

CONCEPTUAL FRAMEWORK FOR POTENTIAL IMPLEMENTATIONS OF MULTI CRITERIA DECISION MAKING (MCDM) METHODS FOR DESIGN QUALITY ASSESSMENT

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Abstract

Architectural design can be considered as a process influenced by many stakeholders, each of which has different decision power. Each stakeholder might have his/her own criteria and weightings depending on his/her own perspective and role. Hence design can be seen as a multi-criteria decision making (MCDM) process.

Considering architectural design, its evaluation and quality assessment within a context of MCDM is not regularly performed within building processes. The aim of the paper is to find/adapt proper methodologies of MCDM, used in other domains for assessment of design quality, adapt them to the construction domain and test their applicability.

Current tools (for instance DQI, DEEP, AEDET, HQI, LEED, BREEAM, BQA) for quality assessment will be reviewed and compared with several MCDM methods (ie. AHP, ANP, PROMETHEE, SAW AND TOPSIS). Advantages and disadvantages of gathered outcomes from comparisons for assessment and applicability within architectural design will be discussed. Finally reflections on the outcomes will be provided.

Keywords: Architectural Design Quality, Analytic Hierarchy Process (AHP), Design Quality Assessment Tools, Multi Criteria Decision Making (MCDM)

INTRODUCTION

Dickson (2004) stated that, the overall design and procurement process can be seen as a series of decisions that lead progressively towards the built reality. Analysing a design process, as the sum of decisions made by each stakeholder with decisive power, is not the most often used way of approaching design (quality) within architecture. Considering design as a multi-stakeholder decision making process, it seems reasonable to apply multi criteria decision making (MCDM) techniques to assess design quality. MCDM can be defined as the evaluation of the alternatives for the purpose of selection or ranking, using a number of qualitative and/or quantitative criteria that have different measurement units (Özcan et al., 2011). Remarkably the most often used tools nowadays are based on evaluation of chosen criteria via Likert/rated scoring systems. The aim of the paper is to find out the potentials of MCDM methods for development of architectural design quality tools. For that reason existing quality tools will be analysed to bring out their strong and weak points. Methods used in other domains for decision making will be analysed to find possible potentials of them to cope with the weaknesses of current tools used in architectural design.

“Since solid theoretical foundation and best practices are rare in architecture and construction, it is recommended to learn from state-of-the-art in other relevant domains, i.e. social and organizational psychology, organizational management and behaviour, and other industries” (Sebastian, 2003, 2007). Built on this statement, this study aims to improve existing quality assessment tools used in architectural design, by using MCDM methods which are used in other domains for decision making. Quality assessments of multi-stakeholders might be useful in terms of providing designers with input for improving their design according to stakeholder preferences. Besides, their attitude is beneficial for taking decisions at design team meetings at stage boundaries, for selection between different design alternatives in case of disputes or design contests, or for post occupancy evaluations. The strategy within this research is to evaluate the most often used current tools more specific on the applicability seen from a multi stakeholder perspective, and to review existing MCDM methods as regularly used within other domains comparing them on their applicability within building processes.

The first part of the paper will cover a review of current tools used for assessment. After this, a discussion will follow to review their strengths and weaknesses, from a multi stakeholder decision making perspective. In the second part, MCDM methodologies will be analysed with the to what extent they might cope with the specific weaknesses which are defined in the first part of the paper as being characteristic for the existing tools most often used in practice. Also comparative analysis of Likert/rated scale to pair wise comparison will be revealed. Finally the outcomes will be discussed to reveal potentials of MCDM methods to use for architectural design quality assessment.

RELEVANCE AND BACKGROUNDS OF THE RESEARCH

Each architectural design most often typically can be seen as a one off production. The design process is complex, considering its content, context, stakeholders, ill-defined problems and moreover multifaceted interactions of them to each other. Design is obviously not a linear-running but an iterative process which is analysing through synthesizing (Sebastian, 2003, 2007). Each design process has special characteristics which cannot be standardized easily. Since buildings are so diverse, serving many different types of occupancies or functions, any attempt to develop a single system to define and rate performance of these buildings will not

be perfect and will even be unsatisfactory for many potential users (MacDonald, 2000). This might be the reason so many different assessment tools are developed for building processes.

As stated, within this research architectural design is considered to be a decision making process. Within the process, decisions are taken by the evaluation of criteria and sub-criteria from the perspectives of stakeholders related to various limitations, so called multi-criteria decision making (MCDM) processes. This might be seen as a valid approach as even in the simplest cases today at least architects in design processes have to cope with their clients or/and users, specialist engineering advisors, governmental bodies and the contractors. This approach is especially valid in case of, complex buildings for instance designs for the Health Care sector, in which projects (depending to a certain extend to their organization and national context) have a multi-faceted client situation (the diverse specialist and health groups and a wide variety of users) whose expert knowledge is an absolute necessity in terms of the future usability of the building and of which many have decisive power within the design and construction process.

In complex circumstances, our practice based experiences, interviews held and literature survey executed are shown that easy-to-use tools may provide unsatisfactory outcomes while intending to use efficiently and repetitively.

ARCHITECTURAL DESIGN QUALITY

Literature was reviewed for a common understanding of architectural design quality. In the history, one of the first written definitions date backs to 20's BC. Utilitas, Firmitas and Venustas – commonly translated as Commodity, Firmness and Delight- was one of the first defined frameworks for criteria used to asses architectural design quality as developed by the Roman architect Marcus Vitruvius. This Vitruvian framework has been an essential base for forthcoming architectural theory later on. The framework up till today is also the most addressed trilogy to define excellence. (Vitruvius, 1993; Volker et al., 2008; Prins, 2009)

Related to Nelson (2006), quality is the degree to which a set of inherent characteristics fulfils stated, implied or obligatory needs or expectations. Nelson (2006) defines quality for domain of architecture as improving the degree to which design fulfils needs and expectations. In the building environment, Volker et al. (2008) outlines that architectural quality embraces all the aspects by which a building is judged while in the construction industry, quality is associated with competency and proficiency levels as a route to customer satisfaction. (Thomson et al., 2003)

Throughout the history of architecture, definitions of criteria and their sub-criteria differ according to era, technology, culture and the society. Quality is a subjective matter meaning different things to different people depending on perceived priorities. (Choy and Burke, 2006) That is to say, quality is in the eye of the beholder. Within this paper, it is intended not only to explore methodologies but also to explore the criteria which may be effective about getting the ideas of stakeholders involved to the quality, rather than trying to create or contribute to the existing series of holistic attempts to define architectural quality.

RESEARCH METHODOLOGY

This paper aims to structure the conceptual framework of an assessment tool for architectural design quality based on MCDM methods. The research is based on an explorative analysis using an inductive approach according to the steps listed below:

- Current design tools –DQI, DEEP, AEDET, BREEAM, LEED and BQA-will be introduced and reviewed. (Tools are selected due to their reputation in academic papers and use in practice)
- Outcomes will be discussed to reveal strengths and weaknesses of the current tools from a multi stakeholder decision making perspective.
- MCDM methods, as widely used in other domains will be introduced and reviewed on applicability for architectural design and construction and compared with the earlier mentioned tools most often used today within the domain.
- The specific potential of MCDM methods will be discussed, more in special compared to the weaknesses of the current tools used in architectural design and construction.

Research questions related with the steps are:

- How are the tools linked to architectural design quality assessment?
- What are the criteria and sub-criteria of the currently used tools for architectural design quality assessment?
- Are the tools flexible/adaptable enough to change the criteria for different types of buildings and for different project teams?
- What are the assessment methodologies?
- What is the difference between Likert/Rated scale and pair wise comparison? Which one should be used for design quality assessment?
- What are the strengths and weaknesses of the current tools?
- Can MCDM methods be used for assessment of quality?
- Can MCDM methods cope with the weaknesses of the current tools, more in special as discussed in an MCDM perspective and for the different usages mentioned?

CRITICAL REVIEW OF ARCHITECTURAL DESIGN QUALITY ASSESSMENT TOOLS

What cannot be numerically measured is deemed not to exist (Prasad, 2004)

Design quality is a complex phenomenon. Everybody has an opinion about buildings and quality, but consensus and scientific explanations are difficult. (Dewulf and van Meel, 2004). Nevertheless to cope with the problem of evaluation, several tools have been developed which have different approaches for assessment. DQI, AEDET Evolution, DEEP, HQI, LEED, BREEAM and BQA are the tools chosen for analysis within this paper. They are selected due to their reputation in academic publications and their usage frequency in practice depending on literature review. (Dewulf and van Meel, 2004 - Gann et al., 2003 - van der Voordt, 2009, 2005 - Volker et al., 2008 – Volker , 2010 - Giddings et al., 2010 - MacMillan, 2004 CABE, 2011) Following brief explanations about the tools, they will be reviewed especially for their criteria selection, methodology, scope of assessment possible usage phases in building process and their efficiency and applicability.

DQI (Design Quality Indicator)

The Design Quality Indicator (DQI), maybe the best known tool amongst the others, was developed based on a “rational-adaptive approach” (Volker, 2010) as an extension of the “*Rethinking Construction Agenda*” for targeting, mapping, measuring and managing performance improvement in construction. (Gann et al., 2003) There is a general DQI for all building types and a specific one for school buildings; together with two subsets, AEDET which focuses on hospitals and DEEP, which is exclusively for military housing (Giddings et al., 2010). The tool is based on a method that integrates measures of ‘hard’ physical attributes and ‘soft’ perceptual viewpoints about the performance of buildings in relation to design decisions. The former are typically found in areas such as build quality and function. (Whyte, j. et al., 2004) More detailed information can be found, in Gann et al (2004).

AEDET Evolution (Achieving Excellence Design Evaluation Toolkit)

The AEDET Evolution (Achieving Excellence Design Evaluation) Toolkit -the latest version of AEDET- is a subset modification of DQI, aims to be used in case of healthcare facilities to evaluate architectural design quality. It delivers a profile that indicates the strengths and weaknesses of a design or an existing building. AEDET is a tool specifically directed towards achieving ‘excellence in design’ rather than ensuring compliance with legislation, regulation and guidance (Aedet web page). It can be used from initial proposals through to post project evaluation. It is also being used as a benchmarking tool. The toolkit comprises a series of key questions supported by lists of related issues that need to be considered (AEDET webpage) (van der voortd, 2009, 2005). A detailed review can be found in Gesler et al. (2004).

DEEP (Design Excellence Evaluation Process)

The DEEP (Design Excellence Evaluation Process) Toolkit is also a subset modification of DQI to be used in buildings of the United Kingdom Ministry Of Defense to evaluate architectural design quality at the key stages in the project life cycle. DEEP determines both the required design standard (usually expressed as a percentage) and compliance with required minimum standards. DEEP provides the technical assurance that a military construction project is both compliant with Government construction policies and of a sufficient design quality to ensure fitness for purpose and value for money over the whole life of the facility. (DEEP web page)

HQI (Housing Quality Indicator)

Housing Quality Indicator (HQI) measures the quality of housing schemes funded through the United Kingdom National Affordable Housing Programme (NAHP)(HQI web page). It was developed with ease of use in mind. The HQI system allows an assessment of quality of the key features of a housing project in relation to location, design and performance. The system was developed such that quality is evaluated from many different aspects (Wheeler, p., 2004). According to Giddings et al. (2010), design quality assessment using this tool, is limited to standards and measurement. More can be found at Giddings et al. (2010) Wheeler,P. (2004) and Franklin (2001)

BREEAM (Building Research Establishment Environmental Assessment Method)

BREEAM (Building Research Establishment Environmental Assessment Method) is one of the oldest building assessment systems. Developed in 1988 by the Building Research Establishment (BRE), the national building research organization of the UK, it was initially created to help transform the construction of office buildings to high performance standards (Ulukavak Harputlugil and Hensen, 2006). BREEAM which covers a range of building types, including offices; industrial premises; retail outlets; schools, etc has been an inspiring tool which

further developed tools have adapted as a reference model, and also is widely used in other countries (Lee and Burnett, 2008). BREEAM nowadays developed into one of the leading and most widely used environmental assessment methods for buildings. It sets the standard for best practice in sustainable design, describing a building's environmental performance. (BREEAM web site)

LEED (Leadership in Energy & Environmental Design)

LEED is an internationally recognized green building certification system. It provides third-party verification that a building or community was designed and built using strategies aimed at improving performance across all the metrics that matter most in this respect: energy savings, water efficiency, CO2 emissions reduction, improved indoor environmental quality, and stewardship of resources and sensitivity to their impacts. (LEED website)

BQA (Building Quality Assessment)

BQA is a tool for scoring the performance of a building, relating actual performance to identified requirements for user groups in that type of building. The quality of a building is defined in BQA as the degree to which the design and specification meets the requirements for that building (Clift, 1996). The BQA system divides the building into nine categories that establish a broad classification of user requirements. The performance and quality of a number of office buildings can be compared at all levels – the overall BQA total, the category and/or section totals and down to the individual factor levels. Individual clients using BQA can choose their own weightings if they wish to emphasize a particular characteristic.

SYSTEMATIC REVIEW OF MOST COMMONLY USED QUALITY ASSESSMENT TOOLS

There are several tools to assess, evaluate and define architectural design quality, some of the most important of them described above. Developing such tools in a wide variety, for different types of buildings system represents the struggle to improve the quality of buildings and the build environment in general (Wheeler, 2004). The quality assessment tools discussed above were reviewed to bring out strengths and weaknesses depending their usage for certain building types, methodology, scope of assessment, their use in the building process, organization and finally their criteria and sub-criteria selection. (Table 2)

	DQI	AEDET	DEEP	HQI	LEED	BREEAM	BQA
1) Building Type	Educational Buildings Specific. (Can also be used on wide variety of buildings)	Hospitals (Health Care facilities)	Military Housing	Housing (schemes)	All types of buildings (residential to commercial)	Housing Eco-homes Office Schools Industrial build. Courts Healthcare Prison Retail education (Other types of buildings)	Office buildings
	DQI, LEED and BREEAM can be used for a wide variety of buildings, while the rest is more or less related with a specific building type.						
2) Aim of Use	-Architectural design quality (ADQ) assessment	-ADQ Assessment -Benchmarking	-ADQ Assessment -Generic Checklist	-Measurement and assessment of potential and existing house schemes based ADQ	-Green building certification system	-Sets the standard for best practice for sustainability	-Performance assessment
	DQI, AEDET, DEEP and HQI aim to assess architectural design quality. LEED and BREEAM try to set the standards for certification of green buildings, while BQA aims to assess the performance of office buildings.						

3)Main Criteria Sub-Criteria	-Functionality Use Access Space -Build Quality Performance Engineering sys. Construction -Impact Character &Innovation Urban&social Integration Staff Environment	-Functionality Use Access Space -Build Quality Performance Engineering sys Construction -Impact Character &Innovation Urban &social Integration Staff & Patient Environment	-Functionality Client Operation Single Living Accommodation Innovation -Build Quality Performance Engineering sys Building Fabric Innovation -Impact Context&estate Planning Form&appearance Internal Environment Conversation of buildings Sustainability	-Location -Site Visual Impact Open space Routes &movement -Unit Size Layout Noise,light, services and adaptability Accessibility Sustainability -External environment Size	-Sustainable Sites -Water Efficiency -Energy and Atmosphere -Materials and Resources -Indoor Environmental Quality -Location& linkages -Awareness &education -Innovation in design -Regional Priority.	-Management Life cycle cost Site investigation -Health and well Being Lighting Water Noise control -Energy Co2 emissions Energy use Noise control -Transport Public Transport Cyclist Deliveries -Water Recycling Irrigation sys. -Materials Re-use Insulation -Landuse &Ecology Re-use Ecological value Bio diversity -Pollution Water sources Refrigerant leaks -Innovation	-Presentation -Space functionality -Access and circulation -Business services -Amenities -Working and environment -Health and safety -Structural considerations -manageability
<p>The tools use adapted Vitruvian frameworks which can be defined as functionality, build quality and impact, extended with ecological approaches like sustainability, health, wellbeing and preserving resources for assessment of architectural design quality. For assessment, design quality is seen as a degree of excellence within the intersection of the main criteria with their sub-criteria.</p>							
4)Adaptability /Flexibility	General adaptation (Not case specific)	General adaptation (Not case specific)	General adaptation (Not case specific)	General adaptation (Not case specific)	General adaptation (Not case specific)	Adaptability for each building type	No adaptability
<p>No flexibility to change or adapt the criteria for different tasks. General modifications or updates on the system take time to get in action in further versions, which makes it hard to adapt the tools case based specific</p>							
5)Methodology	Structured workshop, online form and questionnaires	Stand alone forms, Workshops	Stand Alone Forms Workshops (in some cases)	Stand alone forms	Online certification	Stand alone form	Software based survey
<p>The tools make assessment via standalone forms or in some cases with web based online surveys/questionnaires to reflect stakeholders' priorities. DQI, AEDET and DEEP also use workshops to get individual priorities. LEED, BREEAM, BQA use threshold levels for assessment of quality.</p>							
6)Scope of Assessment	Achieve the best building possible based quality.	Evaluate the quality of design in healthcare buildings.	Identify and minimize risk in the design of projects (MOD Building)	Measurement and assessment of potential and existing house schemes based quality	Accelerate the adoption of green building practices	Energy and sustainability	Assessment of Performance of a building
<p>DQI, DEEP,AEDET, HQI assess the design quality. LEED and BREAM certificates buildings related to energy usage and sustainability, while BQA assesses performance of a building</p>							
7)Phase of Building Process	All stages of building process including all design stages.	All stages of building process including all design stages.	All stages of building process including all design stages.	Design and in use	All stages of building process including all design stages.	Design and in use	Post occupancy evaluation (can be carried out to design stages)
<p>All tools claim that they can be used within the all stages of building process from briefing to in use. Although the tools are introduced as they can be used in any stages of the building process, they can be used effectively in post occupancy evaluation (POE).</p>							

8)Organization (stakeholders)	Internal and external stakeholders (Especially users)	Internal and external stakeholders	Internal and external stakeholders	Internal and external stakeholders	Commercial building project stakeholders or project team members	Internal and external stakeholders	Internal and external stakeholders
	The intention behind the tools on design quality is to get ideas for the stakeholders, especially from users, for the assessment of architectural design quality. Getting stakeholders ideas is a big plus to achieve success for integrated design teams, however transferring ideas to design process as knowledge for design teams can be underlined as missing part of the tools. Tools generally aim to score a building in general, rather than transferring knowledge to design teams.						
9)Weighting System	Likert/Rating Scale	Likert/Rating Scale	Likert/Rating Scale	Likert/Rating Scale, Yes/No Questions	Likert/Rating Scale	Likert/Rating Scale	Likert/Rating Scale
	All of the tools use adapted Likert/rating scale system for assessment. Some of them are using verbal scales while others use point scaling system. HQI also asks Yes/No questions.						

Table 1: Design quality assessment tools review.

Strengths

- Tools tend to be used for assessment of design quality in a wide variety of buildings, although there are still limitations.
- Criteria selection mostly are based on a Vitruvian like framework and sustainable principles often after extended discussions and many iterations before these terms were agreed upon.(Gann et al., 2003)
- Dewulf and van Meel (2004) stress that the recognized importance of the built environment makes it absolutely necessary to discuss design quality with laymen, architects, government and other stakeholders. Proving the statement, there is a growing intention of the tools to get stakeholders ideas, especially users, for assessment of architectural design quality. Reflecting stakeholders’ priorities in building processes is a big plus to achieve success for integrated design teams.

Weaknesses

- Although the tools can be used for different types of buildings and for different phases of building processes, it is still a problem to adapt the underlying system of the pre-defined sets of criteria (something all above mentioned tools have in common) for making a case base specific design evaluation.
- The tools have problems to contribute to design stages since they are not succeeded to make comparative assessment of design alternatives.
- Most often the tools must be used with expert facilitators, or are at least assumed to, which make assessment process tough considering total numbers of stakeholders and time needed.
- A big concern for all the tools reviewed is their weighting systems and their methodologies which they use for assessment. All the tools reviewed use a Likert/rating scale system, some of which use verbal judgments while the others use point system for scaling(HQI also uses Yes/No questions). Outcomes of the surveys related to assessment contain heterogeneous data since using this methodology it is not clearly known what the relative importance is of the each criteria and sub-criteria to each other.
- Another problem is the lack of consistency measurement. Consistency cannot be checked until a certain amount of participants exist. As the tools intend to get also non-expert stakeholders’ ideas, consistency should be considered and inconsistent surveys should be avoided.

Considering the above mentioned weak sides of the currently used tools, multi criteria decision making methodologies will be introduced and evaluated on their ability to cope with them. After the review of methodologies, a comparative chart of the most used methodologies will be introduced to cope with the weak sides of the current tools for further developments.

PROBLEMS OF LIKERT/RATED SCALE

It is hard to find a holistic way of an assessment approach of architectural design quality. Architectural design quality consists of tangible and intangible criteria which may be evaluated from different perspectives of the stakeholders. Who is going to assess the quality? For who are they going to do this and how are the solid questions to be answered? To point out problems of Likert/rated scaling which is used by most of the current tools related to assessment of design quality; rather than stating problems in theoretical ways, it should be better to make a short illustration to analyze problems in practice. Since architectural design is a one off attempt, keeping in mind that criteria may vary for each design problem, let us consider 20 criteria consisting of both tangible and intangible factors for assessment of architectural design quality for an existing building. (Table 2)

Criteria
C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11, C12, C13, C14, C15, C16, C17, C18, C19, C20

Table 2: Criteria List

Having defined the criteria, in the second step, tangible and intangible criteria are grouped separately. (table 3)

Criteria	
Tangible	C1, C3, C5, C7, C9, C10, C11, C12, C15, C18, C19, C20
Intangible	C2, C4, C6, C8, C13, C14, C16, C17

Table 3: Criteria List

Based on Likert/rated scale, for the third step, criteria are listed for quality assessment. The respondents are asked to assign weighting to the importance of each feature; on a scale of Excellent/5/Strongly Agree to Poor/1/Strongly Disagree called “Likert /Rated Scaling” which most of the current tools use as a methodology for design quality assessment.

Criteria	Excellent (5) Strongly agree	Very Good (4) Agree	Good (3) Undecided	Fair (2) Disagree	Poor (1) Strongly Disagree	No idea (0)
C1	+					
C2		+				
C3						+
C4		+				
.....						
.....						
C20			+			

AVERAGE	Average of the building is good/3/undecided
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Table 4: Likert/rated scale based assessment methodology

During the evaluation problems may be stated as:

- 1) Although tangible criteria may be evaluated with numeric values, according to Saaty(2008) intangible criteria cannot be evaluated numerically.
- 2) Since there is no hierarchic formation, every criterion is evaluated at the same level.
- 3) The relative importance of the criteria each other is not clear.
- 4) The consistency of the evaluation cannot be measured until a certain amount of participants exist.

For the next step, to cope with these problems stated above a hierarchic formation can be made. And also using weighting factors for evaluation may be added.

Weighting Factor	Main Criteria	Sub-Criteria	Excellent (5) Strongly agree	Very Good (4) Agree	Good (3) Undecided	Fair (2) Disagree	Poor (1) Strongly Disagree	No idea(0)
3	C1		+					
2		C5				+		
3	C2							+
2		C4		+				
1		C6						
.....						
4	C3				+			
2		C20			+			
AVERAGE			Average of the building is good/3/undecided					

Table 5: Likert/rated scale based assessment methodology-Hierarchy and weighting factors added

Although Hierarchy is formed, weighting factors are defined, there are still problems which may be stated as:

- 1) Still tangible and intangible criteria are evaluated with numeric values.
- 2) The relative importance of the criteria although they are hierarchically formed is still not known.
- 3) To assign weighting factors for the importance of each criterion is problematic since humans can only evaluate 5-9 factors in one task depending on Miller's (1956) famous theorem.
- 4) The consistency of the evaluation cannot be measured until a certain amount of participants exist

Pair wise compared MCDM based methodology will be introduced to cope with the problems stated above in further chapters of this paper.

MULTI-CRITERIA DECISION MAKING

Multi-criteria decision making (MCDM) methods deal with the process of making decisions in the presence of multiple criteria. Decision-makers are required to choose among quantifiable or non-quantifiable and multiple criteria. The objectives are usually conflicting and therefore, the solution is highly dependent on the preferences of the decision-maker and must be a compromise (Pohekar and Ramachandran, 2004). Priority based, outranking, distance based and mixed methods are also applied to various problems. Each method has its own characteristics and the methods can also be classified as deterministic, stochastic and fuzzy. There may be combinations of the above methods. Depending upon the number of decision makers, the methods can be classified as single or group decision making methods. Most used MCDM methods are AHP, ANP, PROMETHEE SAW and TOPSIS. (Pohekar and Ramachandran, 2004) (Triantaphyllou et al., 1998) (Özcan et al., 2011)

Considering its internal and external stakeholders, architectural design can be defined as an affective decision making process which is dynamic: a complex search for information, full of detours, enriched by feedback from casting about in all directions, gathering and discarding information, fuelled by fluctuating uncertainty, indistinct and conflicting concepts (Zeleny, 1982). Although methodology of current quality assessment tools shall be notified as MCDM to some degree, MCDM methods will be reviewed to cope with their ability to assess architectural design quality while keeping in mind the weaknesses of current tools as stated above.

Analytic Hierarchy Process (AHP)

The analytic hierarchy process (AHP) (Saaty, 1980, 1990) is based on decomposing a complex MCDM problem into a system of hierarchies. The pairwise comparison matrix is constructed by using the relative importance of the alternatives in terms of each criterion. The vector $(a_{i1}, a_{i2}, a_{i3}, \dots, a_{iN})$ for each i is the principal eigenvector of an $N \times N$ reciprocal matrix which is determined by pairwise comparisons of the impact of the M alternatives on the i -th criterion (Triantaphyllou et al., 1998). AHP is based on three main principles a) Forming Hierarchy b) Determining supremacies c) Numeric and logical consistency (Topçu, 1999). AHP is an effective method of dealing with complex problems.

Analytic Network Process (ANP)

The ANP, also introduced by Saaty, is a generalization of the AHP (Saaty, 1996). While the AHP represents a framework with a uni-directional hierarchical relationship, the ANP allows complex interrelationships among decision levels and attributes. Related to Yüksel and Dağdeviren (2007), Maede and Sarkis (1998) define that the ANP feedback approach replaces hierarchies with networks in which the relationships between levels are not easily represented as higher or lower, dominant or subordinate, direct or indirect. For instance, not only does the importance of the criteria determine the importance of the alternatives, as in a hierarchy, but the importance of the alternatives may also have an impact on the importance of the criteria. (Yüksel and Dağdeviren, 2007)

Preference Ranking Organization METHod for Enrichment Evaluation (PROMETHEE)

PROMETHEE, proposed by Brans and Vincke (1985), builds outranking relations among alternative pairs. An outranking relation is defined in the set of alternatives such that alternative a outranks alternative b if there are enough arguments to decide that a is at least as good as b , while there is no essential reason to refute that statement. There are two extensions

of the method: PROMETHEE I yields partial rankings (incomparability is allowed), on the other hand PROMETHEE II yields complete rankings.

Simple Additive Weighting (SAW)

SAW method calculates a global (total) score for each alternative by adding contributions of alternative with respect to each attribute (Yoon & Hwang, 1995; Vincke, 1992). A common numerical scaling system such as normalization (instead of single dimensional value functions) is required to permit addition among attributed values. Then alternatives are ranked by using their global scores.

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)

TOPSIS method evaluates alternatives according to their distance to positive and negative ideal solutions (Yoon & Hwang, 1995; Hwang & Ming, 1987). An alternative that would be recommended to the decision maker(s) should have the shortest distance from the positive ideal solution and the longest distance from the negative ideal solution. Positive and negative ideal solutions are imaginary alternatives. A positive ideal alternative has the best performance value for each attribute while a negative ideal alternative has the worst.

ANALYSIS OF MCDM METHODS FOR POTENTIALS OF DESIGN QUALITY

	AHP	ANP	PROMETHEE	SAW	TOPSIS
Decision Making	Individual and group	Individual and Group	Individual and Group	Individual and Group	Individual and Group
Methodology	Creating hierarchical structure and pairwise comparison matrices	Creating network structure and pairwise comparison matrices	Creating matrix structure and comparing pairs of alternatives to form an outranking relation	Creating matrix structure and calculating a global (total) score for each alternative by adding contributions of alternative with respect to each attribute	Creating matrix structure and calculating distance to positive and negative ideal point
Areas of Usage	To support decision making for complexity	To support decision making for complexity	To support decision making for complexity	To support decision making for complexity	To support decision making for complexity
Adaptability/Flexibility	+ easy to adapt case specific	+ easy to adapt case specific	- not easy to adapt	- not easy to adapt	- not easy to adapt
Consistency Measurement	+	+	No need	No need	No need
Weighting System	Pair Wise comparison	Pair Wise comparisons	No specific method.	No specific method.	No specific method. Linear or vector normalization
Criteria Evaluation	Tangible and intangible criteria	Tangible and intangible criteria	Tangible criteria	Tangible criteria	Tangible criteria

Pros	Can give consistent results for every decision making process	Easy to implement, expressive power of modeling	Low level of interaction with decision maker (It may be defined as a negative issue for integrated design teams for assessment of design quality)	Low level of interaction with decision maker (It may be defined as a negative issue for integrated design teams for assessment of design quality)	Low level of interaction with decision maker (It may be defined as a negative issue for integrated design teams for assessment of design quality)
Cons	Linear evaluation	Several pairwise comparison questions. Complex survey process for non-expert participants	Identifying thresholds, incomparable results	Very easy, can give unreliable results	Easy, can give unreliable results

Table 6: Multi Criteria Decision Making Methods(MCDM) comparison

MCDM tools as described above are not used for imposing solutions to the decision makers. They aid decision makers to make decisions under the consideration of evaluation criteria. Their methodologies vary in their ability to cope with problems of design quality assessment in case of multi stakeholder decision making. Related to review above it might be stated that MCDM methodologies, especially the ones using pair wise comparisons, have the potentials to cope with most weaknesses of the current tools stated in the previous chapters.

Design and architecture may be listed amongst the wide variety of domains which MCDM methods are used. Some of the researches and studies (Binnekamp, 2010; Loon and Wilms,2006; Heurkens, 2006, leeuwen and timmermans-editors-, 2006) may be notified as instances/models for usage of MCDM methods in the design domain related to urbanism and architecture. Although several approaches of usage of MCDM for design and design processes are reported, there is no architectural design quality assessment tool in the literature found which is widely used and broadly accepted using MCDM methods based on pairwise comparisons.

PAIRWISE COMPARISON

Saaty (2008) states that “Numerical measurement must be interpreted for meaning and usefulness according to its priority to serve our values in a particular decision. It does not have the same priority for all problems. Its importance is relative”. To cope with the complexity of assessment of architectural design quality, a systematic approach based on Simon’s idea may be formed. Simon(1969) in his famous book- Sciences of Artificial - defines the shape of design as a hierarchy. He believes that to design a complex structure, one powerful technique is to discover viable ways of decomposing it into semi-independent components corresponding to its many functional parts. Considering his statement as a base, to cope the complexity of assessment of architectural design quality, decomposing the quality in criteria and sub-criteria hierarchically may be a fruitful approach. Using pair wise

comparison based approaches instead of Likert/rated scale which as used by all the current tools discussed, may provide better results to cope with many of the weaknesses listed above.

Underlying factors to use pair-wise comparison rather than Likert/rated scale can be endorsed by Saaty’s notifications as follows: “Long before measurement scales were invented, people had no direct way to measure because they had no scales and had to compare things with each other or against a standard to determine their relative order. People still have that ability, and it is still critically necessary to be able to make comparisons much of the time, especially when they cannot measure things. One reason may be that people do not have the instrument or scale to do it. Another reason is that they may believe that the outcome of comparisons using their judgment would be calibrated better to their values than using a scale of measurement that was not devised particularly for the use they are putting it to. A third reason may be that there is no way known to measure something like: political effectiveness, happiness, aesthetic appeal. Ancient people used their judgment to order things. The way they did it was to compare two things at a time to determine which was the larger or more preferred. By repeating the process they obtained a total ordering of the objects without assigning them numerical values. After being ordered they could rank them: first, second, and so on”. (Saaty, 2008)

20 criteria set illustration which was implemented for Likert/rated scale in previous chapter of the paper can be adapted to pair wise comparison matrix. (table 8) Main criteria (c1,c2,c3) and sub-criteria (c4, c5, …,c20) can be ordered hierarchically. Hierarchically structured criteria and sub-criteria regardless of whether they are tangible or intangible can be pair wise compared. If it is needed, it is also possible to evaluate the alternatives. By using MCDM methods, for instance AHP or ANP, consistency can also be measured.

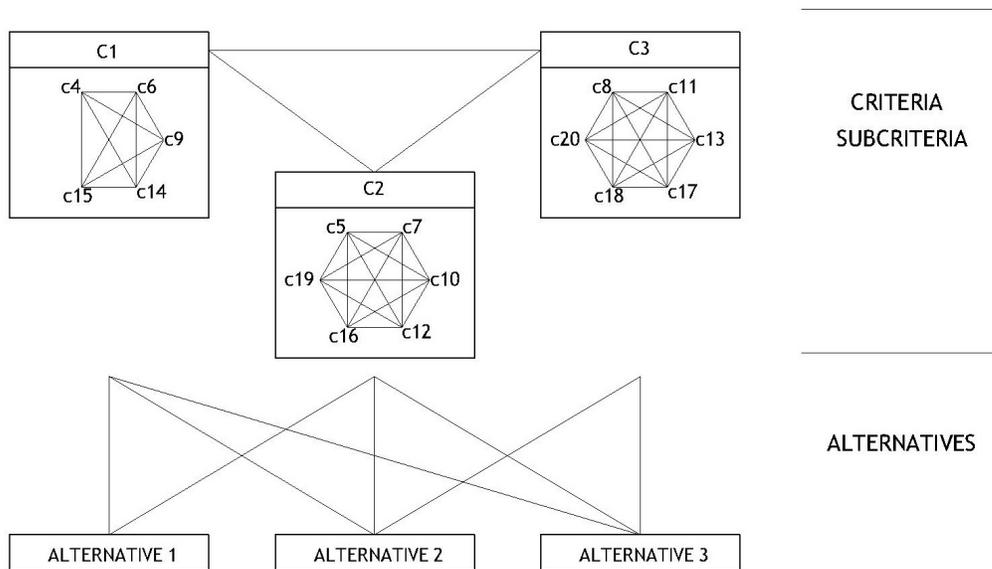


Table 7: Pair wise comparison

By using pair wise comparisons method:

- Criteria and sub-criteria can be grouped hierarchically. So related ones can be compared.
- Tangible and intangible criteria can be evaluated. (Saaty, 1980, 1990, 2008)
- Relative importance of the each criteria and sub-criteria to each other can be defined.

- If it is wished design alternatives can be evaluated.
- It is possible to add decision makers with weighting factors which makes group decision making available.
- Consistency levels of priorities of non-expert stakeholders can be measured with limited amount of participants.

MCDM methods, especially the ones using pair wise comparisons, may bring out relative importance of the criteria of preferences of stakeholders related to architectural design quality. They may be adapted easily for each step of building process mostly to design stages to evaluate alternatives within the design process.

CONCLUSION

This paper has begun by noticing significant problems of quality assessment tools in building processes mostly about architectural design quality assessment. Having remarked weaknesses of current assessment tools and major problems for their methodologies, outcomes to be used further about quality assessment can be listed as below:

- As there is not a universal definition for quality, tools to be created for architectural design quality assessment should consider a flexible/adaptable system for criteria selection. Criteria must be adapted for different building types, for the different phases of the building process and for different project teams.
- Reflection of the ideas of stakeholders to building processes is a big plus for integration. Tools to be designed for design quality should consider adapting stakeholders' preferences accurately into the building design process.
- As design is a complex decision making process, MCDM methods, especially the ones using pair wise comparisons, can be used/adapted for architectural design quality assessment to overcome the some of the weaknesses all current tools seems to have in common. To help designers to get stakeholders ideas into the design process, rather than using Likert/rated scaling system, pair wise comparisons can be used instead to evaluate criteria and sub-criteria. Otherwise the score of assessment will contain heterogeneous data which cannot be transferred to knowledge for design teams. Also consistency should be considered in case of data gathering.
- Assessment tools must put out not only assessment scores but must also provide methodologies about transferring the data to be used as knowledge within the design process by design teams.

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