecture. In this integrated model of transformation, change is not resisted by a rigid, predetermined plan, and yet structure and order are provided in a way that allows for adaptation to inevitable unforeseen circumstances. The fundamental processes of observation, comparison, exploration, decision, instruction and transformation unfold in a circular, iterative pattern throughout the life of the project.

OBSERVATION

Observation is the act of paying attention to our surroundings. In design, observation is generally accompanied by the recording and analysis of observed phenomena. The traditional approach that separates design and construction activities describes observation as an initial data-gathering activity (Archer 1984). The architect sketches on site and talks to users in order to define the context and program of the project. This static view places observation at the start of a linear sequence of design activities. Once this initial data-gathering phase is complete and schematic design begins, further observation is considered unnecessary or extra. The AIA standard contract, for example, excuses the architect from continuous observation during construction (AIA B141, Article 2.6.5).

In contrast to this tradition, observation as defined here is the continuous observation of the building condition throughout the entire design-construction process. In this dynamic design approach the observed condition of the building during construction can serve as the basis for continuous design improvement in a feedback loop pattern of activities similar to Deming's plan-do-check-act cycle of Continuous Process Improvement (Deming 1982) (Figure 3).

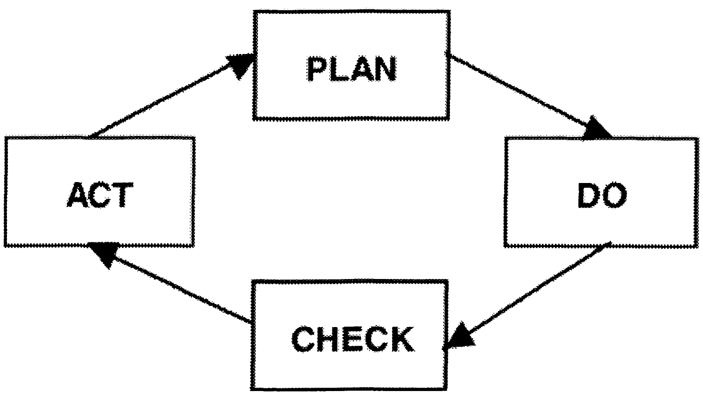

Figure 3. The iterative Plan-Do-Check-Act cycle of Continuous Process Improvement

Standing in a framed room, for example, the architect observes the actual emerging space and structure of the room and directly determines the location of windows in the framed-up wall. His or her observation and analysis of the actual space enters the mix of factors such as lead time, constructability, and the look of the facade, on which design decisions are based. The window as placed then becomes the basis for the next step in the cycle – the location of the mullions within the window, for instance. This does not mean that there was no window design prior to wall framing, only that constructed work may become a consideration in and basis for developing design.

Existing form, whether unbuilt site or evolving structure, is not the only type of condition that requires observation. If the purpose of design is to resolve a discrepancy between actual and desired conditions, then knowledge of actual conditions (factual knowledge) must be accompanied by knowledge of ideal conditions (deontic knowledge) (Rittel and Webber 1973). The dilemma facing the designer is that every step in the act of designing changes the understanding of the desired end. The idea of holding the end or solution constant while the problem continues to evolve is especially confounding. In the integrated model, the team extends the design process into the construction phase that occupies the bulk of the project schedule. This allows additional time to observe, analyze and reconcile the factual knowledge of existing conditions with the deontic knowledge of desired conditions.

In this way, deontic knowledge, the definition of the desired end, can be based not only on factual knowledge of predesign conditions of site and program, but on factual knowledge of the real building as it evolves. Writer John Barth (1994). calls the convergence of actual and desired conditions coaxial esemplasy, "the ongoing, reciprocal shaping of our story by our imagination, and of our imagination by our story thus far." A writer does not attempt to finalize every detail of the story before he or she begins writing, but allows the factual knowledge of the "story thus far" to continuously develop the deontic knowledge of the end (Figure 5).

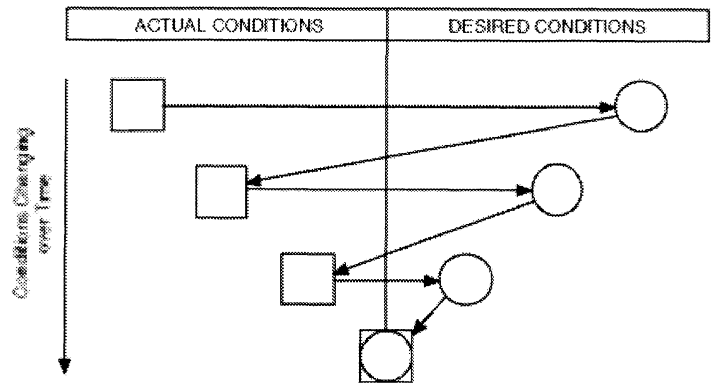

Figure 4. Convergence and mutual influence of actual and desired conditions.

COMPARISON

Comparison is the analytic act of evaluating two or more alternatives according to some criteria. A design problem is identified when we compare actual and desired conditions and find a significant difference between the two. The realization that our built environment is not meeting our needs leads us to take action to correct the problem. It is through comparison of actual and desired conditions that we decide what to do to reconcile a need. Design and construction aim at the transformation of actual conditions toward a more desirable condition.

Both actual and desired conditions change continuously throughout the process of designing and making a building (Simon 1984). The range of possible solutions to any design problem is almost unlimited. Rigid sequencing and hierarchical structures of design decision-making are suspect because problem definition, synthesis and evaluation are continuously changing and influencing each other throughout the design process. Rather than try to imagine all the indescribable details of construction in advance, the integrated approach engages the architect's direct experience of existing conditions in the process of comparison. The real form of the building becomes an ingredient in the comparison of actual and desired conditions much earlier here than in the sequential model (Figure 6). Through procedures for continuous on-site design improvement, much of the design development may occur in small steps in direct response to existing conditions.

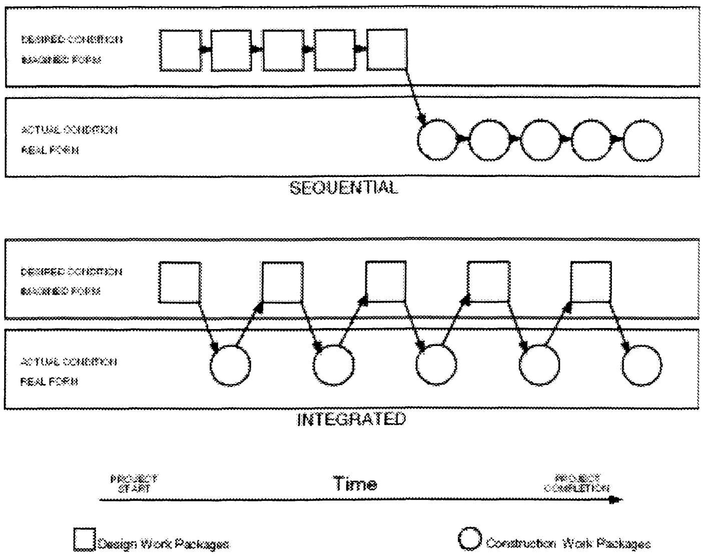

Figure 5. Relationship between design and construction work packages.

In the iterative, feedback-loop process of integrated design and construction, continuous comparison of actual and desired conditions forms the basis of each successive sub-transformation of actual conditions. The real condition of the building under construction is compared to the (current) definition of the desired end, and the next design-construction move is made based on that comparison. Many process models, on the other hand, depict comparison as concluding with the commitment to a plan (Rittel and Webber 1973). In these models, existing conditions are observed at the outset of the project in order to form a definition of actual conditions. This definition is then generally held static as design proceeds, despite the fact that actual conditions may change significantly during the months or years between a project's inception and its completion. In the alternative model, comparison is a continuous process, rather than a static decision-point. The project team is constantly comparing actual and desired conditions and redefining both.

EXPLORATION

The design problem is the discrepancy between actual and desired conditions. Exploration is the search for possible resolutions to that discrepancy. Approaches to exploration may vary greatly. At one extreme, exploration may be defined as the systematic investigation of carefully defined design variables (Ashby 1961). At the other extreme is the dictionary definition of exploration – "to search into or range over for the purpose of discovery" – an informal, open-ended approach to seeking solutions. The exploration of design alternatives is a search constrained by budget, schedule, technology, user needs, and a myriad of other considerations that act as a boundary to the area searched or problem space ranged over. An innovative solution may lead to redefinition of the desired condition - a remapping of the problem space.

Exploration in the sequential model tends toward two extremes, an "all-or-nothing" proposition. Initially, the designer explores an open problem space and is free within the limits of program and budget to return at any time to a previously resolved question and reopen it. Rittel calls this "epistemic freedom". However, once plans are complete and construction begins, the opposite extreme holds – design problems are no longer open. The design is considered complete, and the search for solutions terminated. This is not only due to the fact that commitment to construction makes redesign and rework expensive. The entire organizational and procedural structure of the system strongly discourages change to the architect's plans. Thus the two extremes – an almost entirely open problem space before construction begins, and an almost entirely closed one thereafter.

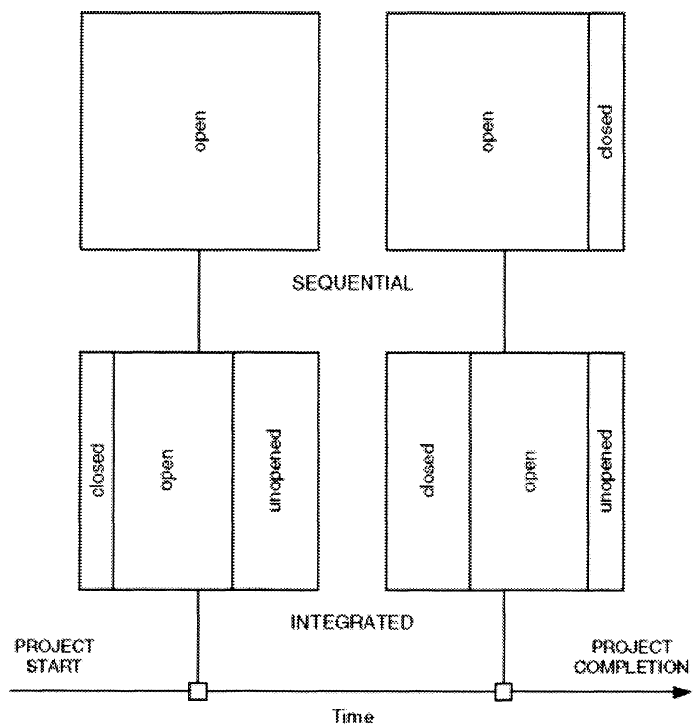

Figure 6. The "all-or-nothing" problem space of sequential process and the "mobile" problem space of integrative process

In contrast, the integrated model offers a more consistent problem space throughout the life of the project (Figure 7). Portions of the problem space close sooner due to the early commitment to construction. The footprint of the building, for example, is extremely unlikely to change once the footings are poured. With the early start of construction many design details remain unresolved, their problem space as yet unopened. As design-construction progresses, this smaller problem space shifts toward smaller details with more design decisions closed by construction and fewer questions remaining unopened.

In the sequential model, exploration is an internal operation used by the designer. Herbert Simon, for example, describes how designers break ill-structured problems down into a series of smaller well-structured problems and move between problem spaces via "noticing and evoking mechanisms," a technique Donald Schön calls "surfacing" (Simon 1984, Schön 1983). In the integrative model, an architect working on site during construction could develop these noticing and evoking skills in order to explore design options directly on site, engaging in what Jones calls "research actions" (Jones 1984). The real structure of the building then becomes an element within the problem space and can be used as a basis for design decisions. Jones cites the problem of cost and time associated with research actions, costs not normally structured into an architect's standard fees. Research actions such as direct exploration could, however, significantly reduce the billions of dollars spent every year on change orders and rework.

DECISION

In order to move the process of transformation forward from idea to object, it is necessary to close the exploration of alternatives with a decision to commit to one plan at the exclusion of others. Decision is the commitment to a plan of action. Decisions and actions are separated into disciplines of design, construction and management in most process models. This model examines decision as an interdisciplinary process recurring throughout all phases of the project. It is important to maintain a holistic perspective on the decision-making process because decisions affecting change in one part of the project affect change in others as well.

Decision makers in an integrated process face a dilemma: since design is not complete when construction begins, some building decisions must be cast in concrete before all questions can be answered about desired conditions. The usual strategy recommended for dealing with uncertainty is to answer as many questions as possible in advance. But all the questions cannot be answered in advance, as Rittel, Schön, Simon and others have shown that desired conditions are in constant flux and can never be completely defined. Studies have found this to be the case in practice as well, where 80% of all capital projects have "significant end uncertainty" at the start of construction (Laufer 1997). Successful transformation depends on the sequence and hierarchy of decisions throughout the entire design-construction process. The essential question for transformation becomes, "Which activities must be closed when?" Leaving some design decisions open poses many challenges, but may also offer rewards.

The alternative model of transformation breaks away from the myth that all planning questions can be answered prior to the start of construction. As Forrester points out, "Symptom, action, and solution are not isolated in a linear cause-to-effect relationship, but exist in a nest of circular and interlocking structures." (Forrester 1994). The alternative model employs a feedback structure that acknowledges the interrelationship and simultaneity of many design and construction decisions. In this view, each decision point is more like a node in a matrix than a point in a line. Here, certain problem spaces are closed by construction while many others remain open. Commitment to one alternative is likely to impact other nodes in the network, resulting in redefinition of desired conditions and constraints. The gradual realization of the design idea in built form creates new information that interacts with future design decisions. In this approach, the information that results from a particular decision becomes an input to the next decision.

Continuous, as opposed to predetermined, design decision-making opens up the opportunity for on-site design decision-making during construction. It brings the decision point as close as possible to the information source for that decision. Viewed in terms of Schön's analysis of design as a conversation with the situation, the integrated approach places the designer in the same situation as the user (the building), rather than in a simulation of the user's situation (drawings). Users often have difficulty making decisions based on plans and drawings. Here, the designer's mode of experience is more in harmony with the user's.

Agreement among project teammates is greatly facilitated when dealing with actuality on site, rather than abstract representations. In *The Logic of Architecture* (1990), William Mitchell describes the different languages used by architects, builders and owners, along with the different modes of representation employed by each. Collaborative decision making (on site whenever possible) reduces reliance on intermediary media and discussion revolves around the actual structure.

INSTRUCTION

Decision is the conversion of information into action; information is the input to decision. An instruction is a defined, sharable collection of information transmitted by one party that guides the actions of another party toward a goal. It may be as simple as a "yes" or "no", or as complex as to encompass details of method, material, organization and reasoning. Instruction identifies what is to be done, who is to do it, when, where, and with what.

The nature of instruction may shift as team collocation and team work on site increase. Conventional plans and specifications are intermediary modes of representation needed to embody the architectural idea and instruct the contractor on the desired condition of finished form. In the integrated model, however, the emerging form of the building begins to play a role in the design decision system and may serve in many cases as the actual, rather than representational, basis of future instruction.

In their study of project information flows, Nicoletti and Nicolò (1998) make an important distinction between dynamic and static information flows. Static information flows clearly define inputs and outputs for precedence relationships between activities thoroughly planned in advance (as in a typical Critical Path Method diagram). Dynamic flows acknowledge the interaction of project activities (as when activity Z cannot be entirely planned until activity Y is complete). Concurrent design and construction creates dynamic information flows. Instructions governing a particular action are likely to be based on information not available until shortly before the start of that action.

While activities cannot always be planned in advance, the architect should be able to identify dependencies between activities and prepare strategies for gathering information and disseminating instruction. Instruction for one activity may be dependent on information from another, and these information links must be prioritized and planned for. Early involvement of downstream information users helps to identify the information requirements for project activities. Finally, the size of information batches may change in the future. In contrast to the complete set of drawings handed "over-the-wall" in traditional project delivery methods, we may soon see more sets of instructions each containing less information changing hands more frequently throughout the design-construction lifecycle.

The involvement of downstream information users early in the process represents a more iterative back-and-forth flow of information and instruction than what we are accustomed to in the over-the-wall method. The question, "Who needs to know what when?" has a very different answer in a collaborative, fast-track project than in its traditional counterpart. One of the biggest problems facing the integrated project team is the diversity of disciplines that need to communicate clearly and frequently in this approach. Differences in values, goals, purposes and methods among disciplines make instruction difficult. Differences of style within each profession, and even among different positions in the same firm complicate communication even further.

TRANSFORMATION

Transformation is the directed alteration of form. Transformation of the design idea into built reality is the aim of the design-construction process. It is the crucial missing link in many design theories and methods (recall Rittel's definition that "design ends with commitment to a plan.") A comprehensive model that embodies the real-world characteristics of today's concurrently designed and built projects must incorporate the physical transformation of resources into a built object.

In sequential design-bid-build project delivery, construction can be seen as a process of conformation (to drawings and specifications laid out in advance by the architect). The model presented here is one of transformation, in which an integrated design-construction team fine-tunes the design details during construction in order to continuously improve the building. In contrast to the sequential model, which seeks to fix design details in advance and then make countless changes during construction, this alternative model of transformation can be seen as a gradual focusing of design intent based on the actual experience of the evolving structure and space on site.

A collaborative approach to transformation must address the problem of specialization. Transformation of idea into object has traditionally been the role of the contractor. In an iterative design-construction process, the architect must understand the material and method implications of design decisions. In a standard architectural contract the architect is not permitted to engage in the means and methods of construction. But as Schön (1983).points out in his analysis of reflection-in-action, true practice requires that ends and means merge in a continuous, iterative cycle.

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