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Mapping Research in Landscape Architecture: Balancing Supply of Academic Knowledge and Demand of Professional Practice

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ABSTRACT

With increasing academic research in the past few decades, the knowledge scope of landscape architecture has expanded from traditional focus on aesthetics to a broad range of ecological, cultural and psychological issues. In order to understand how academic research and knowledge expansion may have redefined the practice, two surveys were conducted: one on Council of Educators in Landscape Architecture (CELA) in 2010 (n=230, response rate=43%), and another on the members of American Society of Landscape Architect (ASLA) in 2012 (n=239, sample rate=5%, response rate=31%). Results revealed that the scope of knowledge has expanded since 1970s in areas such as public welfare and personal pleasure. 2) The need for academic research is widely perceived in landscape architecture profession. 3) Academic research primarily generate explanatory knowledge, which has become an important supplement to judgmental design knowledge learned through systematic professional education and construction design knowledge learned through practice. 4) Practitioners believed that they use more logic thinking than intuition in their practice today, and expected more research to facilitate the former than the later.

Keywords: landscape architecture profession, architecture education, knowledge bases, knowledge dimensions

INTRODUCTION

Landscape architects, as found in Fein's (1972) report, used to make their decisions largely based on knowledge and skills developed by practitioners. This type of knowledge is often tacit (Schön, 1983). Professionals rely largely on tacit knowledge and may have difficulties in

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State of the literature

- The scope of landscape architecture practice expanded from aesthetical to ecological issues in the 1970s.
- There was a lack of consensus on what research was and how research may contributed to practice among landscape professionals and educators.
- A potential gap was observed in landscape architecture knowledge between art and science, between practice and research.

Contribution of this paper to the literature

- The scope of landscape architecture practice has expanded with knowledge advancement through research.
- Research need is widely perceived in the whole profession.
- Educators are primarily engaged in research advancing explanatory knowledge, while practitioners expected more research to be done in analytic/empirical knowledge.
- Not enough academic research was done in analytic/empirical design knowledge, which probably led to the profession's frequent consultation to engineers.

knowledge dissemination (Nonaka, 1994) and justifying professional actions, and therefore likely to be vulnerable in intra-profession competitions, which largely define a professional's status today (Abbott, 1988).

In landscape architecture, a need for research to provide evidence-based justifications for practice was addressed largely by educators (Barton, 1961; Brown & Corry, 2011; Fein, 1972; Jost & Lamba, 2010; LaGro, 1999; Miller, 1997; Robinette, 1973; Stappers, Sleeswijk Visser, & Keller, 2014; Zube, 1981). Responding to this need, a research tradition has been emerging in the profession. In the 1980s, half of educators in landscape architecture did not even use research regularly in their work (Palmer, Smardon, & Arany, 1984). Today, 73% of educators keep close track on refereed journal articles, and 87% of them disseminate their research findings via conferences, refereed journals, professional magazines, and etcetera (Chen, Clements, Miller, & Powers, 2011).

Although increasing research behaviors has been observed among educators over time (e.g., Chen et al., 2011; Chenoweth & Chidister, 1983; Milburn & Brown, 2016; Milburn, Brown, & Paine, 2001), there are not enough evidences suggesting that the need for research is widely perceived by practitioners. There is even less evidence in actual use of research findings in practice that suggest an authentic need, except for a few observations on the perceived research need in general (e.g., Palmer et al., 1984) and in some knowledge areas (e.g., Lewis & Clark Research, 1999; Palmer et al., 1984), which are, however, out-of-date.

LITERATURES REVIEW

The perceived gap(s) of knowledge in landscape architecture and related professions were found along the two following dimensions:

Knowledge Dimension I: Intuitive/Holistic and Analytic/Empirical Knowledge

From the academic perspective, there are two different cultures through which knowledge is advanced (Snow, 1959), intuitive/holistic and analytic/empirical, also known also as humanistic and scientific (Guba, 1990), or constructivism and empiricism/positivism/ rationalism (Littlejohn, 1983; Littlejohn & Foss, 2008; Morris, 2006).

There is a widely perceived pro-science culture, in which professions -- even very intuitive-oriented ones such as music composition -- are expected to justify their work using analytic/empirical knowledge (Abbott, 1988). Analytic/empirical researchers search for general laws, usually causal relationships, that hold up in different condition (Littlejohn, 1983; Morris, 2006). They verify possible causal relationships by observing performances with or without a hypothetical cause, either via experiments in which undesired factors are controlled by manipulated conditions, or via statistical analysis of empirical cases in which undesired factors are controlled as statistical errors of a large sample size (Pedhazur & Schmelkin, 1991). Researchers in landscape architecture (e.g., Corner, 1991; Etter, 1963) believed that the dominating analytic/empirical approaches were unable to understand the complex phenomena that together create the landscape, while interpretive intuitive/holistic approaches were more appropriate.

Knowledge Dimension I1: Systems and Design Knowledge

From a perspective of practice, there are also two types of knowledge, systems knowledge and design knowledge. Systems knowledge, or knowledge-that, is cognition-based descriptive knowledge "knowing that something is the case" (Ryle, 1945), or "knowing propositions of a factual nature" (Roland, 1958), such as the discovery of truth and facts. Design knowledge, or knowledge-how, is action-based knowledge: "knowing how to do things" (Ryle, 1945), or "knowing how to perform skills" (Roland, 1958), such as the discovery of ways and methods of doing things.

It is commonly believed that design knowledge is an incomplete form of systems knowledge (Roland, 1958; Ryle, 1945), and therefore researchers usually are encouraged to first gain systems knowledge, and then transfer their findings to design knowledge, which eventually turn into design. In practice, however, only a fraction of knowledge can be transferred. A cost-benefit analysis of research projects was conducted by Department of Defense in 1960s, in which researchers traced all systems knowledge and design knowledge that contributed to 13 major technological inventions after WWII (Sherwin & Isenson, 1967; Vincenti, 1990). Results revealed that only 8% of inventions were triggered by systems knowledge (including both basic and applied research), while 92% were triggered by design knowledge in the form of earlier technological inventions. An analysis of Landscape Journal articles generated similar observations that 45% provided only general systems knowledge, while only 8% provided design knowledge, including design recommendations, considerations or guidelines (Powers & Walker, 2009).

RESEARCH DESIGN

Constructs and measurements

In this study, we defined and measured the following mental constructs as follows:

1) Research

The word research as used in this profession refers to a broad range of activities and products from scientific experiments to library research (Riley, 1990). Despite its vague definition, research is the most often used term in almost all discussions concerning solid knowledge-bases for practice (Barton, 1961; Brown & Corry, 2011; Deming & Swaffield, 2011; Fein, 1972; Jost & Lamba, 2010; Miller, 1997; Zube, 1981), which cannot be fully captured by other terms, such as evidence-based practice (Brown & Corry, 2011; Deming & Swaffield, 2011). Therefore, the word "research" is used in this study, referring to knowledge-generating activities that are done in a rigorous or systematic manner and can lead to the discovery of new information, new understandings or new applications in the field of landscape architecture. Despite that clarifications were made in the survey instructions, different perspectives of research were found in this study, which will be discussed in a separated paper.

2) Research Need and Supply in General

Three indicators were measured in this study: 1) perceived need for research in practice from the practitioners, 2) use of research findings in everyday practice, 3) changes in the knowledge-base of practice over time due to knowledge advancement via research.

Perception of research need was gauged by ASLA members' attitudes towards two statements: "Research is important to landscape architecture practice", and "There is not enough research being done in landscape architecture." Answers were measured on a five-degree Likert scale (strongly agree, agree, neutral, disagree, strongly disagree) with an unsure option available.

Use of research was measured by self-reporting frequencies of using research findings in practice on a four-degree scale (rarely, occasionally, often and very often) with an unsure option available. In order to understand the use of research findings in a comparative sense, the use of two types of thinking (intuition, and logic/reasoning) and that of eight other knowledge sources (common sense, professional experience, client expressed desires, technical standards, professional education, other specialists, historical information, and the work of other landscape architects) were also gauged in this study, with a self-filling "others" available.

A historical perspective of knowledge-bases was measured in four knowledge areas -- aesthetics, ecological needs, public welfare and enjoyment, and comfort and pleasure for the individual -- using a question "To what extent is each of the following central to your understanding of what the practice of landscape architecture should be concerned with?"

adopted from Fein's study (1972). The results collected in this study in 2012 were compared against Fein's results in 1970s to verify changes in knowledge-bases in landscape architecture practice in the past three decades.

3) Dimensions of Knowledge:

Imbalances of knowledge supply and demand were often found in two dimensions -- the design-systems dimension and the intuitive/holistic-analytic/empirical dimension. Therefore, the two dimensions were examined in four knowledge groups of 19 knowledge areas based on LABOK (ASLA, CSLA, CELA, CLARB, & LAAB, 2004) and CELA knowledge areas (Powers & Walker, 2009). The 19 areas covered both design knowledge and systems knowledge, both intuitive/holistic and analytic/empirical knowledge (**Table 1**).

Table 1. The scope of knowledge-bases of landscape architecture practice

Knowledge areas	Descriptions	CELA topics (Powers & Walker, 2009)	LABOK knowledge areas (ASLA et al., 2004)
Judgmental design knowledge (Intuitive/holistic)			
Design theory and design process	Research addressing theories of design including processes, creative thinking, aesthetics, and criticism of existing theories	Design theory	Creativity and process including design theory and problem-solving strategies
Aesthetics	Research addressing theories about aesthetics		Aesthetic principles of design
Representation and communication	Research exploring communication or representation skills, especially graphic ones	Communication and visualization	The roles of visual communication, including photographic and video documentation
			Graphic presentation techniques, systems and symbols
Professional ethics	Knowledge discussing moral standards and ethic codes	Landscape architecture as a profession	Environmental ethics
			Social responsibility in design
The profession of landscape architecture	Knowledge discussing the issues related to the well-being and future of LA profession, such as practice and knowledge	Landscape architecture as a profession	History of landscape architecture and allied professions
Constructional design knowledge (Analytic/empirical)			
Grading and circulation	Research addressing grading design and circulation design		Grading, drainage and storm-water treatment
			Elements of vehicular and pedestrian circulation systems and their design requirements
Construction techniques	Knowledge discussing the construction techniques used in landscape design		Construction equipment and technologies
Plants and materials	Knowledge addressing the characters of plants and materials as well as their usage in landscape design		
Site engineering (lighting, irrigation etc.)	Knowledge discussing design elements such as water, materials and plants, as well as general design issues such as construction technologies		Utility systems
			Irrigation systems
			Lighting systems

Table 1 (continued). The scope of knowledge-bases of landscape architecture practice

Knowledge areas	Descriptions	CELA topics (Powers & Walker, 2009)	LABOK knowledge areas (ASLA et al., 2004)
Social, cultural, historical systems knowledge (Intuitive/holistic)			
History and culture	Research addressing the landscapes, mostly man-made, which have a strong cultural significance developed over time.	History and culture	Social and cultural influence on design
Community planning and design	Knowledge addressing community planning and design as well as public participation		Planning principles including regional community and neighborhood planning
Garden history	Research addressing the evolution of built landscapes over time, usually about a specific landscape or in a specific time frame	History and culture	NA
Public policy	Knowledge discussing policy making and policy analysis.		Government policies and laws that affect the use and development of land
			Political and regulatory approval processes
Environmental systems knowledge (Analytic/empirical)			
Ecology	Research exploring the managerial, planning and design solutions to modify built environment and human activities to work better with nature systems.	Landscape planning and ecology	Natural site condition and ecosystems
			Natural factors such as ecological relationship
			Relationship between human and natural systems
			Conservation of natural resources
			Ecological planning principles
Environmental psychology	Research explaining how landscapes are perceived by human beings, how this information is processed psychologically and responded to externally via behavior.		Visual resource assessment
			Human factors such as behavior, perception, psychological and sensory response
Water resource management	Research addressing drainage and storm-water management as well as water quality control.		Water resource management
			Wetland management
			Floodplain management
Geospatial tools	Research addressing geospatial tools such as GIS.		Geographic coordination system and layout techniques and conventions
Health and landscape	Research addressing the relationship between designed landscape and human health and well-being		Therapeutic aspects of design
Sustainable design	Knowledge addressing sustainable design and its techniques such as green roof and green wall.	Sustainability	Sustainable construction practice

Principal Component Analysis (PCA) was used to verify the existence of the two underlying dimensions based on the frequencies of use in the 19 knowledge areas. PCA has been widely used in studies, such as knowledge mapping (Burley et al., 2009), landscape preferences (Grahn & Stigsdotter, 2010) or complex mental constructs (Milburn et al., 2001), for pattern recognition and dimension reduction. PCA components and their loadings were used to generate a knowledge map of landscape architecture research.

Research supply and demand were analyzed in two knowledge dimensions collected from 19 areas. It was assumed in this study that research findings were primarily produced by educators and utilized by practitioners, which was also assumed to be true by earlier researchers (e.g., Lamba & Graffam, 2011), though questioned by others such as Elizabeth Meyer (Jost & Lamba, 2010). Research areas of interests were measured by an open description on research interest provided by CELA educators in response to the question "How do you describe the research area(s) you are primarily engaged in?" The descriptions were then assigned into the 19 knowledge areas based on coding analysis. The demand for research was measured by both satisfied and unsatisfied demands, which were reflected by existing research use in practice and expected research need, respectively. To gauge exiting research use, ASLA members were asked to provide their current frequencies of research use rated on a five-degree scale (not part of my practice, rarely, occasionally, often and very often) in sub-questions separately. To gauge expected research need, ASLA members were asked to check as much as applied from the 19 knowledge areas in which they "believe additional research would help [their] practice." A self-filling option as "others" was provided in both questions in case that the research demand was not fully captured by the knowledge areas measured.

Data Collection and Sampling

Two online surveys were conducted for data collection via an online survey software called Survey Monkey (http://www.surveymonkey.com). Research demand from practice was collected from sampled American Society of Landscape Architects (ASLA) members (sample rate = 5%). Researchers randomly sampled one of every 20 full or honorary members with valid email addresses listed on ASLA online member directory (accessed on January 2, 2012). A pretest was conducted among six participants including practitioners, faculty members, and ASLA staffs to test the clarity, comprehensiveness and organization of the survey. Questionnaires were successfully sent to 769 randomly sampled ASLA members (excluding five who contacted the researchers and requested to be removed from the survey) on February 14, 2012. Two follow-up reminders were sent to those had not finished they survey on February 23 and March 1. By March 6, 239 responses were collected, which equals a response rate of 31%. Fourteen incomplete responses were excluded from this final tally.

The distribution of participants' age, gender, educational degree, serving organization and job function suggested that the sample was not heavily skewed on any of the background. The sample demographics were comparable to that of the LABOK survey (**Table 2**).

Academic researchers were identified through data collected from the Council of Educators in Landscape Architecture (CELA). Their contact information was obtained from online CELA directory (accessed on April 11, 2010), and was manually verified with faculty lists on university websites and updated to researchers' best knowledge. The questionnaire was successfully sent to 536 CELA educators (excluding six contacting the researchers requesting to be removed from the survey) on April 25, 2010. Two follow-up reminders were sent to those had not finished they survey on May 25 and August 19. By October 31, 230 responses were collected (excluding five incomplete ones), representing a response rate of 43%.

Table 2. Participants' demographics of ASLA survey compared at that of LABOK survey (ASLA et al., 2004)

Demographics	Count	ASLA Survey collected in 2012 n=239 Percent	Count	LABOK Survey collected in 2003 ASLA member n=207 Percent
Gender				
Male	145	61%	162	78%
Female	58	24%	44	21%
Undesignated	36	15%	1	1%
Age				
Under 25	0	0%	1	1%
25 to 34	25	11%	36	17%
35 to 44	40	17%	27	13%
45 to 54	62	26%	56	27%
55 to 65	61	26%	68	33%
over 65	22	9%	19	9%
Undesignated	29	12%	0	0%
Highest Degree				
No degree	7	3%	3	1%
Certificate program	4	2%	2	1%
Bachelor degree (4-5 yrs)	124	52%	111	54%
Masters degree	87	36%	78	38%
Doctoral degree	4	2%	7	3%
Others/ undesignated	13	5%	6	3%
Types of Organization Currently Working in				
Exclusively landscape architecture firm	75	31%	55	27%
Multi-disciplinary firm	78	33%	62	30%
Government	30	13%	54	26%
Education	19	8%	1	1%
Others/ undesignated	37	16%	35	17%
Job Function				
Sole owner	55	23%	38	18%
Partner or stockholder	44	18%	38	18%
Manager/director/department head	33	14%	30	15%
Associate	24	10%	15	7%
Employee	35	15%	34	16%
Faculty member	15	6%	33	16%
Others/ undesignated	33	14%	19	9%

Although this survey generated a lower response rate and a slightly different demographics compared with two earlier mail-based surveys that targeted at the same population (**Table 3**), there was no significant evidence that suggested a biased sample. Gaps are commonly found between response rates of mail-based survey and those of internet-based surveys (Dillman, Smyth, & Christian, 2009; Sheehan, 2001). Compared with other internet-based surveys, 43% was considered a suitable rate (Sheehan, 2001). The 2012 survey showed a higher representation of doctorate holders (35%) compared with that of 1999 (27%), and a

Table 3. Participants' demographics of CELA survey compared at that of two earlier CELA surveys (Chenoweth & Chidister, 1983; Milburn & Brown, 2003)

Demographics	CELA survey collected in 2010 internet-based survey n =230 response rate=43%		CELA survey collected in 1999 mail-based survey n=297 response rate=63%		CELA survey collected in 1981 mail-based survey n=258 response rate=58%	
Highest Degree	*Count*	*Percent*	*Count*	*Percent*		
Bachelor degree	3	1%	0	0%		
Masters degree	127	55%	216	73%		
Doctoral degree	81	35%	81	27%		
Others/ undesignated	19	8%	0	0%		
Academic rank	*Count*	*Percent*			*Count*	*Percent*
Assistant professor	30	13%			78	30%
Associate professor	81	35%			62	24%
Full professor	67	29%			52	20%
Emeritus professor/retired	16	7%			NA	NA
Adjunct professor/lecture	14	6%			23	9%
Others/ undesignated	22	10%			23	9%
Experience	*Mean*	*Std. D.*				
Years in teaching (full time & part time)	19.3	11.0				
Years in practice (full time & part time)	17.7	12.6				

lower representation of assistant professors (13%) compared with that of 1981 (30%). However, these differences are likely due to transitions in landscape architecture faculties, such as an increasing number of PhDs without full-time practice experience (LaGro, 1999).

The demographics of CELA educators slightly differ from those of two earlier surveys that targeted at the same population (Table 3). More educators who responded to our survey hold a doctoral degree compared at those who responded to Milburn and Brown's survey (Milburn & Brown, 2003). There were also less assistant and adjunct professors and more full and associate professors who responded to our survey compared at those to responded to Chenoweth and Chidister's survey (Chenoweth & Chidister, 1983). Although studies found changing demographics of the CELA educators, such as increasing number of Ph.D.s (Schneider, 1981), without the demographics of the CELA population to compare with, it is difficult to declare with confidence whether these demographic differences were due to changing demographics of the CELA educators in general or sampling bias.

EVALUATED MEASUREMENTS

General Demand and Supply

Research was widely accepted as important and was perceived by many as not being conducted in sufficient quantity, which suggested an authentic need for research perceived from practice. It is found in the survey that 94% of ASLA members believed that research is important to landscape architecture practice. Despite this belief that research is perceived important to practice by most professionals, a substantial percentage believe that there is not enough research being done in landscape architecture (agreed or strongly agreed by 52%).

Table 4. Types of Thinking or Knowledge Sources that Support Decision-Making in Practice Used by ASLA Members (2012)

Question: How often do you use each of the following types of thinking or sources of knowledge in making decisions in your practice?

No.	Sources of knowledge or types of thinking	Not sure or rarely	Occa-sionally	Often or very often	Mean*	SD*
Types of thinking						
A4_3	Logic and reasoning	0%	2%	98%	3.76	0.47
A4_1	Intuition	3%	15%	82%	3.27	0.81
Sources of knowledge						
A4_2	Common sense	<1%	2%	98%	3.69	0.52
A4_5	Professional experience	<1%	1%	98%	3.84	0.42
A4_10	Client expressed desires	1%	4%	95%	3.60	0.56
A4_8	Technical standards	1%	10%	89%	3.35	0.69
A4_6	Professional education	1%	13%	86%	3.31	0.73
A4_11	Other specialists	6%	22%	70%	2.97	0.79
A4_4	Research findings	5%	28%	67%	2.89	0.86
A4_9	Historical information	4%	31%	65%	2.83	0.81
A4_7	The work of other landscape architects	3%	34%	62%	2.82	0.81

Note: * The numerical means and standard deviations were calculated on the following coding: *not sure*=system missing, *rarely* =1, *occasionally*=2, *often*=3, *very often*=4

Compared with 1980s, a substantial increase in the use of the results of research was found in this study, which indicates a research need from practicing professionals. Sixty-seven percent of landscape architects today use research often or very often to make their decisions (**Table 4**), compared to only 21% in the 1981's survey (Palmer et al., 1984). However, results indicated that professional decisions in landscape architecture are still largely made based on 1) traditional professional knowledge including professional experience (98%) technical standards (89%), and professional education (86%); and 2) non-professional information including common sense (98%), client expressed desires (95%), and other specialists (70%).

Landscape architects cooperate with a wide range of specialists, in particular engineers. Some 69% of ASLA members responding to the survey consulted with engineers to a great or very great extent). Respondents also consulted with architects and planners (50%), and natural scientists (16%) frequently for their valuable expertise (**Table 5, 6**).

Results indicated that the scope of landscape architecture practice had expanded from traditional focus on aesthetics to more concrete and specific concerns. Compared with practice in 1970s, landscape architecture practice more recently is less based on subjective standards, such as aesthetics (those found it central to practice to a very great extend decreased from 67% to 46%, $p<.01$, see **Table 7**), but more based on measurable standards -- such as public welfare (increased from 14% to 69%, $p<.01$) and individual comfort (increased from 22% to 42%, $p<.01$).

Table 5. Frequencies of Profession Consulted by ASLA Members (2012)

Question: How often do you consult with the following professions? (%)

No.	Professionals consulted	Not at all	Not too much	Fair degree	Great or very great extent	Missing
A8_2	Engineers	0%	6%	25%	69%	0%
A8_1	Architects and planners	1%	7%	32%	50%	0%
A8_4	Natural scientists	11%	28%	44%	16%	0%
A8_8	Systems analysts and computer specialists	26%	39%	29%	6%	1%
A8_7	Liberal artists (e.g. painters)	33%	41%	23%	4%	0%
A8_6	Applied artists (e.g. industrial designers)	36%	39%	21%	5%	0%
A8_3	Behavioral scientists	52%	37%	7%	3%	0%
A8_5	Humanistic academicians	60%	33%	5%	1%	0%

Table 6. Consulting Service Perceived by ASLA Members (2012)

Question: If you do seek the knowledge and expertise of other professionals in your work, which of those professionals provides knowledge and expertise that you consider to be is most important to your practice? Why?

Professionals consulted	Number	Percentage
Engineers	88	35%
-*Civil engineers*	*45*	*18%*
-*Structural engineers*	*19*	*8%*
- *Geotechnical engineers*	*5*	*2%*
Natural scientists in forestry, botany, biology and etc.	45	18%
Architects	37	15%
Planners	14	6%
Building contractors	10	4%
Landscape architects	9	4%
Artists	7	3%
Behavior scientists and other social scientists	5	2%
Developer and related economical experts	5	2%

Research demand and supply in two dimensions

The scope of research knowledge, measured by 19 knowledge areas, was reduced into five PCA components. This explains 61% of the total variation in the use of knowledge in 19 topics, resulting in a Cronbach's alpha value ranging from .687 to .841 (**Table 8**). These five components -- judgmental design knowledge, constructional design knowledge, environmental systems knowledge, social-cultural systems knowledge, and historical-cultural systems knowledge -- were generally consistent with the four domains in **Table 1g** with small differences. These differences may have resulted from technical limitations, since the identification of later components in PCA was heavily influenced by the results of earlier ones and therefore turned less distinctive (Meyers, Gamst, & Guarino, 2006). Reliability test indicated a moderate coherence among the areas in social, cultural and historical systems knowledge (Cronbach's alpha=.695), which was split into two components in PCA.

Table 7. The Scope of Landscape Architecture Practice (1972, 2012)

Question: To what extent is each of the following central to your understanding of what the practice of landscape architecture should be concerned with?

No.	Concerns		Undesignated or not at all or not too much	Fair degree	Great extent	Very great extent	Mean*	SD	T-Test	
									T**	P
A3_1	Aesthetics	2012	2%	6%	45%	46%	3.38	0.66	-4.24	<0.01
		1972*	1%	4%	28%	67%	3.62	0.56		
A3_2	Ecological needs	2012	<1%	5%	33%	62%	3.57	0.58	-0.85	not sig
		1972*	1%	5%	25%	70%	3.62	0.65		
A3_3	Public welfare and enjoyment	2012	1%	3%	27%	69%	3.66	0.54	16.47	<0.01
		1972*	11%	38%	37%	14%	2.56	0.86		
A3_4	Comfort and pleasure for the individual	2012	<1%	9%	49%	42%	3.33	0.63	7.71	<0.01
		1972*	8%	29%	41%	22%	2.79	0.87		

* Scale: *undesignated* = system missing, *not at all* =0, *not too much* =1, *fair degree*=2, great extent=3, *very great extent*=4. In Fein's survey, <1% is calculated as 0.5%.

** Fein's survey was collected from 1521 ASLA members, while this survey was collected from 239 ASLA members.

Table 8. Current research use and knowledge domains revealed by PCA

Question: If you engage in the following as part of your practice, please indicate how often you use research on that topic.

No.	Knowledge areas	PCA components					Used often or very often	Mean *	SD
		Judgmental design	Constru-ctional design	Environ-mental systems	Social-cultural systems	Historical - cultural systems			
A12_16	Professional ethics	.736	.230	.188	.228	.008	35%	2.15	1.18
A12_13	The profession of landscape architecture	.731	.271	.085	.198	-.046	46%	2.42	1.18
A12_5	Aesthetics	.720	.211	.159	.108	.160	63%	2.90	1.02
A12_4	Design theory and design process	.601	.156	.282	-.059	.369	47%	2.45	1.06
A12_6	Representation and communication	.581	.149	.123	.378	.240	52%	2.48	1.12
A12_18	Site engineering (lighting, irrigation etc.)	.218	.807	.013	.090	.074	70%	3.02	1.01
A12_9	Construction techniques	.043	.787	.329	.086	.057	69%	2.99	1.03
A12_10	Plants and materials	.204	.754	.136	.006	.096	83 %	3.32	0.82
A12_19	Grading and circulation	.356	.737	-.028	.161	.023	64%	2.92	1.07
A12_8	Water resource management	.006	.350	.707	.273	.157	57%	2.60	1.23
A12_14	Environmental psychology	.293	-.102	.651	.330	.170	21%	1.65	1.12
A12_15	Health and landscape	.428	-.042	.626	.114	.097	33%	2.05	1.11
A12_12	Sustainable design	.294	.302	.588	.128	-.043	79%	3.17	0.84
A12_3	Ecology	-.016	.227	.563	.081	.493	64%	2.79	1.05
A12_11	Geospatial tools (e.g. GIS)	.049	.172	.143	.758	.021	34%	1.96	1.22
A12_7	Community planning and design	.245	.047	.136	.748	.077	57%	2.56	1.22
A12_17	Public policy	.255	.049	.278	.610	.213	42%	2.28	1.25
A12_2	Garden history	.169	.157	.057	-.004	.826	26%	1.84	1.17
A12_1	History and culture	.104	-.060	.166	.303	.780	44%	2.29	1.27
	Cronbach's Alpha	.832	.841	.775	.687	.707			
					.695				
	Component eigenvalue	6.66	2.05	1.43	1.23	1.00			
	Variance explained	35%	11%	8%	7 %	5%	Total	61%	

* Scale: not part of my practice= 0, rarely =1, occasionally=2, often=3, very often=4.

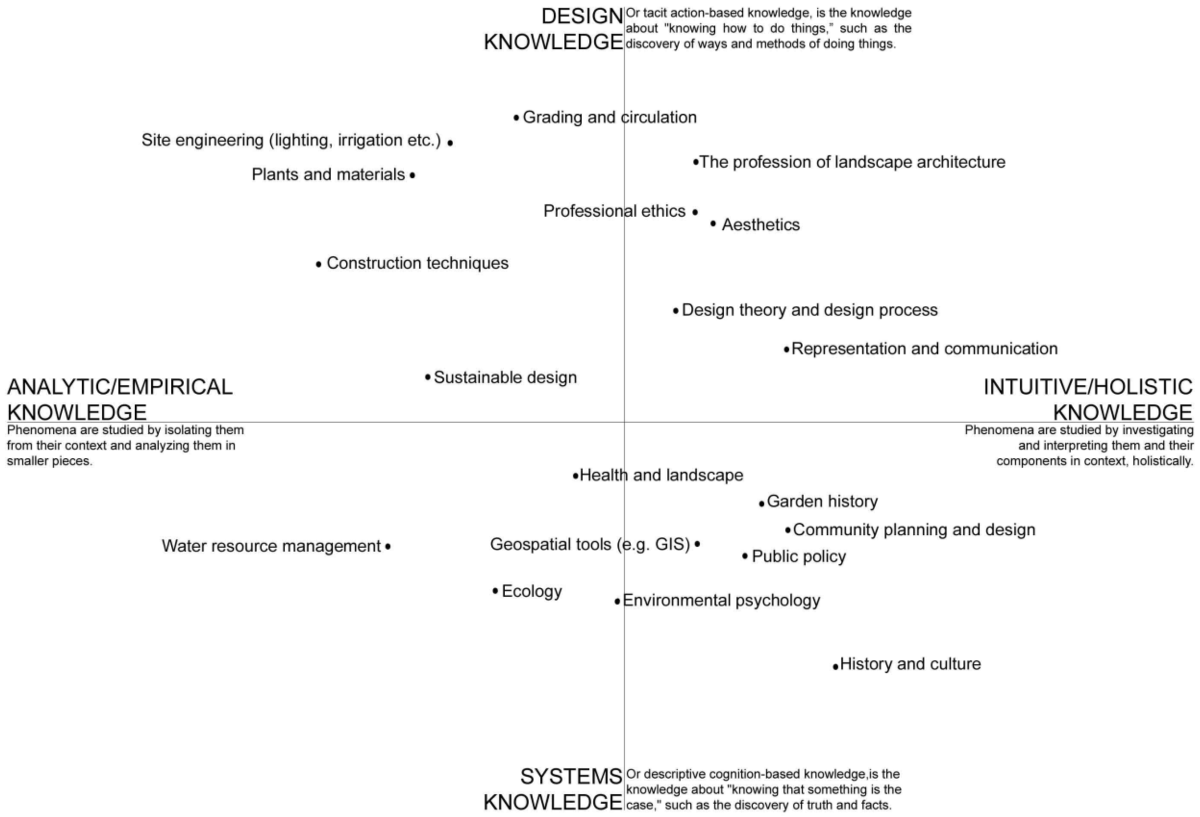

Figure 1. Knowledge map of research in landscape architecture practice

Linear combination was used to reveal conducted the two knowledge dimensions by extracting them from the five PCA components. In the design-systems dimension, design is measured by judgmental (component 1) and constructional design knowledge (component 2), while systems knowledge is measured by environmental (component 3), social-cultural (component 4), and historical-cultural systems knowledge (component 5). In the intuitive/holistic-analytic/empirical dimension, intuitive/holistic knowledge is measured by judgmental design (component 1), social-cultural systems (component 4), and historical-cultural systems knowledge (component 5), while analytic/empirical knowledge is measured by constructional design (component 2) and environmental systems knowledge (component 3). Therefore, the degree of knowledge areas in the two dimension can be calculated as following:

$$X\left(\frac{intiutive}{holistic} - \frac{analytical}{emprical\ score}\right) = (PCA1+PCA4+PCA5)/3-(PCA2+PCA3)/2 \quad (1)$$

$$Y(\text{design - systems score}) = (PCA1+PCA2)/2-(PCA3+PCA4+PCA5)/3 \quad (2)$$

A knowledge map was generated using the two scores as x and y values in an orthogonal coordinate system (**Figure 1**). The 19 knowledge areas investigated in this study, as revealed in the map, were well distributed and covered all the four quadrants in the map.

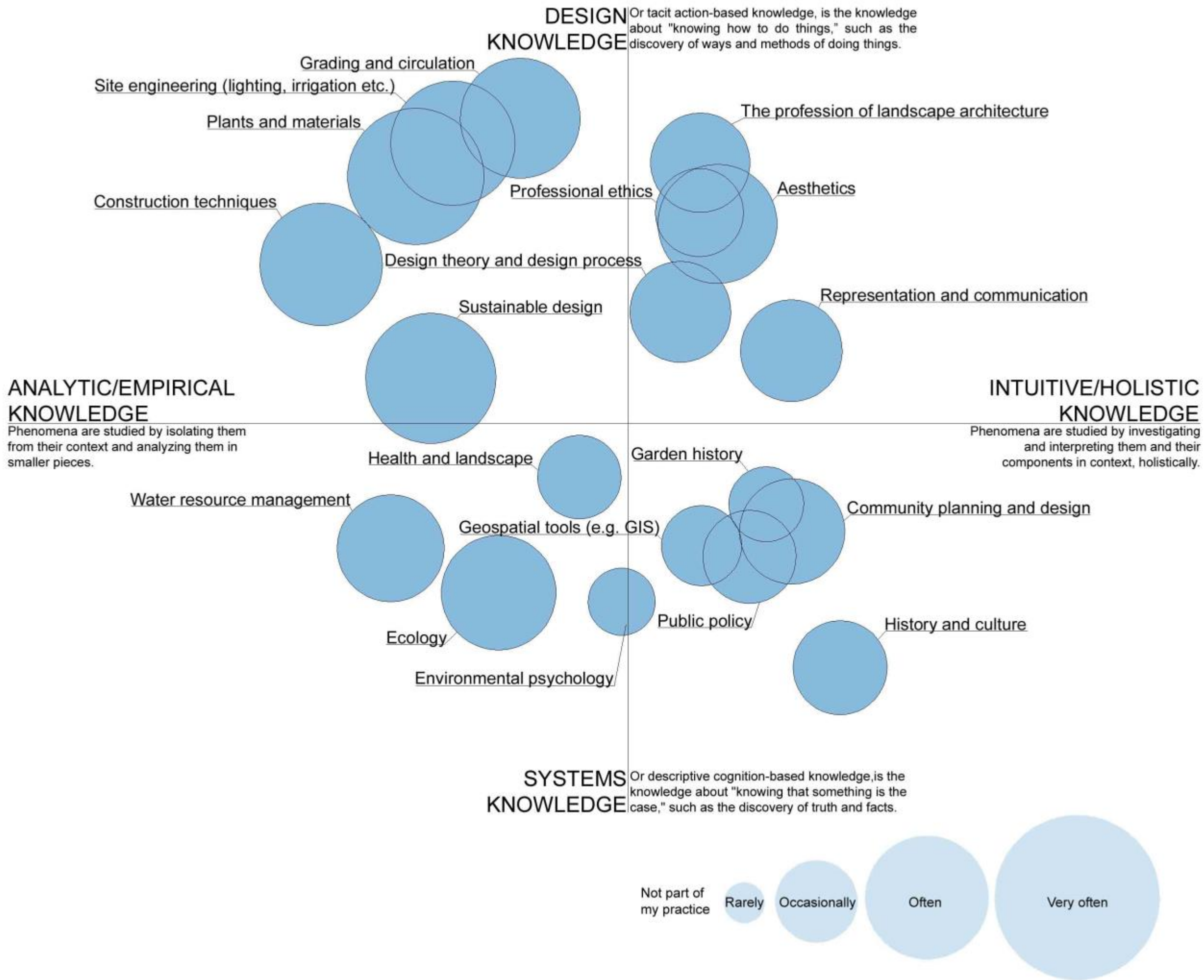

Figure 2. Current research use map perceived by ASLA members (2012)

The sequence of knowledge areas on the design-system spectrum based on the PCA calculated knowledge map was consistent with intuitive understanding of the contents of these areas, with grading and circulation and site engineering as typical design knowledge, and history and culture and environmental psychology as typical systems knowledge. The sequence of knowledge areas on the analytic/empirical-intuitive/holistic spectrum was also consistent with common sense, with history and culture and community planning and design as typical intuitive/holistic knowledge, and construction techniques and water resource management as typical analytic/empirical knowledge.

Demand of research by knowledge areas

Results suggested that current landscape architecture practice relies on research knowledge in all four quadrants **Figure 2**). Comparatively, practice depends slightly more on analytical/empirical (means = 1.65~3.32, mean of means = 2.70) than on intuitive/holistic knowledge (means = 1.84~2.90, mean of means = 2.32); slightly more on design (means =

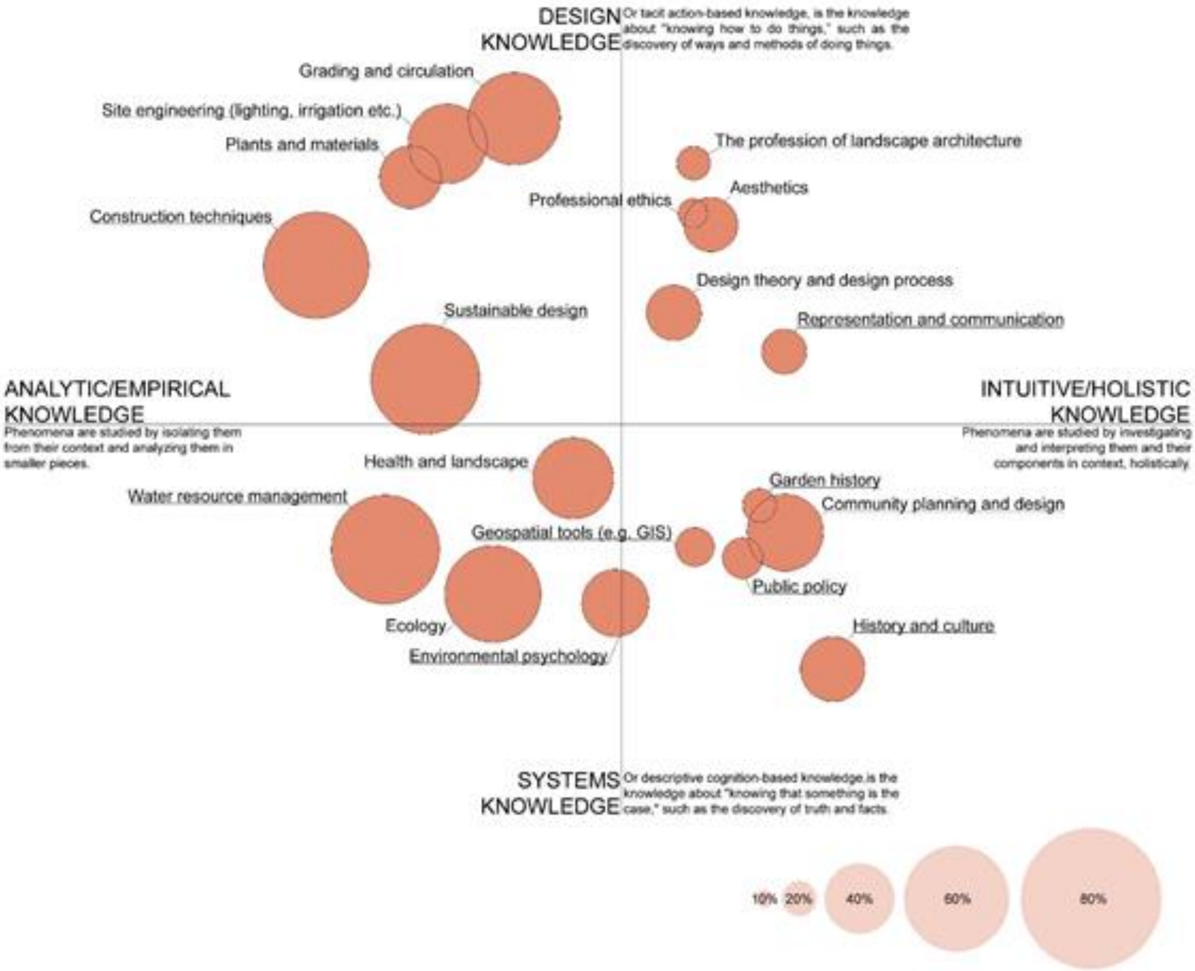

Figure 3. Additional research need map perceived by ASLA members (2012)

2.15~3.32, mean of means = 2.78) than on systems knowledge (means = 1.65~2.79, mean of means = 2.22).

Self-reported additional research need revealed that landscape architects expect more research in analytic/empirical knowledge (means = 36~62%, mean of means = 51%) than intuitive/holistic knowledge (means = 17~44%, mean of means =27%). Areas that were perceived by ASLA members with highest need for additional research (**Figure 3**) -- such as sustainable design, water resource management, and construction techniques -- were identified as more specialized knowledge areas which were usually learned from post-professional master programs, or from specialized practice (ASLA et al., 2004). Knowledge areas that were traditionally seen as design core taught in most professional degree programs (ASLA et al., 2004) -- including representation and communication, aesthetics, design theory and design process, and grading and circulation -- were found outside the ten most needed areas for additional research.

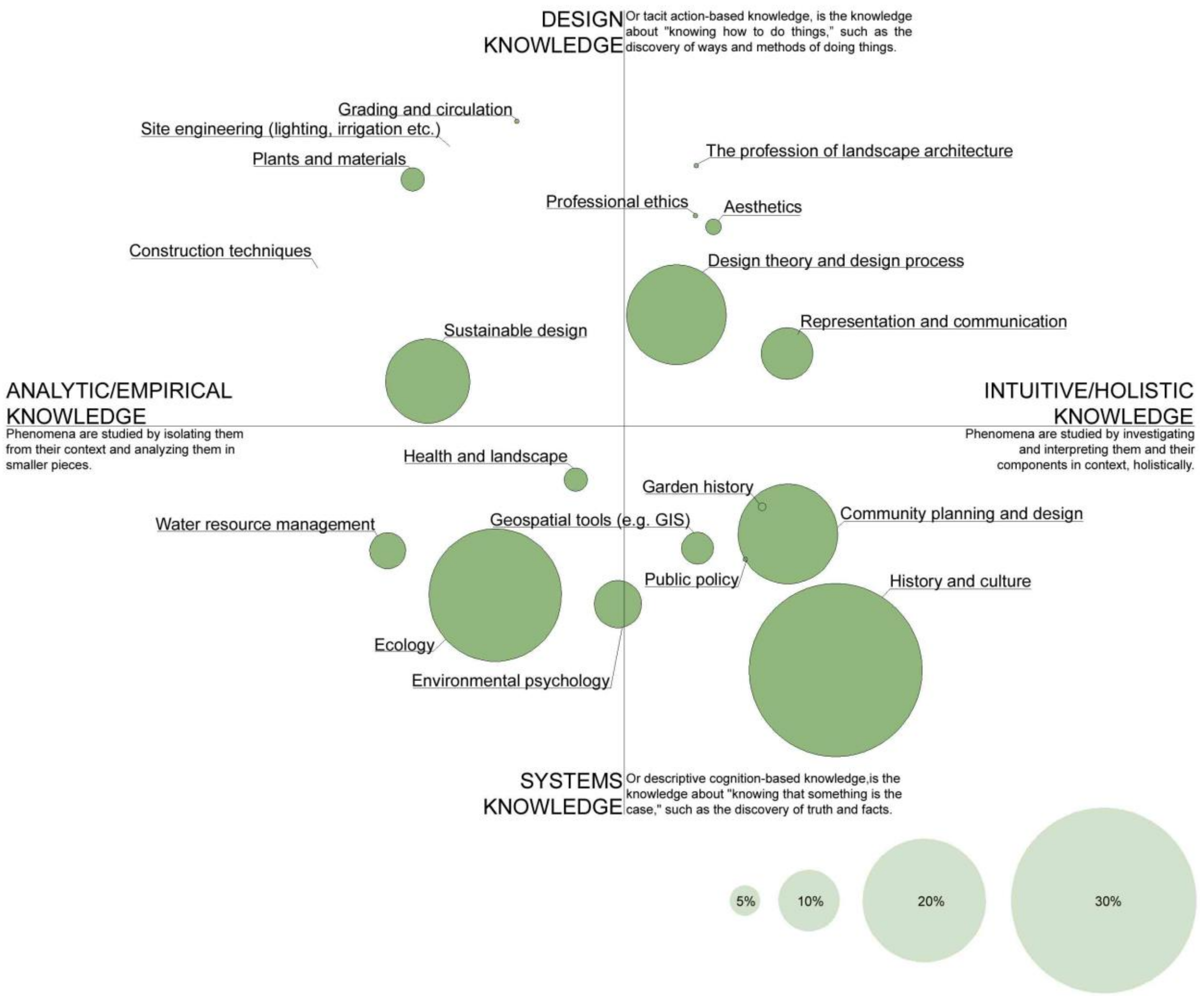

Figure 4. Research engagement map reported by CELA educators (2010)

Supply of research

Content analysis of self-reporting research interests of CELA (**Figure 4**) suggested that educators were currently engaged in much more research in systems knowledge (means = 1~28%, total 9 topics = 91%) than that in design knowledge (means = 0~16%, total 10 topics = 48%). However, there seems no significant differences in whether they obtain knowledge via analytic/empirical (means = 0~22%, total 9 topics = 67%) or intuitive/holistic approaches (means = 1~28%, total 10 topics = 72%).

CONCLUSION AND RECOMMENDATION

There is an increasing need for solid knowledge and evidence-based practice in the profession of landscape architecture in the past few decades. This need is responded, at least partially, by increasing research activities found in landscape architecture educators (Chen et al., 2011; Chenoweth & Chidister, 1983; Milburn, Brown, Mulley, & Hilts, 2003). As observed in this study, the accumulation of academic knowledge had resulted in the following impacts on landscape architecture practice and its knowledge-bases.

Expanding knowledge scope and Landscape architecture practice

Knowledge-bases of landscape architecture practice have expanded as academic knowledge advanced. Landscape architecture had a significant knowledge advancement in analytic/empirical explanations through academic research during the 1950-70s decades, especially in ecological planning (e.g., Fabos, 1979; Lewis, 1968a, 1968b; McHarg, 1969; Steinitz, Murray, Sinton, & Way, 1969) and in environmental psychology (e.g., Kaplan & Kaplan, 1982; Leopold, 1969; Litton, 1968; Shafer & Brush, 1977; U.S.D.A. Forest Service, 1975), and another advancement in intuitive/holistic explanations in the 1980-90s (Simo, 1999; Swaffield, 2002), especially in cultural landscape studies (e.g., Barnes, 1998; Groth, 1997; Groth & Bressi, 1997).

Fein (1972) observed that research and knowledge advancement in ecological planning had expanded landscape architecture practice from traditional focus, i.e. aesthetics, to ecological needs in the 1970s. We observed that the scope of practice has continued to grow in areas such as public welfare and enjoyment (mean=3.66 compared at 1972 mean =2.56, $p < .01$) and comfort and pleasure for the individuals (mean=3.33 compared at 1972 mean =2.79, $p < .01$), which were probably associated with accumulative academic knowledge in areas such as cultural landscape studies, community planning and design, and environmental psychology.

Widely recognized need for research among practitioners

The need for research was not only found in academia, but was widely perceived in the whole profession -- by 95% ASLA members to be specific. Only 8% of ASLA members believed that current levels of research was adequate. Others either believed that research was not enough (52%), or reserved their opinions (41%, including not sure, neutral and undesignated). Two thirds (67%) of ASLA members today used research findings often or very often in making their design decisions, which were much more often than they were in the 1980s (21% used regularly, Palmer et al., 1984).

Academic research and explanatory systems knowledge

As found in LABOK study (ASLA et al., 2004), tacit judgmental design knowledge is mostly learned through systematic professional education, while construction design knowledge is largely gained through practice. The profession controls the two knowledge domains via accreditation of professional education and professional registration, with the former focused more on judgmental design knowledge while later more on construction design knowledge.

Academic research primarily generates explanatory knowledge, which has became an important supplement to tacit design knowledge (e.g., design theories) and construction knowledge. Practitioners used research findings in design knowledge -- both tacit judgmental and construction -- (means =2.15~3.32, mean of means = 2.78) as much as, if not more than, those in explanatory systems knowledge (means = 1.65~2.79, mean of means =2.22), such as ecology and history & culture. However, academic research conducted by educators are largely aimed to advance explanatory systems knowledge (means =1~28%, total 9 topics =91%; compared at means of design knowledge =0~16%, total 9 topics =48%).

The role of academic research in advancing explanatory knowledge is probably associated with modern professions and competitions. Studies in professionalization revealed that modern professions evolve together through competitions (Abbott, 1988). Therefore, a modern profession needs not only to successfully perform certain tasks, but it also has to gain and defend its authority by justifying their actions via systematic explanations .

Research and a sense of certainty

Unlike their academic peers, practitioners' perception about research seem to be associated more with authority and certainty:

> *Landscape Architects absolutely must back up their ideas with facts. As a profession, we have a tendency to assume others will iron out the finer points, but this is our responsibility. We can't just assume things will work (stormwater, safety, ecology); we must know they will work. Either we have to research this ourselves or engage the help of related professions. (comment from a participant in ASLA survey 2012)*

A sense of certainty is usually more likely to be generated from analytic/empirical research (e.g. ecology and construction techniques) than from intuitive/holistic research (e.g. aesthetics and history and culture). In fact, we did observe among ASLA members a higher expectation for additional research in the former than the later (analytic/empirical means = 36~62%, mean of means = 51%; compared at intuitive/holistic means = 17~44%, mean of means = 27%). Consistent with their preference towards analytic/empirical research, practitioners also claimed that they use more logic and reasoning than intuition (mean difference =.49, $p<.01$) in practice today.

To obtain a higher certainty, practitioners also consult a broad range of professions, especially engineers, architects, planners and natural scientists. We are a little surprised to find that landscape architects today consult engineers more often than architects and planners. It is possible because that engineering knowledge is usually "more certain" than knowledge generated by architects and planners. Another explanation is that engineers have developed an efficient way of advancing knowledge in a practical and yet rigorous manner (Kelly, 1998; Vincenti, 1990), which is similar but different to scientific knowing (Layton, 1971, 1974, 1976; Seely, 1993).

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