Expert Knowledge or Creative Spark? Predicaments in Design Education

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What is the difference between 'sound' and 'creative' design? What knowledge qualifies a designer as an expert? Is creativity included in the baggage the expert designer is expected to posses? Do educational settings have strategies for maximizing the expert/creative design behavior of their graduates? If so, are instructional strategies that cater to the one also appropriate for the enhancement of the other?
In this paper we analyze empirical data from instructional encounters in the architectural studio according to itemized models of knowledge that is expected to be transmitted to students through studio instruction. We find that it is rare for instructors to explicitly state or prescribe specific design goals or to refer to knowledge categories to be attended to, that would eventually contribute to design expertise. Both students and instructors expect students to define their own design goals, emphasize clear concepts ("leading ideas"), and pay much attention to spatial composition. An implicit underlying premise calls for self-expression and rewards creative behavior.

When architecture became a separate profession during the Renaissance, permission to practice was granted on the basis of well-defined qualifications which represented expertise in several aspects of design and construction. The first known legal disputes concerning alleged breeches of terms associated with the right to design go back to the 16th century. Such was, for example, the legal case of van der Borch against van Noort, tried in Utrecht in 1542, in which the former complained to the court that the latter practiced design without the necessary qualifications (Schneider 2000). Remaining records of that case contain evidence of similar law suits at an even earlier date (ibid.). Expertise embodied in qualifications had always been the basis of all formal professional certification and licensing that persists as the norm, in various versions, almost everywhere. Schools of architecture are therefore the place where aspiring architects are meant to acquire the knowledge and skills that eventually lead to the required expertise and credentials. The studio has always been the spot where expertise was meant to be forged, where knowledge was to be assimilated in practice, where experience was to be gained under the guidance of the studio master, or instructor.

As a learning setting for the acquisition of professional expertise, the architectural studio appears to be an ideal venue. Schön (1985) referred to the studio as an exemplar for professional training, and Glaser (1996)

recommends a learning environment that is highly compatible with the studio as we conceptualize it (ibid., p 305-6):

> For the development of expertise, knowledge must be acquired in such a way that it is highly connected and articulated, so that inference and reasoning are enabled as is access to procedural actions… an environment for learning [is recommended] where there are opportunities for problem solving, analogy making, extended inferencing, interpretation, and working in unfamiliar environments requiring transfer."

Is the studio really as ideal a setting for the acquisition of design expertise as Schön, and by extension also Glaser, lead us to believe? Following the changes that the discipline and the profession of architecture have undergone during the 20th century, which were accelerated during its last quarter, the culture of the studio in architectural schools has also experienced profound transformations. Innovation and creativity have significantly gained in currency and have become a primary expectation from students' work. In juries, the assessment of projects often hinges on their demonstrated originality and "fresh ideas" as perceived by jurors and critics, rudimentary and underdeveloped as they might be. At the same time, expertise based on "specialized skill or technical knowledge"[1] continues of course to be expected by employers, clients, authorities, and many educationalists, and school officials make every effort to develop curricula that respond to this expectation. A dichotomy between a quest for creativity and an aspiration to attain expertise appears to be inherent in today's architectural studio. Every concerned party would state that the aim of studio education is to enhance students' creative capacities whilst equipping them with such knowledge-bases that prepare them to practice architecture with confidence. In reality, however, there is much tension between the two goals and policy makers and instructors alike often favor one view over the other, at least implicitly. Moreover, it is not unusual for instructors to espouse one vision and to practice another. In the struggle between expertise-oriented and creativity-driven instructional tendencies, the upper hand is with the latter. This state of affairs in the studio is in violation of another prerequisite that Glaser (ibid.) puts forth for the acquision of expertise:

> A fundamental mechanism proposed in early studies of expertise, pattern-based retrieval, reflects the acquisition of well-organized and integrated knowledge that provides a structure for representation that goes beyond surface features.

Based on several studies, Ericsson and Delaney (1998, p 105) assert:

> Across domains, exceptional performances of all types are more correlated with time spent in deliberate efforts to improve than with the amount of experience in activities within the domain.

In this view, expertise entails the expansion of the functional capacity of the expert's working memory system for relevant material. Experts "store potentially useful domain-related information in LTM and index it with specific retrieval cues." (Ibid., p 94). We maintain that in the studio,

therefore, students must be exposed to relevant knowledge, both declarative and procedural, that will enable them to improve their work. This must be done in a variety of ways and the student must be able to understand the causal relationships between knowledge used and the quality of a design solution. We also postulate that 'creativity' cannot be taught; at best it can be identified, encouraged and supported. In contrast knowledge and information of all types can and should be underscored, contextualized, and transmitted in the studio (and elsewhere). Design expertise, then, is seen as the possession of domain-knowledge that can be readily retrieved, applied to specific design problems, and implemented in their solution. Our aim in this paper is to inspect how studio instructors understand their task in this respect. It is not their theories we are interested in; rather, we explore their instructional behavior and deduce their attitudes from their actions.

1. Models of design knowledge

The domain knowledge an architect is expected to possess must reflect the factors that are important for the appropriateness of a design solution to the fulfillment of the needs for which the design is carried out. Many researchers touched upon such factors, especially during the "design methods" era, by way of explaining and illuminating them or as a starting point for design methodologies. Let us first look at a few examples dealing with declarative knowledge.

In his seminal *House form and culture*, Amos Rapoport (1969) claimed that the form of houses (the study pertains to vernacular buildings) is determined primarily by socio-cultural factors, with climate and technical matters as modifying factors. He listed six major groups of categories that partake in those factors: Climate, materials, construction and technology, site, economics, and religion. For the most part these factors are believed to be valid for contemporary professionally-designed houses as well. Hillier and Leaman (1972) wished to re-define an agenda for research in architecture, and talked about four factors that invariably modify design decisions: Climate, human behavior, resources and culture. Later, Goldschmidt (1983) described four imperatives that must always be taken into account in design considerations. They are: functional needs, cultural heritage, climate and site characteristics, and available resources. Heath (1986) developed a design method by which the various stages of the design process follow four independent but interlinked environment-behavior inputs. Those inputs concern issues of site, technology, values and activities (of occupants of the prospective buildings). We see that in all of these examples the categories of knowledge are quite similar. Heath's values, for example, fall into Rapoport's socio-cultural factors, and his activities are almost synonymous with Hillier and Leaman's behavior and with Goldschmidt's functional needs.

The categories we have briefly surveyed above stand for declarative knowledge that the designer is expected to already possess at the outset, or gain in the process of designing. They do not refer to procedural knowledge, or skills the designer must own if he or she is to conduct a successful design process.[2] Skills and procedural knowledge are much

more difficult to define, yet they are crucial in professional performance and certainly in expertise in any field. Design methodologists saw skills as the mastery of design methods, which they thought should and could be developed scientifically. An example is Broadbent's comprehensive work (1973), listing "problem-solving techniques" and "creative techniques" that fall within "four distinct ways of generating three-dimensional form" (ibid., p 25). He refers to them as pragmatic, iconic, analogic and canonic design. Each requires the use of different types of information which the architect must be able to access, and to do so methods (i.e. techniques) must be developed expressly, or adapted from other fields (e.g., mathematical methods, psycho-analytical methods, interaction methods, and more). Broadbent also stresses the need to learn about basic human and social needs (declarative knowledge).

Based on his observation of design processes and conversations with designers, Donald Schön, an outsider to the field, listed what he called *normative design domains* (Schön 1983). These domains are of both the declarative and procedural varieties and include, in the order listed by Schön: Program/use, siting, building elements, organization of space, form, structure/technology and scale, cost, building character, precedent, representation, and explanation. Several of these domains resonate with what we have seen in the studies reported above, namely: program/use, organization of space; siting; building elements, structure/technology; cost; form, precedent (there is no mention of climate). However, scale (at least in a certain sense of the term), representation, and explanation are new items that fit less easily into the categories of knowledge we have encountered earlier. The two latter domains can clearly be defined as design skills.

Needless to say, there are many other studies that touch on similar issues, some of the same period, some more recent (yet others go back to Vitruvius). The studies reported here, diverse in nature, give us a sufficiently representative picture of the kinds of knowledge that researchers in architecture have defined as necessary, if not sufficient, for competent practice in the field. Table 1 below is a summary of the categories of knowledge in architectural design reported above.

So far we have heard the voice of academe. The profession itself, i.e. those who practice it, voices its credo through the skills it is looking for in young graduates who are seeking employment. A study conducted in the United States in 1995[3], in which several hundred architecture firms took part, yielded the following list of skills that the firms valued in graduates, in order of importance: CAD (fluency in the use of Computer Aided Design software), construction detailing, design, graphic presentation, project management, construction administration, written communication, speaking skills, and office management. In addition to reflecting the state of the art (we doubt the scene has changed much since the mid-90s), this list adds managerial skills to our previous categories of procedural knowledge.

Table 1 - Categories of knowledge in architectural design (design literature)

Knowledge Category		Rapoport 1969	Hillier & Leaman 1972	Goldschmidt 1983	Heath 1986	Broadbent 1973	Schön 1983
Declarative	Culture, societal concerns	socio-cultural	culture	cultural heritage	values	socio-cultural	precedents, form, building character
	Functional optimization: space, human factors	socio-cultural	behavior	functional needs	activities	ergonomics	program/ use, organization of space, form
	Environment: site, climate	climate, site	climate	climate & site characteristics	site	environmental issues	siting
	Material resources	construction, materials, technology, economics	resources	available resources	technology	—	building elements, structure/ technology, cost
Procedural	Representation: norms & conventions	—	—	—	—	—	representation
	Communication	—	—	—	—	linguistics	explanation
	Programming					check-lists, operational research etc.	
	Quantifying methods					statistics, optimization	
	Idea-generation					brain-storming	

It is logical to take design expertise as hinging on knowledge in the categories we extracted from the literature. Therefore, we must expect schools to include them in their curricula. In addition to domain specific courses in the various categories, we can, and should, expect the studio to be an environment in which such knowledge is being transferred to students in various ways. Let us now go to the studio and look at its quotidian work, to see whether our expectations are fulfilled.

2. Studio critiques

The studio is a unique setting which, while preparing students to practice the *profession* of architecture, is also a locus of discourse on, and of, the *field* of architecture.

According to Stevens (1998) there is much confusion between the *profession* of architecture and the *field* of architecture. In business the two entail very different patterns of practice in terms of motivation, daily activity and type of compensation. Practitioners, according to this view, belong to dissimilar sub-disciplines. The two facets of architecture are reflected in the studio, where students at various stages of their studies may expect instructors to contribute more to specific areas of expertise *or* to architectural discourse (Wilkin 2000). The latter is conceived as a privileged area, and architects who are associated with it belong to a narrow elite group. One of the hallmarks of the work produced by this elite squadron is outstanding creativity and their work must be,

accordingly, innovative and ground breaking. Instructors are not requested to position themselves on what Stevens (1998) calls the continuum from workaday practice to activity in a sphere of symbolism, nor do most schools set specific educational goals in this respect. Instruction is therefore based on the intuitive behavior of instructors and those who select them for the job.

The desk 'crit' (critique) is the basic, most fundamental component of studio instruction in all schools of architecture (e.g., Belkis 2000, Cuff 1991, Goldschmidt 2002, Uluo_lu 2000, Wendler and Rogers 1995). During many cycles of such crits instructors discuss with students a large number of issues, as may be relevant to projects at any state of their development. The assumption is that in the long run students absorb knowledge as well as attitudes and values that are transferred through desk crits (and reviews) into their knowledge structures. The entire studio system is based on this assumption, with the belief that knowledge is best assimilated when it is offered precisely when the learner needs it. It is not easy to monitor transfer of knowledge, which may be explicitly recognized only post factum at a later stage in one's development.

The instructor uses multiple strategies in order to transfer to the student the knowledge he or she thinks is appropriate, and expresses attitudes and stances regarding general theoretical and philosophical topics, as part of the prevailing architectural discourse of the culture (or micro culture) in question. Uluo_lu (2000) has listed over a dozen instructional strategies which she calls knowledge transmission moulds. They include interpretation, examples, analogies, and scenarios, but also pedagogic devices like demonstration, description, reminders, evaluation (positive and negative), and more. She did not classify the knowledge transmitted through the instructional strategies and devices into categories of the kind we presented above.

Other classifications are possible, of course. For example, one could look at the elicitation of examples, scenarios or precedents as helping the student develop a repertoire of cases, building types and so on. In parallel one could be building up a 'diagnostic' skill which allows the student-designer to classify a problem into a recognizable problem category, thereby facilitating the retrieval of examples or analogies for the production of an acceptable solution. Thus declarative and procedural knowledge may be inseparable, and the student learns through explicit and implicit knowledge communicated by the instructor during the desk crit and implemented later. Students learn to generalize and abstract rules from many encounters with similar commentary, but they also learn by singular examples as they understand why they are relevant to what they are trying to do.

For our purpose here we are interested in the balance between the normative knowledge, required for sound practice and expertise, and the messages communicated to students that encourage them to behave creatively, so they would be able to partake in shaping 'elite' work of symbolic significance. In the next section we look at examples of desk

crits which we analyze in order to get a first-hand impression of what is actually transmitted to the student during a typical desk crit.

3. What is transmitted?

A number of desk crits have been taped in design studios at the Technion's Faculty of Architecture and Town Planning (winter 2002-2003). We have chosen to describe three crits, taped in two different second year studios within the same week – in the middle of the first semester, shortly before a mid-term review. The syllabus calls for the design of a small neighborhood. The given site, used in both studios, was in an old and fairly run-down Tel Aviv neighborhood where surrounding buildings are 1-3 stories high. At the existing density the site can accommodate about 20 dwelling units.

Students A and B belonged to the same studio. A, a male student, was described by the instructor as "difficult", someone who does not listen, who perceives the crit as a confrontation in which he struggles to 'win'. B, a female, was described as a regular student, not a very strong designer, with whom there are no interaction problems. Student C, a female, belonged to the second studio. The instructor in this studio was an older and more experienced practitioner, but had approximately the same amount of teaching experience as the first instructor. Student C felt 'stuck' when she arrived in the studio that day, and thought the crit had helped her get 'unstuck' in some measure.

The transcribed protocols of the three crits, which we take to be representative of desk crits at this stage of design education, are the subject of a brief analysis of the contents of what the instructor says in the desk crit interaction with each student. We coded numbered protocol lines according to the knowledge categories in Table 1[4]. Since these are not regular design sessions but educational settings in which instructors try to advance their students in every possible way, we decided to add categories that were not included in Table 1 but were powerfully evident in the protocols. The first is formal composition (two and three dimensions). In addition we identified verbalizations that addressed issues of design methodology (procedures) that do not match those elicited by Broadbent (Table 1), and concept clarification. A third new category we have included, under a separate title ("what do you want"), is one in which the instructor probes the student in order to have him or her spell out what their design goals and wishes are. We found it unnecessary to draw a line between categories of declarative and procedural knowledge, as we have addressed issues that were raised in the crits rather than explicit modules of knowledge. The results of this analysis are given in Table 2.

Desk crits are obviously context and actor dependent. We do not expect "normative behavior" or compare findings with pre-established conventions. Students' personalities, their needs, and their abilities to benefit from crits vary considerably. Instructors have different propensities both in terms of their personal qualities and in terms of the values they subscribe to and their professional knowledge. Above all,

different design problems invite different types of inputs and additionally, the educational setting may call for emphasis on some issues at the expense of others. The stage in which a project is at a given moment in time is also of relevance, and what was not mentioned in one desk crit may well have been talked about in the previous crit. Having voiced the evident qualifications, we still learn a lot from the feedback provided by this random sampling of desk crits, because it gives us an approximation of the state of the art in one mainstream school of architecture.

Table 2 - Desk crit: instructor's input

	Student A's crit	Student B's crit	Student C's crit
No. of verbalizations [instructor = student]	114	66	69
No. of Protocol lines Instructor/Student	173/217 44%/56%	159/87 65%/35%	225/145 61%/39%
Longest instructor's verbalization (lines)	7	13	27
Categories of issues/knowledge visited			
Social*	27	21	2
Functional	24	10	25
Site**	--	--	14
Technology	2	--	--
Representation	--	1	54
Communication	--	--	
Methodology, concept clarification	25	51	21
Formal composition	7	30	76
"What do you want"	36	13	2
Other***	52	33	31

* No reference was found to any general cultural issues; no precedents or examples were elicited.

** No reference was found to any climatic issues.

*** Many of the 'other' verbalizations are clarification questions, technicalities, and short exclamations like "aha", "yes", "no" and the like.

Let us remind ourselves that the desk crits we scrutinize here were offered in preparation for an upcoming mid-term review, in which the entire project was to be presented. It is not unreasonable to expect, then, that a crit at this point would 'cover' a fairly standard 'checklist' of relevant issues. Therefore it is surprising to find that the standard categories of knowledge in architectural practice, as listed in section 2 above, are not rigorously apparent in the crits. When summing up these categories (in Table 2: social, functional, site, technology, representation and communication) we count 180 verbalizations, which represents 40.8% of the total number of instructors' coded verbalizations (a total of 441, excluding 'other' verbalizations). This percentage is only somewhat larger than that of the combined sum of verbalizations in the categories of methodology and concept clarification and "what do you want", which amounts to 33.6%. The category of formal composition is a close competitor at 25.6%.

Of particular interest is the fact that some categories are all but missing altogether, like technology and site concerns (climate is totally absent and site considerations are brought up only in student C's crit). It is surprising because the small site the students designed on is surrounded by a an existing fabric of housing that has a distinct character and one may expect the novice designers to be seriously preoccupied with the relationship between their designs and that fabric. That the instructors fail to raise the issue, if it is not brought up by the students, is curious, and indeed sketches reveal that the students' designs are often independent enclaves that barely react to the urban reality all around. Likewise, the hot climate of Tel Aviv has inspired, over the years, certain rules of thumb regarding optimal orientation for dwelling units, which are not observed in these students' projects. It seems that the current crop of students and instructors alike prefers to rely on air-conditioning alone.

Matters of function which, in this project, pertain mainly to layouts of dwelling units, access to them, and relations among them (questions of parking were deliberately omitted), receive moderate attention at best. It is possible that at this point in the development of the project not much was expected. Instructor 2 notes that student C is behind in this respect: "… perhaps this plan does not know precisely where the rooms are located or how exactly the relationships within the unit [are to be], or how it is composed. This too is one of the things you must do urgently..." Instructor 1 asks student B: "How will he [tenant] get here? Will he enter through here?" But in general, as confirmed by the students' sketches, the instructors seem to be content with very rudimentary designs in which dwelling units are only roughly outlined. In contrast, the volumetric relations among those boxes, and their expected elevations, receive quite a lot of attention (in the formal composition category). Student A, for example, is asked: "So visually you want to distinguish between something higher and something lower…" A similar concern is brought up in Student C's crit, where formal composition occupies center-stage: "…and also they are like two different volumes because here it actually gives the feeling of a composition of different volumes at different heights."

Social concerns are brought up primarily by instructor 1, but always at a very general level as in this comment to student A: "… so try to define what relations among neighbors, or social [relations] let's call them, if you want. What are you trying to achieve? What would you like... what kind of relations would you like to see happening in this site." This comment is symptomatic in that it asks the student to determine what kinds of relations he would like to see. Not a word is said about the tenants: who could they be? What are some of their characteristics and needs? What patterns of relations can be expected among them as a function of who they are and how can the designer best cater to those patterns? These unasked questions lead us to realize that in these crits, the designers also write the plot. They are to shape their design solutions exclusively after their own desires. The instructors seem to say: tell me what you want and I will help you get there. What the designer wants is not to be questioned, or evaluated against hard knowledge, but in terms of the exercise is accepted a priori. Instructor 1 keeps telling student A: " And the question

[is], you must determine what you want, anyway…" And student B is asked: "Let me ask you a question. How do you want the rest of the neighborhood to be involved here?" and a little later the instructor explains: "… Because according to what you will decide you want, you will be able to check whether what you do is right…" Instructor 2 is less persistent but she too asks: "So what do you want here? Do you want some kind of an internal garden? Secret? What?"

Whereas the almost total absence of any reference to materials, technology or other resources may be understandable at the phase in which these projects are, the total absence of any cultural references is surprising. As mentioned above, it is quite possible that such issues were brought up earlier and later in the semester, but the design process, and its instruction, are not linear. We would expect some commentary pertaining to cultural contexts in just about any desk crit, certainly before a mid term review. In these crits there is not a single reference to a precedent or an example of successful infill design (a class that would describe the exercise in question) at the same scale, in Tel Aviv or elsewhere. Since we are looking at three crits only, this could be nothing but a rare coincidence. However, an informal reading of at least half a dozen other second year crits in the same semester (which are not analyzed here) seems to indicate that our findings are rather typical. We must therefore try to understand why this is the case, and we do so in section 4 below.

The students are young, this is only their third semester. It is not long since they mastered the conventions of drawing and they are still hesitant in their representational practices. Instructor 2 is very conscious of this fact and offers explicit and detailed coaching in the use of layered sketches: "… Because one puts a sheet of paper over it and looks at the things and the… more conceptual elements, one lays over with paper and one produces an illustration that is more correct..." Instructor 1 says to student B: "I am saying this according to the model," thereby demonstrating to the student how important representation and the choice of the right media are to an understanding of design intentions. A discussion of communication is absent from these desk crits.

We see that perhaps counter to prior expectations, a typical desk crit does not necessarily lean on knowledge that is, according to the research literature, essential to a good solution, nor does it point to its necessity, or offer ways to acquire it. Not even rules of thumb or quick fixes are brought up. Instead, in choosing their reactions to work their students present to them, instructors appear to be led by the students' personalities, questions and insistent behavior (instructor 1 shies away from a 'fight' with student A, who dominates the conversation in an atypical way; see Table 2), or by their own priorities. Obviously what they tell the student reflects what they believe is important for the student's project to develop in the best possible way. In assessing their verbal behavior, therefore, we do not ask for their opinion but extract their attitude indirectly from their on-line performance as critics.

4. Expertise, how mundane...

Many years ago the author of this paper, then a young architect and design instructor, was the coordinator of the first year design studios at the Technion. There were six or seven studios, and the students were assigned the studios in which they were to work (second semester). Before soon the coordinator was swamped with students' requests to change their studio placement: they were not happy with their assigned instructors and had other preferences. The coordinator inquired what was wrong with the original assignment. One of the 'dissidents' explained: "some instructors teach *function* and others teach *form*. We want to study form!" It turned out that the students were very clear about what they thought was a good design education. Yes, they said, of course we need knowledge in a whole lot of areas (generalized as "function"), but that can wait. We have our entire careers to learn and develop expertise under real-world conditions, we will learn on the job when we work in offices. We are here at school to be creative: this is our chance to be free of "real" constraints; we should be allowed to take off and play exciting games where the sky is the limit. We want our studio instructors to help us attain the most creative feats, and not waist our time with tedious and boring facts.

What was shocking about these young students' behavior was not their attitude but the clarity with which they expressed it. Schools can be very strict about maintaining the highest professional profile, but a lecture about the latest aluminum technology will barely fill a small classroom whereas a lecture by a form-giver like Frank Gehry obliges the police to evacuate the crowds who menace to break the doors of the largest available auditorium, in which not even standing room is left. The field of architecture overpowers the profession of architectural design: this is true in the public eye, the media and the journals, and it is true in schools. Facts about employment prospects are still powerless to transform the heroic myth embedded in our "star system." Design instructors are part of the design culture. Their messages to students are not always explicit, but as in the desk crits we have looked at the tacit message is clear: what the designer wants is the ultimate directive. A leading concept is essential and it should be 'strong' – we do not necessarily bother to check its validity. Good composition is a must – this is where you display your creativity – which is in good currency, beyond all else. Your dwelling units have no layouts? Yes, make a note of it, you should give us some indication. Climate? Materials? Technology? Later, maybe. There is a world around your site, and people who have characteristics and typical behaviors that should be acknowledged, and a culture that this project is part of, maybe even a historical dimension – no, we do not expect you to address all of those issues, lest they might interfere with your quest for a strong concept and a breathtaking interplay of forms and shapes.

Instructors do not have to say this. It is enough to not mention certain things, or to pay more attention to some issues than to others. It is quite possible that they would even be surprised if faced with an analysis of the kind we have carried out. Tacit messages can be stronger than those spilled out in a loud voice. The totally random, run-of-the-mill desk crits

we have analyzed bear evidence of the state of the art. The instructors in question do not ignore knowledge and do not take issue with the need for expertise, but their theory in practice is ruled by the field of architecture, not by the profession. Students do, of course, take courses in which knowledge is gained in all categories we are concerned with. But the studio is expected to be the locus of synthesis and integration of this knowledge into practice, and this is the single most important reason for maintaining the studio 'institution' in a higher education system as we know it today. Success in integrating hard knowledge into the studio does exist, but instances are rare. It is time to re-think our pedagogic means in order to correctly assess what we can– and what we cannot – achieve in the studio.

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Notes

1 Webster's Third International Dictionary, 1976.
2 Finer-grain taxonomies of knowledge do exist, of course. For example, a distinction is often made among factual, semantic, schematic and strategic knowledge (Mayer 1991). However, since knowledge acquired in an undergraduate course is by definition limited, and so is the expertise towards which it leads, we find it unnecessary to go beyond the basic differentiation between declarative and procedural knowledge.
3 Poster published by the Center for the Study of Practice, College of Design, Art, Architecture and Planning, University of Cincinnati, Ohio, 1995.
4 The category of managerial skills referred to in Note 2 above, was not included.

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