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Situated Design-Thinking in Architectural Practice:
Analyzing and Extending Schön's Epistemology

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Abstract
Nearly thirty-five years ago Donald Schön proposed an epistemology of design practice as an antidote to the crisis of legitimacy in architecture and other professional design disciplines. His theory of reflective practice is popular in teacher and nursing education programs and 'design-thinking' has gained credibility to promote innovation in business. Yet he failed to provide the epistemic credibility for architectural practice he promised. This critical analysis compares constructs in Schön's theory against knowledge from mind and brain science to assess their validity and limitations. Findings inform suggestions for extending his theory toward developing a more complete epistemology of architectural practice.

Today benefits of design-thinking to drive organizational innovation are embraced by corporations, yet architects continue to suffer inability to sufficiently communicate their legitimacy and worth.

1. Introduction

The 1980's saw emergence of a new research stream: empirical study of design cognition as a way-of-knowing distinct from science or humanities (Cross, 2007). Central to this effort was Donald Schön's (1983), *The Reflective Practitioner*, which challenged Simon's (1996 [1969]) "Technical Rationality" suggesting design be made more rigorous "by the application of scientific theory and method" (ivi, p. 21). Through ethnographic study of architects (and also engineers, town planners, managers, and psychotherapists), Schön described physically and socially situated processes of design-thinking[1]. He focused attention to *lived experiences* of professionals *in-action* solving ill-defined problems – illuminating tacit knowledge and *artistry* (improvisation) in their practices. Importantly, Schön positioned design-thinking as expertise acquired through practice and worthy of empirical examination.

Today benefits of design-thinking to drive organizational innovation are embraced by corporations (Johansson-Sköldberg *et al.,* 2013), yet architects continue to suffer inability to sufficiently communicate their legitimacy and worth (Cohen *et al.*, 2005). This is due, in part, to the growing complexity of architectural practice – where buildings contribute to the larger environmental and socio-cultural ecosystem – and challenges architects face in explaining or quantifying their intuitive design processes for clients (Cohen *et al.*, 2005; Schön, 1983, pp. 3-20). Given demands for increased rigor in architectural practice to improve building outcomes, the value of *design as a discipline* continues to be called into question. Architects implicitly understand and appreciate advantages of *designerly* over *other* ways of knowing, but benefits are not always salient to clients and users. Despite decades of design cognition research, architecture still lacks epistemic evidence to sufficiently convey its worth to the *non*-designerly world.

Schön (1983) proposed "Reflective Practice" as "an epistemology of practice implicit in the artistic, intuitive processes which some practitioners... bring to situations of uncertainty, instability, uniqueness, and value conflict" (ivi: 48). His theory has been highly influential in education, healthcare and management professions and today knowing-in-action,

reflection-in-action, and reflection-on-action yield 48,100,000, 34,500,000, and 147,000,000 Google results, respectively. Despite widespread application and popularity, researchers criticize Schön's theory for:

- Lack of clarity/vague constructs (Eraut, 2004; Webster, 2008)
- Problems of implementation (Ekebergh, 2007)
- Ignoring socio-political context (Boud and Walker, 2002; Webster, 2008)

This paper examines Schön's thesis by critically analyzing his findings with respect to knowledge from mind and brain science. The aims of this effort are threefold:

1. Evaluate construct validity by comparing Schön's knowing-in-action, reflection-in-action, reflection-on-action, artistry, and knowing-in-practice against theories of situated cognition.
2. Assess criticisms of Reflected Practice Theory as listed above with respect to construct validity analysis.
3. Recommend how Reflective Practice might be extended to provide a more fully developed epistemology of architectural practice.

2 . Reflective practice constructs
Schön (1983) proposed Reflective Practice theory to lend credibility to *experience* as a form of intuitive knowing in-situ, distinct from (and superior to) the linear, rationalist approach advocated by others (ivi, pp. 21-69) – for example, Simon's IDC model (Fig. 1).

2.1. Modes of design-thinking
Basing his argument on ethnographic data drawn from working practices of engineers, architects, town planners, psychotherapists, and business managers,

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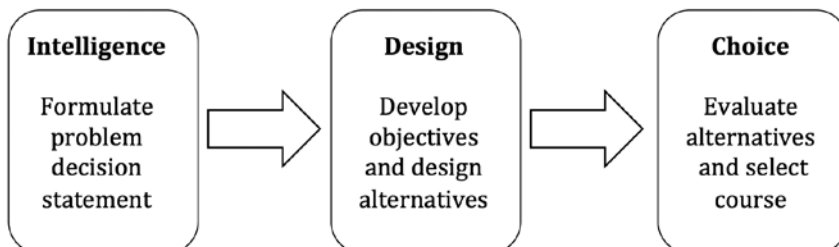

Fig. 1 - Simon's Rational Decision-Making (IDC) Model.

Architects engaged in three cognitive processes while solving ill-defined, complex problems.

Knowing-in-action and reflection-in-action occur during action present, defining the conceptual problem space for a project or process.

Schön found practitioners engaged in three cognitive processes while solving ill-defined, complex problems:

1. *Knowing-in-action*: intuitive performance developed through practice (p. 54).
2. *Reflection-in-action*: critical thinking occurring within the scope of a problem-solving activity (e.g., design project), often triggered by an unanticipated situation (p. 56).
3. *Reflection-on-action*, evaluation of a project or process after completion (p. 61).

2.1.1 Action present
Knowing-in-action and reflection-in-action are complementary processes, together forming an iterative approach toward managing complexity in ill-defined problems. Knowing-in-action is the physical expression of intuitive 'knowing in practice' (*knowing-how*). It reveals that "competent practitioners usually know more than they can say" (p. viii). Reflection-in-action is the explicit *thinking* complement (*knowing-that*) to knowing-in-action's *doing*. It describes how people recognize what they know in the consequences of their moves – and that their knowledge may be deeper than what they could articulate ahead of time. "Doing extends thinking in the tests, moves and probes of experimental action and reflections feeds on doing and its results... each sets boundaries for the other" (p. 280). Through these two processes, the designer *constructs* the problem space by developing "an understanding of the situation" (p. 129). Schön used the term *action* to reference physically-situated ways people incorporate their bodies and environments (e.g., tools, materials, and other people) into their design-thinking systems. He also used *action* to define the scope of a design project; *action present* (p. 278) is the time-period when a designer's action still affects the outcome of design project (p. 62). Knowing-in-action and reflection-in-action occur during action present, defining the conceptual problem space for a project or process (Fig. 2).

2.1.2. Learning from design cases
Reflection-on-action happens outside of a project scope. It is a process of rationalization postmortem involving critique of previous decisions and behaviors affecting solution outcomes. This is reflection for *future* action and Schön used the concept to explain

Fig. 2 - Schön's Reflective Practice.
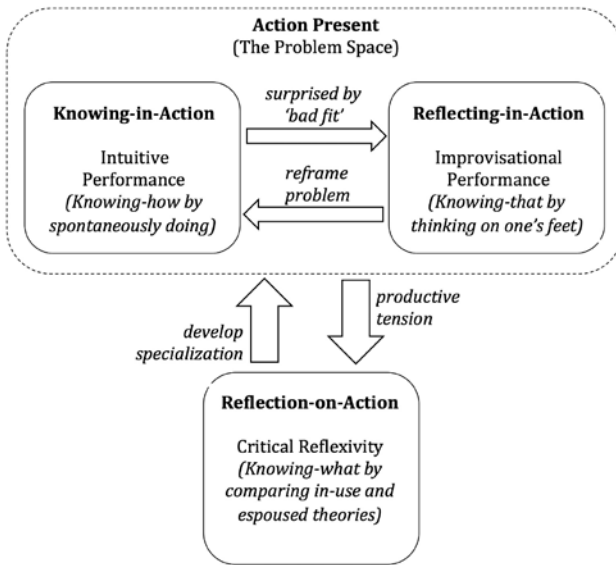
case-based learning. Reflective practice emphasizes the uniqueness of design cases, however reflection-on-action is self-reflexive, metacognition by which a practitioner learns concepts, ideas, or skills that are transferable to other cases. Per Schön, 'We reflect *on* action, thinking back on what we have done... to discover how our knowing-in-action may have contributed to an unexpected outcome' (p. 26). Designers bring different perspectives to their work, including "values, goals, purposes, and interests" (p. 17) implicit in their knowing-in-action. Critical reflection-on-action identifies and resolves conflicts between implicit and explicit theories; it is common for actions (*guided by theory-in-use*) to be *inconsistent* with stated goals or intentions (*espoused theory*). Reflection-on-action surfaces similarities and differences between espoused theory and theory-in-use when practitioners compare what *actually* happened during a project with beliefs about the design. Tension arising from theory differences promotes new insights and learning, evolving design-rationale, expertise and professional growth.

2.2 Design-Thinking Expertise: Inquiry, Reflection, Reframing
2.2.1. Artistry through frame experimentation
Schön argued that design's 'crisis of confidence' arises from inability practitioners have in explaining expertise (*knowing-in-practice*) – "making sense of uncertainty, performing artistically, setting prob-

Designers treat each design case uniquely, constructing knowledge through frame experimentation and developing expertise by reflecting on the case postmortem.

lems" – when such processes are not considered "invariant, known, and teachable" (pp. 18-20). Design-thinking differs from rational problem-solving because its goal is to find 'the right problem,' not solve a given problem. The designer problem-finds through *artistry* – improvisational exploration of the problem space using *frame experimentation*: iterating inquiry, reflection, and problem framing/reframing. Frame experimentation, Schön reasoned, gives rigor *to reflection-in-action employing strategies* similar to scientific research, but particular to design practice (pp. 68-69).

2.2.2. Specialization and intuitive knowledge
Designers treat each design case uniquely, constructing knowledge through frame experimentation and developing expertise by reflecting on the case postmortem. With practice, a designer "encounters certain types of situations again and again", and becomes a specialist, developing "a repertoire of expectations, images, and techniques" (p. 60). A growing repertoire helps the designer better predict outcomes of actions. Less often surprised, her knowing-in-practice becomes increasingly intuitive and harder to explain. *Specialization* also brings fewer opportunities for reflection, increasing risk the designer develops "patterns of error" and "parochial narrowness of vision" (pp. 60-61).

3. Design thinking-in-action: embodied, embedded, enactive, predictive
Although published decades ago, Schön's (1983) *Reflective Practice* theory describes the physically-situated[2] nature of design-thinking. Today, scientists generally agree human cognition is both socially and physically situated (Anderson, 2003; Robbins, Aydede, 2009), meaning people's knowledge cannot be separated from the socio-physical contexts where they develope and use it. Neuroscience research also suggests the mind is a *sophisticated hypothesis-testing system*. Supported by neurophysiological evidence, *Predictive Mind theory* describes brain function as a 'prediction machine' that continuously tries to match internally driven (top-down) expectations with externally driven (bottom-up) multi-sensory experiences in the environment (Clark, 2015). Schön's concepts of knowing-in-action, reflection-in-action, and artistry suggest both physical grounding of cognition and predictive processing in design-thinking.

3.1. The Brain-Body-Environment Cognitive System
Situated cognition integrates theories from social psychology, ecological psychology, and biology to describe human cognition as dependent upon bodily characteristics, intellectual abilities, mood, activities, socio-cultural context, and physical environment (Gallagher, 2009). Three tenets (*3E's*) take *physical grounding* as their focus: *embodied, embedded,* and *enactive* cognition. Embodied cognition explains how human perception is shaped by the characteristics and capabilities of the body (Gibson, 1977; Varela *et al.,* 1991). Embedded cognition considers ways people exploit features of their physical (Clark, 2008) and social (Hutchins, 1995) environments to improve cognitive capabilities. Enactive cognition theorizes knowledge is constituted through a person's actions in, and interactions with, their environment (Thompson, Varela, 2001). Central to each of these tenets is belief that action and perception are coupled, an idea supported by neurophysiology research on neural processing of vision and hearing[3] and the brain's mirror neuron system[4] (Garbarini, Adenzato, 2004; Wilson, 2002).

3.1.1. Ecological approach to perception
The 3E's underscore the importance of action in perception (an idea central to Schön's epistemology) and how people incorporate items from the physical environment into their cognitive systems. Form and capabilities of a person's body along with its interactions with the external environment shape that person's conception of the world (Wilson, 2002). This ecological view of cognition was popularized with psychologist J.J. Gibson's (1977) Theory of Affordances. Gibson believed people understand the world in terms of functional relevance (affordances). Affordance is *action opportunity* constituted through the relationship between a person's capabilities and features of the environment. The ecological view of perception suggests people are inherently goal-directed and wired for action; they perceive their environments in terms of the action opportunities (field of affordances) they present. Figure 3 illustrates how a person's action in the world changes the field of affordances available to him and, in turn, his field of affordances affects his perception.

3 - Two-stream hypothesis argues vision and hearing are each characterized by distinct systems: ventral stream ('what pathway') and dorsal stream ('where/how pathway'). fMRI studies illustrate complementary responsiveness in the vision-for-perception and vision-for-action pathways.

4 - A mirror neuron fires when a person performs an action and when watching an action performed by another, suggesting object-action linkage in cognitive processing.

3.1.2. Embodied knowing-in-action

Knowing-in-action describes the embodied, practical knowledge people exhibit through doing. It has the following properties (p. 54):

1 Actions, recognitions, and judgments are carried out spontaneously, without prior thought.
2 People are often unaware of having learned them.
3 They are usually unable to describe the knowing revealed in their actions.

Schön's story of Quist, an architect, and Petra, his student, illustrates how practitioners communicate embodied-knowing through drawing. Petra has problems with a complex slope in her design for a school. Quist

Fig. 3 - Perceiving-in-Action.
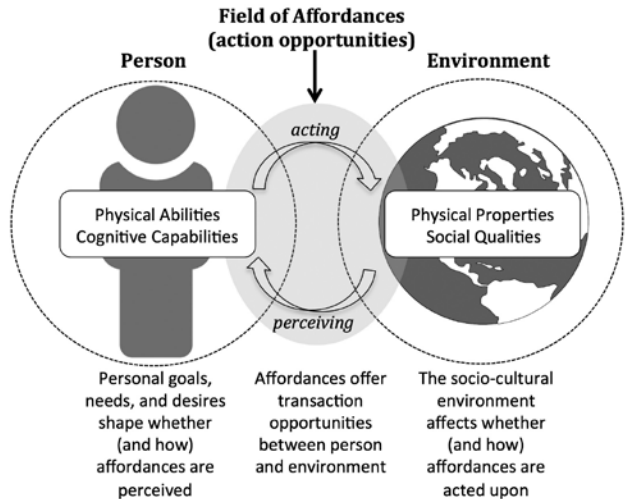
places tracing paper over her drawing, demonstrating design expertise through knowing-in-action while drawing. His sketches reveal knowledge, with words mainly referencing what he is doing:

Quist's lines are unclear in their reference except insofar as he says what they mean. His words are obscure except insofar as Petra can connect them with the lines of the drawing. His talk is full of dychtic utterances – 'here,' 'this,' 'that,' – which Petra can interpret only by his movements. (p. 81)

Quist is thinking *by* drawing. Drawing tools and paper are *transparent equipment*; he *sees through them* to externalize knowing-in-action (Clark, 2008). His body

helps *constitute cognition* through interactions with artifacts in the environment, in this case drawing instruments.

3.1.3. Embedded reflection-in-action

Reflection-in-action is an explicit process to remedy 'bad fit'; it is triggered by a surprise when intuitive performance yields unexpected results (Schön 1983, p. 56). Feedback from "materials of a situation" (p. 78) prompt the designer to "surface and criticize the tacit understandings" of the problem (p. 61). Quist relies upon his repertoire of experience to select one problematic aspect of Petra's design: the relationship between L-shaped classroom and site slope. He reframes the problem, suggesting geometry ("discipline") be imposed upon the "screwy" site (p. 85). Then he conducts a frame experiment to test his idea by drawing plan and sections (pp. 86-87):

1. The L-shaped classrooms are carved into the slope as in sketch A [plan].
2. The 'differentiation potential' [of the site is 15',] shown in the sectional sketch B... The slope is now divided into three levels, one for each of the classrooms...
3. [Section] C shows the 'interval' from the ground on one level to the roof of the classroom... on the next lower level [5'].

Quist uses different drawings as *things to think with* while testing his frame experiment: imposing 'discipline' on the site. Each drawing reveals affordances explored in a subsequent drawing. In plan A, three L-shaped classroom buildings are arranged with respect to site topography. Affordances of this organization are investigated in section B, revealing a 15' site drop ('differentiation potential') between classroom buildings at the top and bottom of the site. In section C, Quist examines affordances of stepping buildings in 5' intervals. A new idea emerges: to provide 'nooks' for the children.

Reflection-in-action describes *embedded cognition*. Quist off–loaded cognitive work to his drawings to investigate tacit assumptions and reveal unanticipated affordances. Manipulation of features and qualities of the problem environment is critical even for experts like Quist to understand complex situations through "incremental cognitive self–stimulation" sustained by

feedback from changing environmental conditions (Clark, 2008, p. 61).

3.1.4. Artistry enacted through conversation with materials
The enactive thesis describes how understanding is constituted through (enacted by) people's interactions with aspects of their environments. This concept aligns with embodied and embedded theories, because cognition that is embodied and embedded must also be enactive (Ward, Stapleton, 2012). Reflective practice describes a form of enactive cognition in that it focuses attention on the *importance of action* in ways practitioners intuitively manage complexity toward developing creative solutions to ill-defined problems (Malinin, 2016). Schön described this as *artistry*:

A designer makes things... Typically his making process is complex. There are more variables – kinds of possible moves, norms, and interrelationships of these – than can be represented in a finite model. Because of this complexity, the designer's moves tend, happily or unhappily, to produce consequences other than those intended... He shapes the situation, in accordance with his initial appreciation of it, the situation 'talks back,' and he responds... (p. 79).

Artistry is transactional and improvisational performance between designer and the product of his making, *enacted* by feedback from the materials of the design situation. He perceives-in-action as his idea takes form; *shifting in stance* he "must oscillate between involvement and detachment" (p. 102) in response to the conversation unfolding from the materials at his hand.

3.2. Mind: A prediction machine
Predictive Mind theory also emphasizes the importance of action in perception (Clark, 2015). The argument here is that our expectations shape how we experience the world, determining what we attend to with our sensory systems of sight, sound, smell, touch, and taste. The nervous system, it hypothesizes, is designed to adapt to uncertainty, providing real-time feedback from the environment to confirm or contradict expectations about it. The brain, wired to conserve resources, 'surfaces uncertainty' by comparing *expectations* to *experiences*, prioritizing attention where it is needed. Perceptions

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of the environment that confirm expectations are not given much importance. Instead, unexpected feedback (Schön's 'bad fit') is prioritized, and sensory inputs improve accuracy of future predictions and behaviors. Attention and action are bound together as an effortful 'error detection' system. Thus, *sustained attention in the absence of action becomes harder* because the mind craves new sensory information (Clark, 2015).

3.2.1. Knowing-in-practice: specialized prediction-system

Knowing-in-practice is an intuitive, disciplinary-specific, 'error detection' process developed from patterns of experiences in similar design cases.

As a practitioner experiences many variations of a small number of types of cases... he learns what to look for and how to respond to what he finds. As long as his practice is stable, in the sense that it brings him the same types of cases, he becomes less and less subject to surprise. His knowing-in-practice [becomes] increasingly tacit, spontaneous, and automatic... (p. 60)

Quist's problem-solving repertoire includes "sites he has seen, buildings he has known, design problems he has encountered, and solutions he has devised for them" (p. 138). He has acquired domain-specific technical expertise (for example, orthographic drawing) and developed domain design-language (e.g., program, site, elements, form, structure, scale, precedent, representation, etc.) (p. 96). This repertoire structures 'priorities for attending to features of a situation' (p. 98) and shapes affordances he perceives.

3.2.2. Reflective practice is situated design-thinking

Schön's concepts – knowing-in-action, reflection-in-action, artistry, and knowing-in-practice – align with cognitive theories of embodied, embedded, and enactive perception and predictive mind. This analysis, summarized in Table 1, suggests *foundational principles underlying his constructs are valid and supported by research from the mind and brain science*. In the next section, the analysis is used to evaluate criticisms regarding conceptual clarity, implementation, and socio-cultural context.

4. Limitations of Schön's theory

Criticism of Schön's reflective practice theory largely come from problems associated with applying it to

Table 1: Alignments Between Situated Cognition Theories and Reflective Practice Constructs

Theory	Related Constructs	Schön's Examples
Embodied Cognition	**Knowing -in-Action**	Quist's architectural knowledge is embodied and revealed through drawing processes. Words are obscure, with 'dychtic utterances' referencing drawings. Drawing tools are transparent, incorporated into his cognitive system.
Embedded Cognition	**Reflection -in-Action**	Quist uses drawings as things to think with. He selects one problematic design aspect and conducts a frame experiment. Predicting reorganized building forms will work better with the 'screwy' site, he tests this through diagram, plan, and section drawings, partially confirming his prediction.
Enactive Cognition	**Artistry**	Quist's design emerges through 'conversation with' drawings. Each drawing reveals new affordances investigated in subsequent drawings. He shifts stance between immersion in drawing and detachment when perceiving unanticipated results. Iteratively he tests predictions, responding to unanticipated outcomes of actions.
Predictive Mind	**Knowing -in-Practice**	Quist's repertoire of experiences, skills, and design language develop through stable practice involving similar cases. This repertoire makes him less often surprised by situations and his practice becomes more tacit. It also helps him intuitively prioritize features of a design to attend to, shaping affordances he perceives. Knowing-in-practice is a "self-reinforcing system" (p. 226) of prediction and error-detection.

instructional practices in teacher preparation, nursing programs (Boud, Walker, 2002; Ekebergh, 2007) and architectural education (Mewburn, 2012; Webster, 2008). These are reframed as three questions to consider:

- What distinguishes reflection-in-action from knowing-in-action and reflection-on-action?
- Is it possible to 'reflect' during intuitive activities?
- What role does socio-cultural context play in people's abilities to critically reflect 'in' and 'on' their actions?

4.1. Reflection problems: Construct and implementation
What distinguishes reflection-in-action from reflection-on-action?
At the root of this question is that Schön used 'reflection' to describe different cognitive processes. The

concept of 'action present' delineates reflection-in-action from reflection-on-action. However, the former he described as *appreciative* (p. 101), promoting "recognition of implications" in a situation (p. 103). It is directed toward the object of design. The latter, he explained, is a *self-reflexive* process whereby practitioners "can explore the [tacit] understandings they have brought to their handling of the case" (p. 61). Significantly, in the context of architectural practice reflection-in-action would be fueled by *feedback from abstracted representations* of a design (typically diagrams, drawings, and models) during the project phases of programming, schematic, development, and construction documents. Reflection-on-action, following action-present (e.g., the project scope), would thus be promoted by *unexpected outcomes of building use* (e.g., from post-occupancy evaluation). This distinction between reflection-in-action and reflection-on is unclear, in part, because Schön used an educational setting to explain his concepts.

What distinguishes reflection-in-action from knowing-in-action?
Schön also muddies the distinction between knowing-in-action and reflection in action. He describes different reflective processes during reflection-in-action, calling them different *stances*: "involvement" and "detachment" (p. 102). *Involvement* refers to an intuitive process of "thinking on your feet" (p. 54), when people "find the groove" and have a "feel for" a situation, making "on-the-spot adjustments" to their performance (p. 55). *Detachment* is an explicit assessment of a situation that "hinges on the experience of surprise" (p. 56). It is a way to rectify 'bad fit' by surfacing tacit understandings that may have led to the situation, and then developing new intentions ('appreciations') toward it – often by reframing the problem. He fails to explain differences (if any) between the *involvement* stance of reflection-in-action and knowing-in-action – which he describes as intuitive knowing "implicit in our patterns of action and in our feel for the stuff with which we are dealing... (p. 49).

Is it possible to 'reflect' during intuitive activities?
Although he described both intuitive and explicit processes of reflection-in-action, Schön acknowledged reflection will interfere with action (pp. 277-279). He

In the context of architectural practice reflection-in-action would be fueled by *feedback from abstracted representations* of a design.

Reflection-on-action, following action-present, would thus be promoted by *unexpected outcomes of building use*.

asserted, however, that this apparent contradiction is due to misunderstanding that thinking must be separate from doing–and because there are different types of reflection (involvement versus detachment). He failed to resolve this apparent conflict between intuitive doing and reflecting, stating that even if reflecting-while-doing is feasible, it could be dangerous (p. 277). He suggested instead that thinking and doing are complementary processes that build off of each other; "doing extends thinking in the tests, moves, and probes of experimental action, and reflection feeds on doing and its results" (p. 280). This explanation seems to contradict his examples of (involvement-stance) reflection during improvisational performances, such as while pitching a baseball or playing jazz (p. 55).

4.2. Evolving design-rationale problem: Socio-cultural context
What role does socio-cultural context play in abilities to critically reflect 'in' and 'on' actions?
Schön acknowledged designers bring different perspectives to their designs through implicit "values, goals, purposes, and interests" (p. 17). He suggested feedback from actions promotes opportunities to surface and challenge tacit assumptions by reflecting 'in' and 'on' action. Designers' abilities to perceive affordances for reflection, however, are limited by their learned bodily behaviors (e.g., skills/training), domain knowledge, norms of practice, and shared organizational expectations. Schön considered the role of organizational structures in promoting or inhibiting reflection (p. 242), but neglected to consider how organizational culture shapes perception and ways people resist, violate, or transform shared expectations of their design firm or general field of practice (Webster, 2008).

5. Extending Schön's epistemology
Although Schön captured the physically-situated nature of design-thinking, he left the concept of reflection vague–perhaps intentionally so, since his purpose was to free design from the limits of technical rationality. For a more complete epistemology of architectural practice, the limitations discussed in the prior section must be addressed. To that end, a conceptual framework is proposed here that extends Schön's theory in two ways:

1. It proposes clearer definitions for different forms of reflection, by illustrating cognitive processes involved.
2. It suggests how to incorporate socio-cultural contexts of reflection within its purpose for evolving design-rationale and organizational transformation.

5.1. Reflection to evolve creativity

> You stop thinking,
> you just look at the piece of foam and you try to make it beautiful,
> you cut.
> Sometimes you slice something,
> and then another thing,
>
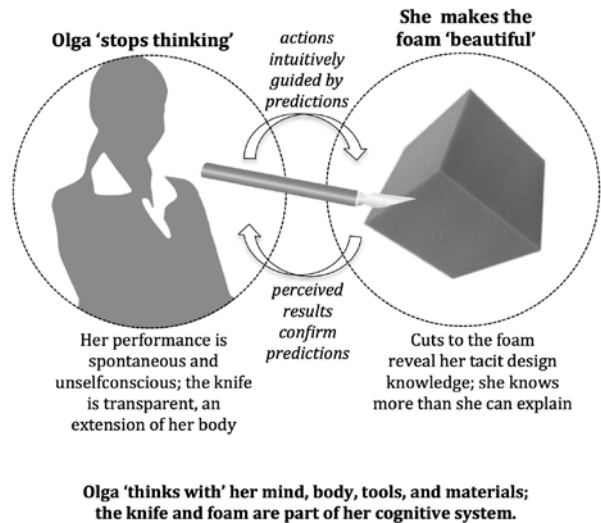> and ou-u-u-p-p-p something is there.
> And you think:
> "Oh, that's interesting;" it's there. (Yaneva, 2009, p. 57)

This quote from Yaneva's (2009) study of the Office for Metropolitan Architecture (OMA) serves to illustrate how Schön's concepts of knowing-in-action and reflection-in-action might be clarified to more accurately represent design cognition during action-present., In it Olga, an architect, explains how she comes up with 'a smart idea.' She describes involvement (first part) and detachment (second part) stances similar to Schön's reflection-in-action. However, Olga does not stop-and-think when cutting the foam to reflect on each outcome of an action; instead she 'stop(s) thinking.' Each cut is intuitively confirmed to align with her intentions until she realizes 'a bad fit' and is happily surprised by the outcome. Surprise gives her pause to assess (think about) the opportunities in this unexpected outcome. Before her moment of surprise, Olga is perceiving-in-action, a process of tacit error-detection. Her knowing is *in* her actions and she perceives by doing. The 'involvement' Olga describes sounds like Schön's knowing-in-action; she intuitively knows what is good (predicted) and what is 'bad fit' (unpredicted). Each action is guided by prior embodied, foam-cutting experiences and perceived affordances shaped by prior practice, personal values, and the workplace socio-cultural environment (Fig. 4).
Olga's creativity evolves through action, intuitively "recogniz[ing] bad fit within a familiar pattern"

(Schön 1983, pp. 52-53). She describes this feeling (*ou-u-u-p-p-p something is there*), which triggers a semi-detached stance (*And you think*) for reflecting-in-action (*"Oh, that's interesting;" it's there*). Olga's reflection is valuative and situated in action; she might rotate the foam to help perceive opportunities in the model. She becomes aware of her thinking (*it is explicit*). Yet valuation remains guided by intuitive knowledge embedded in the foam (it's there). This is not critical reflection; Olga may ignore some problematic features or personal assumptions in order to help identify unforeseen affordances in the design. When analyzed with respect to knowledge from cognitive science, examples of architectural practice like Olga's and Quist's help clarify Schön's knowing-in-action and reflection-in-action constructs. Theoretical perspectives of enactive cognition and predictive mind suggest Olga is predictively-perceiving-in-action when involved in foam-cutting; she *anticipates* the outcomes of each action during her performance. Schön's 'involvement' stance, therefore, may more accurately describe knowing-in-action than reflec-

Fig. 4 - Knowing-in-Action. An embodied, sensorimotor, intuitive, error-detection process where understanding is constituted through interactions with objects in the environment.

Olga 'stops thinking'   actions intuitively guided by predictions   She makes the foam 'beautiful'

Her performance is spontaneous and unselfconscious; the knife is transparent, an extension of her body

perceived results confirm predictions

Cuts to the foam reveal her tacit design knowledge; she knows more than she can explain

Olga 'thinks with' her mind, body, tools, and materials; the knife and foam are part of her cognitive system.

tion-in-action, because it appears guided by intuitive prediction/error-detection processes as opposed to reflection. Reflection-in-action is conceptually clearer when limited to the (semi) 'detached' stance and explicit process of valuative reflection. In practice

these two complementary processes often appear intertwined (e.g., Quist's artistry example in Table 1), particularly as professionals develop artistry, expertise in evolving creative exploration by moving fluidly between involvement and detachment (Fig. 5).

5.2. Reflection to evolve design-rationale and practice
Schön claimed practitioners acquire expertise by

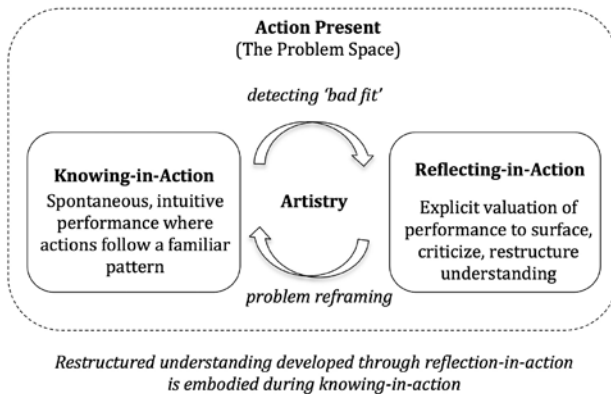Restructured understanding developed through reflection-in-action is embodied during knowing-in-action

Fig. 5 - Artistry. Design professionals fluidly move between the complementary processes of knowing-in-action and refection-in-action to evolve creativity through intuitive experimentation, error detection, valuative reflection, and problem reframing.

evolving design-rationale through reflection on-action and on-practice. Reflection-on-action helps a practitioner develop specialization–the ability to more accurately predict outcomes of intuitive actions. Reflection-on-practice, however, is crucial for avoiding the pitfalls of specialization: narrow vision and replicating patterns of error (ivi, pp. 60-61). Despite arguing their importance, Schön gave little attention to how these processes are promoted in professional practice or what factors they involve. Given what we know about how learning is socially (as well as physically) situated, the importance of organizational and disciplinary culture should be accounted for in epistemology of architectural practice.

First, the role of critique must be considered with respect to project team and firm (design business). Critique is central to evolving design-rationale because reasoned opinions of other people about design products or actions can trigger reflection-in-action or reflection-on-action (Fischer *et al.*, 1993). Schön simplified the critique interactions between Quist and Petra, focusing on Quist's role as expert in modeling reflective practice. Schön's critics argue he ignored power dynamics, warning that Quist imposes his values and

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5 - Changing
demographics of
the architecture
student influence
firm culture and
design-rationale,
for example see
Hawthornes (2017)
article discussing
democratization
of the profession
and the citizen
architect.

6 - See for example,
Yeneva's (2009)
study finding
model-building
with blue foam is
integral to OMA's
design-thinking
culture when
architects struggled
to 'think' without
it during 'no-foam
month'.

Professional design
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action.

design philosophy when mentoring Petra (Mewburn, 2012; Webster, 2008). Similar power dynamics occur in professional teams, where interns might work in collaboration with licensed project architects or firm partners. Further, Mewburn (2012) points out Schön ignored instances when Petra questioned Quist's methodologies. In so doing, Schön missed an opportunity to explore how feedback from others (including novices) can help experts overcome pitfalls of specialization by engendering reflection.[5] Professional design practice is situated in the socio-physical context of a firm, which affects employee's values and philosophies along with available tools, materials, and methodologies they use to think-in-action[6]. The design team typically includes members from inside and outside the firm, including allied professionals (engineers and contractors) and building stakeholders holding different values, philosophies, skills, and methodologies. Feedback from various forms of critique (e.g., novice, expert, cross-disciplinary) and methods of ideation/visualization (e.g., diagrams, drawings, models, etc.) help professionals evolve design-rationale, such as by recognizing tacit repetition of ineffective or problematic design patterns. Second, the role of feedback from implementation and use is essential for a more complete epistemology of architectural practice. Schön's example of reflective practice involved the architectural studio where students worked on simulated projects that were never built or used by occupants. Direct feedback from design use is necessary for making salient to the designer unexpected outcomes of the postmortem design project, triggering reflection-on-action (McCall, 2013). Critical reflexivity helps the designer evolve design-rationale by surfacing underlying assumptions, reframing problems, and developing new theories of action that may be applied to future design situations. Without feedback from building use there is often insufficient stimulus to effectively promote critical reflexivity (Malinin,Cunningham, 2014). This suggests the ability to evolve design-rationale rests heavily on effectiveness of post-occupancy evaluation (POE) processes to elucidate expected and unexpected outcomes of a building design. Firm organizational culture, however, determines if and how POE's are conducted, including what information might be considered valuable and whether affordances revealed by POE's are perceived or actualized to evolve design-rationale.

Finally, a more complete epistemology must consider how architectural practice evolves within the firm and discipline as a whole. Certainly critique and POE processes play a role, however these typically evoke incremental changes. If we consider 'cultures of practice' are shaped by domain knowledge/skills and organizational norms, methods, and procedures, then reflection-on-practice might best be promoted through *feedback from outside that culture*. For example, transformational practices like Universal Design or Biomimicry are responses to disruptive pressures from outside the field to prioritize accessibility and sustainability in architectural solutions. Disruptive technologies are also common triggers for reflection-on-practice; they may help curtail unproductive group-think arising through shared knowing-in-practice, inviting organizational transformation (Malinin *et al.*, 2016). For example, building information model (BIM), 3d printing, virtual and augmented reality (VR/AR) are a few technologies impacting design practices today. Paradigm shifts are often caused by external disruptions that challenge assumptions, methodologies, or philosophies within a community of practice (Crilly, 2010; Kuhn, 1996). Disruptions trigger reflection-on-practice by inciting practitioners to re-examine previously established disciplinary knowledge. After a period of resistance (or critique), disruptive pressures may ultimately yield transformation of disciplinary values, philosophies and methodologies.

The central theme underlying reflective practice constructs is the importance of feedback – from materials (e.g., products, tools, and technologies) and critique – in promoting reflection, helping the designer 'surface uncertainty' to evolve thinking about complex problems.

- For knowing-in-action, *feedback confirms intentions* (predictions), helping the practitioner maintain attention by responding to new sensory information in the situation.
- Reflection-in-action r*elies on the designers' perception of unexpected feedback* from actions to detect and remedy 'bad fit'
- Reflection-on-action *hinges on feedback from implementation and use* (i.e., critique external to the

The role of feedback from implementation and use is essential for a more complete epistemology of architectural practice.

firm) to stimulate critical reflexivity and evolve design-rationale.

• Reflection-on-practice is *triggered by external disruptions* to established assumptions, methodologies, values or philosophies within a practice community and promotes new paradigms.

Figure 6 provides a conceptual sketch, extending Schön's epistemology of practice with the ideas proposed in this section, as a step toward defining a more complete picture of how design-thinking knowledge is constructed and evolved through architectural practice.

Fig. 6 - Extending Schön's Reflective Practice Theory.
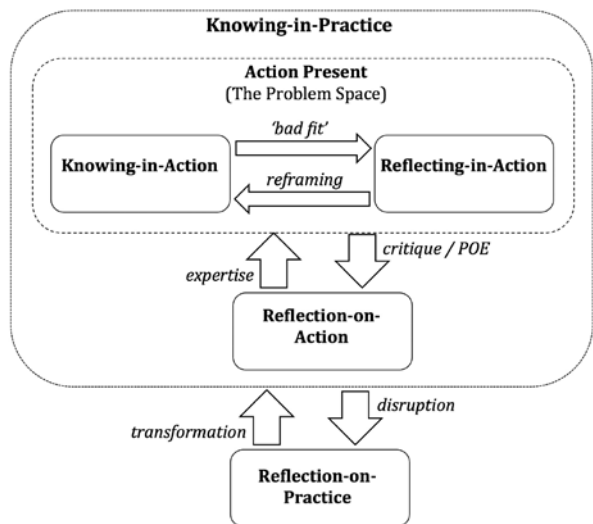
6. Conclusion
In the 1980's Schön examined designers' lived experiences, describing how they exploit affordances in their environments when thinking-in-action to extend cognitive abilities. His epistemology of practice granted credibility to experience and intuitive know-how (artistry) – and introduced concepts foundational to modern theories of embodied, embedded, and enactive cognition. He explained how designers overcome their natural tendency to fall into patterns of prediction, employing design-thinking to 'surface uncertainty' and perceive unforeseen affordances in problematic situations. Although incomplete, reflective practice theory provides a solid foundation upon which to build a more complete epistemology of architectural

practice. It underscores how architects rely on technologies (non-humans), to promote reflection, thereby improving capabilities for managing complexities of design practice and challenging tacit understandings in ill-defined situations. By extending Schön's theory we may compose a more complete picture of architectural practice, lending legitimacy to it methodologies and the creative value it brings toward solving complex societal problems.

References

Anderson, M.L. (2003), *Embodied cognition: A field guide,* "Artificial Intelligence", 149 (1), pp. 91-130, DOI: 10.1016/S0004-3702(03)00054-7.

Boud, D., Walker, D. (2002), *Promoting reflection in professional courses: The challenge of context,* in Harrison, R., Reeve, F. (eds), *Supporting Lifelong Learning: Perspectives on Learning,* Hove, East Sussex, Psychology Press.

Clark, A. (2015), *Surfing uncertainty: prediction, action, and the embodied mind,* Oxford - New York, Oxford University Press.

Clark, A. (2008), *Supersizing the mind : embodiment, action, and cognitive extension,* Oxford - New York, Oxford University Press.

Cohen, L., Wilkinson, A., Arnold, J., Finn, R. (2005), *Remember I'm the bloody architect!,* "Architects, organizations and discourses of profession - Work Employ", n. 19, pp. 775-796.

Crilly, N. (2010), *The structure of design revolutions: Kuhnian paradigm shifts in creative problem solving,* "Design Issues", 26 (1), pp. 54-66.

Cross, N. (2007), *Forty years of design research,* "Design Studies", n. 28, pp. 1-4, DOI: 10.1016/j.destud.2006.11.004.

Ekebergh, M. (2007), *Lifeworld... based reflection and learning: a contribution to the reflective practice in nursing and nursing education,* "Reflective Practice", n. 8, pp. 331-343, DOI: 10.1080/14623940701424835.

Eraut, M. (2004), *The practice of reflection,* "Learning in Health and Social Care", 3 (2), pp. 47-52, DOI: 10.1111/j.1473-6861.2004.00066.x.

Fischer, G., Nakakoji, K. *et al.* (1993), *Embedding critics in design environments,* "The Knowledge Engineering Review", 8 (4), pp. 285-307, DOI: 10.1017/S026988890000031X.

Gallagher, S. (2009), *Philosophical antecedents of situated cognition,* in Robbins, P., Aydede, M. (eds), *The Cambridge Handbook of Situated Cognition,* Cambridge - New York, Cambridge University Press.

Garbarini, F., Adenzato, M. (2004), *At the root of embodied cognition: Cognitive science meets neurophysiology,* "Brain and Cognition", 56 (1), pp. 100-106, DOI: 10.1016/j.bandc.2004.06.003.

Reflective practice theory provides a solid foundation upon which to build a more complete epistemology of architectural practice.

Gibson, J.J. (1977), *The theory of affordances*, in Shaw, R., Bransford, J. (eds), *Perceiving, Acting, and Knowing: Toward an Ecological Psychology*, Hillsdale, Lawrence Erlbaum Associates, distributed by the Halsted Press Division, Wiley, pp. 67-82.

Hawthorne, C. (2017), *Reinventing architectural education*, "Architect - The journal of the american institute of architects", http://www.architectmagazine.com/practice/reinventing-architectural-education_o, accessed on 05 January 2018.

Hébert, C. (2015), *Knowing and/or experiencing: a critical examination of the reflective models of John Dewey and Donald Schön*, "Reflective Practice", 16 (3), pp. 361-371, DOI: 10.1080/14623943.2015.1023281.

Hutchins, E. (1995), *Cognition in the wild*, Cambridge, The MIT Press.

Johansson-Sköldberg, U., Woodilla, J., Çetinkaya, M. (2013), *Design thinking: past, present and possible futures*, "Creative and Innovation Management", 22 (2), pp. 121-146, DOI: 10.1111/caim.12023.

Kuhn, T.S. (1996 [1962]), *The structure of scientific revolutions*, Chicago, University of Chicago Press.

Malinin, L. (2016), *Creative Practices Embodied, Embedded, and Enacted in Architectural Settings: Toward an Ecological Model of Creativity*, "Frontiers in Psycholgy", 6, art. 1978, pp. 1-19, DOI: 10.3389/fpsyg.2015.01978

Malinin, L.H., Cunningham, D.S. (2014), *'Usage-centered' design practice: Extending Schön's Reflective Practice Theory to inform building design and evaluation processes*, paper presented at the Fifth International Conference on the Constructed Environment, Philadelphia, October 16-17, 2014.

Malinin, L.H., Williams, A., Leigh, K. (2016), *The psycho-spatial dynamics of workplace designs for creative disruption*, in De Filippi, R., Rieple, A., Wikström, P. (eds), *International Perspectives on Business Innovation and Disruption in Design*, Northampton, Edward Elgar.

McCall, R. (2013), *Critical conversations: Feedback as a stimulus to creativity in software design*, in Carroll, J.M. (ed.), *Creativity and Rationale, Human-Computer Interaction Series*, London, Springer, pp. 11-40.

Mewburn, I. (2012), *Lost in translation: Reconsidering reflective practice and design studio pedagogy*, "Arts and Humanities in Higher Education", 11 (4), pp. 363-379, DOI: 10.1177/1474022210393912.

Robbins, P., Aydede, M. (2009), *A short primer on situated cognition*, in Robbins, P., Aydede, M. (eds), *The Cambridge Handbook of Situated Cognition*, Cambridge, Cambridge University Press, pp. 3-10.

Schön, D. (1983), *The reflective practitioner: How professionals think in action*, New York, Basic Books.

Simon, H.A. (1996 [1968]), *The sciences of the artificial*, Cambridge, The MIT Press.

Thompson, E., Varela, F.J. (2001), *Radical embodiment: neural dynamics and consciousness*, "Trends in Cognitive Science", 5 (10), pp. 418-425, DOI: 10.1016/S1364-6613(00)01750-2.

Varela, F., Thompson, E., Rosch, E. (1991), *The embodied mind: cognitive science and human experience*, Cambridge, The MIT Press.

Ward, D., Stapleton, M. (2012), *Es are good: Cognition as enacted, embodied, embedded, affective, and extended*, in Paglieri, F. (ed.), *Consciousness in Interaction: The Role of the Natural and Social Context in Shaping Consciousness*, Philadelphia, Benjamins.

Webster, H. (2008), *Architectural education after schön: cracks, blurs, boundaries and beyond*, "Journal for Education in the Built Environment", 3 (2), pp. 63-74, DOI: 10.11120/jebe.2008.03020063.

Wilson, M. (2002), *Six views of embodied cognition*, "Psychonomic Bulletin & Review", 9 (4), pp. 625-636, DOI: 10.3758/BF03196322

Yaneva, A. (2009), *Made by the Office for Metropolitan Architecture: An ethnography of design*, Rotterdam, 010 Publishers.