International Journal of New Technology and Research (IJNTR)
ISSN:2454-4116, Volume-2, Issue-2, February 2016 Pages 34-42

Towards Environmentally Responsive Educational Buildings: A Framework for User-Centered Post Occupancy Evaluation (POE)

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Abstract— **Post occupancy evaluation (POE) is defined as the process of evaluating building systematically and comprehensively after user occupied. What makes this process differs significantly from other conventional surveys is that it uses the direct, unmediated experiences of building users as the basis for evaluating how a building works for its intended use. Focusing mainly on building users and their needs, provides them with the opportunity to participate in the evaluation process, and this makes them take more ownership in the building.**

This paper reviews approaches used in carrying out post occupancy evaluation process in educational buildings. It focuses on evaluating the environmental aspects as the core interest of users. It develops a framework for user-centered post occupancy evaluation that correlates a combined set of environmental assessment aspects, to evaluation methods and techniques classified as either qualitative or analytical. Finally, another dimension is added to this framework by ranking the evaluation methods and techniques regarding the degree of user involvement.

Index Terms—**Educational Buildings, Environmental Aspects, Post Occupancy Evaluation (POE), POE Framework**

I. Introduction

According to the User Centered Design (UCD) philosophy, prospective end-users should be given a central role in a design process. The foremost purpose of including users in the design process is to get better insights into future use situations in order to design products, services or forms of organisation that meet the users' needs [1]. Accordingly, involving users, their preferences, and their knowledge in architectural, engineering, and construction (AEC) projects is gaining importance. This is due to a number of recognized gaps between the demand from the users, or 'the planned', and the design provided by architects.

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In addition, the increasing difficulties in achieving the usability caused by condensed workspaces, users' demands for their participation, and evidence of the benefits of user involvement in the manufacturing industry add another dimension for this approach [2]. Thus, various methods of user involvement, such as quality function deployment (QFD), post occupancy evaluation (POE), and ergonomic design, have been developed and used in AEC projects [3].

In this regards, post occupancy evaluation (POE) is not seen as the end phase of a building project; rather, it is an integral part of the entire building delivery process. It is also part of a process in which a POE expert draws on available knowledge, techniques, and instruments in order to predict a building's likely performance over a period of time [4]. Perhaps one of the areas in which POE has a most compelling role, and is also most likely to make inroads in institutional terms, is in the design and construction of schools. As opposed to private and corporate construction processes, schools are in the public domain and need to balance utility and innovation and, in many districts, must respond to serious public accountability [5]. Historically these evaluations consider the facility's physical condition, usage (as a function of area appropriated for each type of use, e.g. classroom, music room, cafeteria, student lounge) and energy use by using POE and evaluation database programmes usually facilitated by professional assessors.

Involving users as a pivot in POE process implies taking the interrelationships between different categories of key performance indicators into consideration [5]. Since school buildings are very complex systems, and their interaction with occupants further compounds the complexity of possible interrelations and potential malfunctions, it is imperative that the study of building post occupancy be based on a multi-level, multifaceted system of checks and tests. These should involve thermal comfort alongside heating, ventilation and air-conditioning; illumination and visual comfort; occupants' satisfaction and behaviour; and, not least, physiological and psychological comfort, since all of these issues together will affect energy consumption and human well-being.

II. The Impact of School Environment

It is commonly examined through Literature that school environment affects more than academic performance—it influences students' emotions and health behaviors as well [6]. Students, who feel socially connected to others, in schools that hold them to high academic standards, are more engaged in their education. A positive school environment

enhances motivation, increases educational aspirations and improves attendance and retention. Contrarily to this, an unhealthy school environment is a likely setting for high absenteeism, misbehavior and interpersonal aggression. A large study found that in schools that were more communal, there were lower dropout rates and less class cutting and absenteeism.

It is evident that school climate is a key ingredient in academic success. Positive school environments not only engage students academically but they are also strongly associated with a range of positive health and behavioral outcomes. From an extensive review of school climate materials, four components emerge as being critical for successful schools: caring, safety and structure, academic rigor and support, and participation [6].

- Caring Environment: a precondition for learning, a positive school environment is built upon caring relationships among all participants-students, teachers, staff, administrators, parents and community members.
- Safe and Structured Environment: in a safe, structured environment, students can focus their attention on learning. Many factors combine to promote a feeling of safety, ranging from the physical environment to discipline policies to perceptions of fairness.
- Academic Environment: a sense of belonging is important to student success, but it alone is insufficient to produce desired outcomes. School leaders need to create an environment that is focused on excellence in teaching and learning-and communicate this emphasis to students, teachers and parents.
- Participatory Environment: a more positive school environment is created when all stakeholders feel they are contributing to the school's success. This process begins with leadership and a shared agenda, both clearly defined and clearly communicated. Leadership at its best is not confined to teachers and administrators but also involves parents and students in decision making and planning.

III. Measuring School Environment

Evaluating the school environment presents powerful opportunities to discover and address issues that undermine learning and healthy development. The evaluation process itself has the potential to promote a more positive school environment, particularly when students are empowered as resources for information.

Before an evaluation process begins, performance evaluators should consider the intense effort required to gather and analyze the information—and plan in advance how they intend to use the results. However, there are many ways to measure climate, but they fall broadly into two categories, direct and indirect [6].

A. Direct measures include:

- Surveys or interviews that crave information from various Stakeholders; students, teachers, staff, parents and community members. A number of predesigned survey forms could be used and modified according to the specific typology of the examined school. A list of these forms includes the followings:
- School Climate Profile: One of the most frequently used measures of school climate; it assesses the strengths and weaknesses of a school climate from the students' perspective.
- The Comprehensive Assessment of School Environments (CASE)
- The Comprehensive School Climate Inventory (CSCI)
- The Organizational Climate Descriptive Questionnaire (OCDQ)

B. Indirect measures include

- Analyzing student records for attendance, office referrals and suspensions
- Observing the physical environment, with attention to noise levels, cleanliness, hallway and classroom appearance
- Observing classrooms and interpersonal interactions
- Using the School Climate Observation Checklist adapted from "Skills for Successful School Leaders," AASA, [7].

IV. Evaluation Aspects and Standards

The last decade of the 20th Century witnessed an emergence of the green building, or high-performance, building movement. Largely fueled by the launch of a new green building rating system, LEED (Leadership in Energy and Environmental Design) in 1998, this new movement grew significantly in the early 2000s, and today is largely acknowledged to be one of the most significant influences on school design and construction in recent years [8], [9]. Along with the LEED standards, the Collaborative for High Performance Schools developed its design criteria, based on LEED but written initially for school facilities in California [10]. These standards and organizations promote the responsible use of energy and natural resources while providing the user with healthy indoor environmental conditions. A detailed study of the internal environmental aspects is conducted approaching; ventilation, heating and air quality, lighting, and acoustics [11].

A. Ventilation, Heating and Air Quality

In recent years, the studies have largely reached a shared agreement about the basic needs of classrooms in terms of heating, ventilation and air quality, but some questions still remain. As noted, "students will perform mental tasks best in rooms kept at moderate humidity levels (forty to seventy percent) and moderate temperatures in the range of twenty to twenty-three Celsius (sixty-eight to seventy-four degrees Fahrenheit") [12]. There is also growing appreciation of the need to keep CO2 levels below a certain level, although there is still some disagreement as to whether 1500 or 1000 ppm is the safe maximum level (ventilation researchers prefer 1000 ppm, while practitioners often cite 1500 ppm) [13].

In regards to air quality, research in the 1990s and 2000s has found that many schools in the U.S. have significant problems with particulate matter and other air pollutants, leading some to speculate about the effect school air quality may have on growing asthma rates in children [14]. However, scholars have noted that the research in this field is not conclusive, due to the paucity of well-controlled studies looking carefully at the effects of specific air quality factors [15].

Today, ASHRAE continues to support research investigating the connection between outdoor air supply and student performance, but ASHRAE Standard 62 (now 62.1)

still uses the rate established by research from 1936, of 10 cfm per person as its minimum acceptable outdoor air ventilation rate [16].

Another major development in the realm of thermal comfort and ventilation is the growing use of natural ventilation and mixed-mode systems and associated adaptive thermal comfort standards [17]. While these methods and standards are new to today's designers, they largely follow the inherent logic laid out by Hamlin over a century ago, when he declared that no artificial systems could ever take the place of fresh air and sunshine [11]. The adaptive model of thermal comfort incorporates the goals of energy conservation and indoor environmental quality through work done by Brager and DeDear which shows that occupants in naturally ventilated environments (who necessarily have control over their window openings) have larger ranges of comfort in regards to temperature [17]. This research has contributed to major changes in ASHRAE Standard 55 for Human Thermal Comfort (ASHRAE, 2010a). It has coincided with a design trend towards reconsidering the possibilities of ventilating classrooms naturally (or with mixed-mode systems), to which significant research is now being conducted [18].

B. *Lighting*

Although illumination standards for classrooms have largely leveled off in recent years, there is still some disagreement about even the most basic question of how much illumination is necessary in classrooms. For example, the current ASHRAE Advanced Energy Design Guide, which is supported by IESNA (the former Illumination Engineering Society is now called the Illumination Society of North America), advocates for anywhere between 30 and 70 footcandles (323-753.5 lux) for classroom spaces, while the IESNA guidelines for classrooms still use 50-100 footcandles (538.2-1076.4 lux) as a guideline [19]. Still, this disagreement is largely overshadowed by other concerns regarding quality and distribution of light, as well as specific issues in daylighting design. Contemporary research and thought regarding lighting in classrooms has largely focused on the need for performance-based standards that accurately represent both illumination and visual comfort metrics. There has been considerable debate about the appropriate metrics for daylighting in particular, as the studies has moved back towards the desire for naturally lit spaces [20].

Research on lighting in classrooms in the past 20 years has also had a significant impact on practice, since a recovery of findings in the value of natural light have emerged [11]. For example, one study in 1992 looked at cortisol (a hormone) production and concentration abilities in students without access to natural light, and found that natural light was positively correlated with this important hormone [21]. In 1999, another important study was published on daylighting in classrooms. This study can certainly be credited with having had a significant impact on the industry, as it was one, if not the, major study cited to support the notion that high-performance school buildings can have a positive impact on student learning [22].

Recent years have seen increasingly convincing studies on the importance of daylighting. Still, the major barrier remains that while expert lighting designers and researchers have a sense of what a good visual environment should look like, and how one might measure these lighting and daylighting phenomena, no simple standard has yet been developed to clearly specify the performance standards needed for the industry to respond accordingly. As such, the past two decades have produced many school buildings with sufficient natural light but little attention to issues of visual comfort and glare. Initial research findings are indicating that occupant comfort is often sacrificed in these spaces, but more research is needed to corroborate this finding [11], [23].

C. *Acoustics*

Research conducted in the 1980s and 1990s greatly contributed to understanding of the necessity of good acoustical conditions in classrooms [11]. A number of studies, which covered the importance of low background noise level, speech intelligibility and the avoidance of sites with periodic acoustic disruptions (sites near airports, train lines, etc) helped to identify not only that acoustics mattered, but also the appropriate thresholds for acoustical standards [24], [25].

These studies all contributed to the launching of ANSI Standard 12.60 in 2002, a standard written by the Acoustical Society of America, which has since been adopted into the LEED standards for school buildings and a variety of other related performance standards for buildings (Acoustical Society of America (ASA), [26]. This standard calls for a maximum background noise level of 35 dBa in standard classrooms, with reverberation times between 0.6 and 0.7 seconds, along with guidance and specifications for Sound Transmission Class ratings for exterior and interior wall assemblies, and Impact Insulation Class ratings to address floor-to floor noise transmission. It is considered to be a very comprehensive standard, and is the first of its kind for any typical building space type (there is no such standard for office buildings, hospitals or other similar spaces, although some of these standards are in development) [11].

V. Framework for User-Centered POE

Users are the focus of any buildings' evaluation process and the items to be evaluated is related to their activities. The proposed framework investigates the relationships between different areas and aspects where the users are involved in POE process. It correlates number of evaluation aspects -extracted out of well-established approaches used in building assessment- to POE's methods and techniques used in practice. This part of the study focuses on the aspects related to environmental performance of the educational buildings and the most appropriate methods used to collect data regarding these aspects.

A. *Assessment Approaches and Evaluation Aspects*

There are differences between the quantitative and qualitative aspects of building performance and the respective performance measures. Many aspects of building performance are in fact quantifiable, such as lighting, acoustics, temperature and humidity, durability of materials, amount and distribution of space, and so on. Qualitative aspects of building performance pertain to the ambiance of a space (i.e., the appeal to the sensory modes of touching, hearing, smelling, and kinesthetic and visual perception, including color). Furthermore, the evaluation of qualitative aspects of building performance, such as aesthetic beauty or

visual compatibility with a building's surroundings, is somewhat more difficult and subjective and less reliable [27].

Sub goals of building performance may be structured into three performance levels pertaining to user needs [4]: the health-safety-security level, the function and efficiency level, and the psychological comfort and satisfaction level. With reference to these levels, a sub goal might include safety; adequate space and spatial relationships of functionally related areas; privacy, sensory stimulation, or aesthetic appeal. For a number of sub goals, performance levels interact and may also conflict with each other, requiring resolution.

For each setting and occupant group, respective performance levels of pertinent sensory environments and quality performance criteria are required (e.g., for the acoustic, luminous, gustatory, olfactory, visual, tactile, thermal, and gravitational environments). Also relevant is the effect of radiation on the health and well-being of people, from both short- and long-term perspectives.

As indicated earlier, occupant needs versus the built environment or products are construed as performance levels. A three-level breakdown of performance levels reflects occupant needs in the physical environment. This breakdown also parallels three basic levels of performance requirements for buildings (i.e., firmness, commodity, delight), which the Roman architect Vitruvius had pronounced.

These historic constructs, which order occupant needs, were transformed and synthesized into the "habitability framework" [28], by devising three levels of priority.

- Health, safety, and security performance;
- Functional, efficiency, and work flow performance; and
- Psychological, social, cultural, and aesthetic performance.

These three categories parallel the levels of standards and guidance designers should or can avail themselves of. Level 1 pertains to building codes and life safety standards projects must comply with. Level 2 refers to the state-of-the-art knowledge about products, building types, and so forth, exemplified by agency specific design guides or reference works such as Time-Saver Standards: Architectural Design Data [29]. Level 3 pertains to research-based design guidelines, which are less codified but nevertheless of importance for building designers and occupants alike.

1) Assessment Approaches

This part of the study presents four approaches for school building assessment; Functional Assessment, Inclusive Assessment, Self-Guided Tour Assessment, and Comprehensive Assessment. Each of these approaches is developed based on a conceptual understanding to the interrelationships between items of assessment [30].

a) Functional Assessment

This method tackles an approach that deals mainly with functional aspects, the most important being utility value and experiential value, i.e. the experiences and requirements of the people who use the building day by day. The evaluation assigns values to such items as the basic layout and the layout of individual rooms, the way the general form is perceived, the interior climate and behavioral factors (use of space, privacy, social contact, spatial orientation, etc.). Design is generally either treated as an 'independent variable' or evaluated autonomously. Technical aspects (load-bearing structure, technical services, etc.) are only taken into account to the extent that they affect use and the well-being of the users.

This approach determines evaluation aspects based on a vision of a functional building as one that is suitable for the activities for which it was intended [31]. The users inside the building must be able to function efficiently, comfortably, healthily and safely. However, this also means that they must be able to reach and get into the building easily and move round the building comfortably. The building must be sufficiently in harmony with human perceptions –in the way it looks, sounds, smells and feels. The users must also feel physically comfortable, which means that the building must not be too hot or too cold nor must it be dirty, dark or noisy. They must be able to see how the parts of the building fit together and be able to find their way round. All psychological needs must be taken care of, e.g. the need for privacy, social contact, freedom of choice and autonomy. The building must also be capable of being adjusted to suit changing circumstances, new activities and different users.

With this as a basis, the concept of functional quality is divided into nine evaluation aspects: [31]. These aspects are as follows: Reachability and parking facilities, Efficiency, Accessibility, Flexibility, Safety, Spatial orientation, Privacy, territoriality and social contact, Health and physical well-being, and Sustainability. Regarding the focus of this paper, the functional approach determines the detailed items of "Health and physical well-being" aspect as follows [30]:

- Light
  - The quality of the light (daylight, artificial light, sunlight),
  - The quantity of light (to allow things to be seen properly and to avoid dazzle and excessive contrast between light and dark),
  - The direction of the light and the color of the light.
  - The properties of the surroundings (affect the way light is perceived)
  - The way light is reflected (depending on color and the material used)
  - The extent to which the users can influence the lighting themselves.
- Noise
  - Does the distraction from noise in this part of the building have a negative effect on your work performance?
  - Is there significant distraction from noise outside the space?
  - Is there significant distraction from background noise?
- Air quality
  - Does the quality of the air in this part of the building have a negative effect on your work performance?
  - Is the air fresh or stale?
  - Is the air humid or dry?
  - Is there air movement?
  - Do you have control over ventilation?
- Temperature
  - Does the temperature in this part of the building have a negative effect on your work performance?
  - Is the temperature in winter too cold or too hot?
  - Is the temperature during the summer too cold or too hot?
- Cleanliness
  - How clean is the building?

b) Inclusive Assessment

This method is developed by The Council of Educational Facility Planners International to perform the post occupancy evaluation for elementary school. This method depends on an approach that evaluates both functional and educational facilities [30].

It breaks down sub-items related to:

- Building Features,
- Safety and Security,
- The School Site,
- Educational Adequacy, and support area.

As the focus of this study, the subdivision of evaluation aspects related to the environmental performance are classified under the items: Building features, and Educational Adequacy, and support area as follows:

- Building Features
  - Building details, color schemes, material, and décor are aesthetically pleasing.
  - Year-round comfortable temperature is provided throughout the building.
  - Ventilation system provides adequate circulation of clean air.
  - Mechanical systems operate quietly and don't disrupt learning areas.
  - Building acoustics provide for appropriate ambient noise levels.
  - Quantity and quality of windows contributes to a pleasant environment.
- Educational Adequacy
  - Lighting is sufficient for tasks.
  - Light switching is conveniently located.
  - Room lighting levels can be controlled for audio-visual presentations.

c) Self-Guided Tour Assessment

The self-guided tour assessment is used as an approach for developing a deeper understanding of the school environment [30]. Unlike other assessment strategies that rely upon conventional social science techniques for describing and judging the environment, the Six Factor School Building Assessment offers individuals and groups a procedure for taking a structured walk through and around a building. This is an impressionistic approach that increases people's awareness of the environment by focusing on observable factors. The results of such a walk-through encourage responses about views, walkways, barriers, orientation, wayfinding and appearance.

Tom Markus, in his book, Buildings and Power [32], describes the distinct elements of buildings to be form, or what things look like; what people do in the building; and how we sense where we are, in what relation to other spaces inside and outside the building. Observers using this checklist appraise visual and spatial quality in terms of six key elements [30]. --context, massing, interface, wayfinding, social space, and comfort. Any building or group of buildings is amenable to such appraisal. By using a series of checklist questions and a rating scheme, each factor is appraised. The process requires comments to supplement the factors described in the checklist.

The answer for four questions is responsible for determining the quality of environmental related aspects. These questions are:

- Do the learning spaces in the building suit an individual's thermal comfort?
- Is there an ability to adjust thermal comfort on an individual basis?
- Does the light level in the building support learning spaces?
- Is the noise level in a typical learning space distracting?

d) Comprehensive Assessment

The School Building Rating Scale is considered a comprehensive assessment tool. It is performed in two complementary scales; macro and micro one. The former is concerned with the school building as a whole while the latter is focused on the classroom as the building entity. This qualitative assessment tool is organized into categories that are essential components necessary for meeting the demands of an optimum learning environment. Regarding the macro scale, the components of the rating scale include physical features, outdoor areas, leaning environments, social areas, media access, transition spaces and circulation routes, visual appearance, and safety and security. Fifty-five statements pertaining to the school building are rated by building users such as students and school staff. The rating scale is based on a continuum from very unsatisfactory (VU) to very satisfactory (VS). Since all the criteria are based on qualitative impressions of the school environment, perceptual differences are bound to occur between students and school staff [30].

B. Evaluation Techniques

A range of techniques can be used to carry out an evaluation. The relevance of a technique depends upon, the following items [33]:

- The level of detail required;
- The level of information available;
- The resource available in terms of time and money;
- How quickly the study is to be carried out;
- The skill levels of those who will be undertaking the study;
- The extent to which a problem has already been identified.

The most accurate evaluation can usually be gained from employing a combination of techniques, e.g. a widely circulated questionnaire with a focus group to examine in more detail any major problem identified by the questionnaire survey. According to the higher Education Funding Council for England [33], a number of precautions have to be taken into consideration while using these techniques. One of these points is to be holistic (consider the interplay between the physical environment, facilities provision, and organizational attitudes). Another important point is to use transparent methodology so that results can be interpreted with the appropriate degree of assurance, limitations can be understood, and repeatable if benchmarking is to be undertaken.

1) Walk through and observation

This can use both observation, reflecting on how space is performing, and informal discussions with users to identify conflicts.

- Advantages
  - Few staff resources needed
  - Can be done without any end user involvement or inconvenience
  - Can provide quantitative data if designed appropriately
  - Enables unbiased view
- Disadvantages
  - Methodology may demand rigorous application e.g. observations at particular times of the day
  - Comparison can be difficult unless observer is given a methodology to apply

2) Interviews

Interviews with individuals are a useful way of getting very specific, detailed information and developing a deeper understanding of particular problems. They are best facilitated by a professional who is able to be objective. Whilst there needs to be a focus to an interview they are often most useful when conducted with a loose agenda, allowing free discussion to pick up issues that may not be initially obvious. Interviewees must be carefully selected to provide a balance of perspectives.

- Advantages
  - Detailed exploration of issues
  - Fine grain of detail and insights can be generated
  - Target very specific knowledge
  - Easier to arrange meetings with individuals than groups
- Disadvantages
  - Specific opinions do not necessarily represent broad views
  - Biased response likely
  - Cannot benchmark
  - No anonymity

According to literature, there are broadly two ways of carrying out interviews [33]. A structured interview where there are very specific questions or the semi-structured interview where there is an agenda of questions and issues, but allows the discussion to develop which may identify issues not already established.

Interviews should last no more than one hour and be preceded by a visit to the area of the building where the interviewee works making notes about any unusual features of the space which could impact on the views given. In addition each interviewee should be given an agenda which explains the purpose of the investigation and issues to be covered in the interview.

3) Focus Groups

Focus groups are a good way of drawing out information on a range of topics. Often they are a useful adjunct to a questionnaire survey where the responses to that have identified key problem areas but you need to get more qualitative information on them to understand the problem.

- Advantages
  - Management time needed to prepare is less than for questionnaire survey
  - Involves relatively in few people
  - Enables specific issues to be addressed in detail
  - Interactions between attendees enables deeper insights
  - Flexibility of coverage, agenda can allow issues to be explored as they are uncovered
  - Useful for teasing out broad issues uncovered by questionnaire survey
- Disadvantages
  - Expert facilitation needed
  - Qualitative data lacks statistical rigour of survey questionnaire
  - Bias of those who attend – therefore selection of attendees critical
  - No anonymity – people may be reticent to say what they think

According to literature, a good focus group size is 6-8 people [33]. Groups of this size are manageable and it enables the facilitator to get input from everyone present at the same time as getting a broad range of views. A maximum length of 1 hour enables attendees to feel that they can devote time to it and usefully contribute. If the sessions are longer then breaks would be necessary which would break the flow of the session. It is important to consider the selection process and identify the right mix of people. For example do you include both staff and students? Do you need to be careful of some dominant personalities? It is important that the selection is made objectively. Voluntary attendance may bias the responses.

4) Questionnaires

Questionnaires are a valuable way of collecting data from a large group of people. It is important to consider whether a standard or tailored questionnaire is required. Standard questionnaires offer the advantage of being able to gather consistent data across different facilities. The benefit of this is that it can benchmark buildings, or parts of buildings against each other. A standard questionnaire that is available from expert consultancies enables benchmarking a building project against others in the sector.

Tailored questionnaires enable examination of issues specific to the building or institution. However, these two approaches could be combined and standard questionnaire with a section that is prepared specifically to the facilities circumstances could be used altogether.

- Advantages
  - Generates detailed quantitative data from end users
  - Allows performance benchmarking
  - Problems can be geographically pinpointed (i.e. where in building respondent works)
  - Obtains a broad based opinion
  - Anonymity can be given
  - Enables comparative surveys to identify trends and responses to remedial action
- Disadvantages
  - Requires skilled design
  - Requires careful administration to ensure response
  - Requires staff time to complete
  - Requires skills to analyze and interpret responses

To guarantee the accurate feedbacks, it is of special importance to identifying the sample; consider which categories of people from whom responses are needed, the number of responses needed to maintain some statistical consistency and where they are located or which parts of the building they use. To get a large enough response it is important that people can complete the questionnaire within

20 minutes at the most. It is also important to ensure that collected soon then they are more likely to complete them

Table I. The Framework for User-Centered Post Occupancy Evaluation (POE) of Environmental Aspects in Educational Buildings
The framework correlates the Combined Assessment aspects to different user-centered methods and techniques used in (POE)

√√ Strongly related √ Related -- Not related □ Self-Developed
User-Centered 'C' User-Centered 'B' User-Centered 'A'

			Evaluation Methods and Techniques								
			Qualitative Assessment						Analytical Assessment		
			Walk through and observation	Interviews	Focus groups	Photo. Quest.	Wish Poem	Workshops	Questionnaires	Measurement	Benchmark
Combined Assessment Approach	Quality of Lighting	• Does the light level in the building support learning spaces?	√	√	--	--	□	--	√√	√	√
		• The quality of the light (daylight, artificial light, sunlight).	√√	√	√	√	□	√	√√	--	√
		• Lighting is sufficient for tasks.	--	√	√	--	□	√	√√	√√	√
		• The direction of the light and the color of the light.	√	√	--	√	□	--	√√	--	--
		• The way light is reflected and perceived.	√	√	√	√	□	--	√√	--	--
		• Light switching is conveniently located.	√√	√√	√	√	□	√	√√	--	√
		• The extent to which the users can influence the lighting themselves.	√	√√	√	√	□	√	√√	--	√
		• Room lighting levels can be controlled for audio-visual presentations.	√	√√	√	√	□	√	√√	--	--
	Sonic Comfort	• Building acoustics provide for appropriate ambient noise levels.	√	√	√	--	□	√	√	√√	√
		• Is there significant distraction from noise outside the space?	√	√	√	--	□	--	√√	√√	√
		• Is the noise level in a typical learning space distracting?	√	√	√	--	□	--	√√	√√	√
		• Mechanical systems operate quietly and don't disrupt learning areas.	√	√	√	--	□	--	√	√√	√
	Air Quality	• The impact of the quality of air on functional performance.	--	√	√√	--	□	√	√√	--	√
		• The properties of the air.	√	--	√	--	□	--	√	√√	√
		• Ventilation system provides adequate circulation of clean air.	--	--	√	--	□	--	√	√√	√
		• Do you have control over ventilation?	√	√	√	--	□	--	√√	--	√
	Thermal Comfort	• Year-round comfortable temperature is provided throughout the building.	--	√	√	--	□	--	√√	√√	√√
		• Do the learning spaces suit an individual's thermal comfort?	--	√	√	--	□	√	√√	√√	√√
		• Does the temperature in this part of the building have a negative effect on work performance?	--	√	√	--	□	√	√√	√	--
		• Is there an ability to adjust thermal comfort on an individual basis?	√	--	√	--	□	--	√√	--	√
	Building Appearance	• How clean is the building?	√√	√	√	√√	□	√√	√√	--	--
		• Building details, color schemes, material, and décor are aesthetically pleasing.	√√	--	√	√√	□	√√	√√	--	√
		• Quantity and quality of windows contributes to a pleasant environment.	√√	--	√√	√√	□	√√	√√	--	--

respondents are clear about the actions to be taken in response to questionnaire results. It is very easy to inadvertently raise expectations that all problems identified will be corrected immediately. Also, people appreciate that they will be given some results.

Questionnaires can be distributed and completed using the web as well as by hard copy. Clearly an advantage of using web technology is that it cuts out the need for data input and analysis software can be linked to the database that is collecting the information. However, when deciding to use this approach it is important to consider what specialist skills are available within the organization for using the technology.

When distributing hard copy questionnaires it is important to consider how they are to be returned. One way to manage the response is to distribute questionnaires by hand to individuals and say that they will be collected within an hour. This is easier to manage if people are working at desks. However, if they know that the questionnaires will be rather than put it off until later.

a) Photo Questionnaires

Photo questionnaires and interviews are an effective means used to elicit evaluative comments about physical settings [30]. People interpret the identity and meaning of their environment from the interaction of, and their interaction with, a wide variety of physical features. In the school environment, there are a variety of inside and outside places that evoke either good or bad feelings.

Becoming aware of perceived environmental effects is a necessary first step in striking the delicate balance between familiarity and monotony and boredom, and between variety and confusion and disorientation. With understanding of how the physical surroundings affect us psychologically, we can become more aware of our effects on them, and on ourselves, when we allow them to be changed. We will then start to

realize the importance of our concern for our surroundings, and eventually work toward the improvement of their quality.

5) Wish Poem

A wish poem is an approach that encourages students, teachers and parents to fantasize about their dream school through an open, yet structured process. Wish poems are considerably more effective than stating objectives, particularly if the intention is to keep the thinking global and exploratory. Unlike traditional poems that rhyme, wish poems are spontaneous and allow for the free flow of information. The process consists of a group of statements composed of responses to the phrase, "I WISH MY SCHOOL...."

Comparisons can be made between the wishes of students from different grade levels, teachers, and parents. When wish statements are combined they provide a profile of the school community's desires [33].

C. Design Team Facility Visit

The key purpose of a facility visit is to inform the design process. It is conducted by the design team to learn about the school, the students, the staff, the administration, and the community in which it is located [30]. The facility visit gives the members of the school community and the design team a common frame of reference on which to base critical design decisions. A visit also provides the opportunity to clarify values, goals, and expertise of individual participants; and identify conflicts early so they can be resolved. Another advantage of a systematic walkthrough or touring visit is the surprises it may bring, along with the opportunity to consider new possibilities. Two touring teams of two people each could diagnose a school building in a few hours. The actual site visit typically includes:

- An initial orientation interview with the principal and staff members familiar with the school being studied to gain an overall orientation to the site, the mission, and the educational philosophy.
- A touring interview where the team visits the major spaces in the school with someone familiar with the educational program, asking questions and observing building features to identify what works well and what works less well.
- Recording observations of all major spaces on a 'Space assessment worksheet' that includes a photograph of the space, a rating system and written notes.
- Conducting a wrap-up meeting at the site to identify new options and to clarify how the results of the visit relate to the design project. The product of a walkthrough visit usually includes a visual record and written notes. Photographic prints of the major spaces and features are useful reminders later in the design process.

Prior to the site visit it is useful to have plans of the school building. If these are not available, even fire evacuation plans can be used. Creating the appropriate documentation in advance, such as preparing the 'Space assessment worksheet', allows the information about the visit to be easily assembled into a report.

VI. Conclusion

POE systematically analyses a particular environment to gain understanding of the impact it has on occupants of a building. Information of the building's condition is gained by reviewing what the occupants' feel and how they response to their needs by use and occupy the building. And accordingly, user involvement is gaining importance in POE process, and multiple methods for involving users have been developed and used.

This paper discusses POE process from users' point of view. It investigates the environmental qualities of educational buildings as the area where the users are directly influenced. It determines four types of environmental domains that the users are directly manipulated. As discussed along the paper; realizing the spatial requirements of these types is a prerequisite for attaining the required comprehensive successful educational environment. These types are; Caring Environment, Safe and Structured Environment, Academic Environment, and Participatory Environment.

As the focus of this paper, it discusses the LEED based standards for promoting responsible use of energy and natural resources while providing the user with healthy indoor environmental conditions. It studies the metrics of ventilation, heating and air quality, lighting, and acoustics measured in internal educational environment as one of the *'analytical assessment'* techniques. It adds "Benchmarking" and "Questionnaire as other two assessment methods used under this category. In addition it discusses six *'qualitative assessment'* methods; walk through and observation, interviews, focus groups, photo questionnaire, workshops, and wish poem. These methods and techniques are classified according to the role of user into three categories ('A' strongly related, 'B' related, and 'C' minimally related) as shown in Table I.

Based on reviewing different assessment approaches used in evaluating the environmental aspects of educational buildings, the paper concluded a combined list of evaluation aspects categorized under five categories; quality of light, sonic comfort, air quality, thermal comfort, and building appearance.

Finally, the paper develops a framework for user-centered POE of environmental aspects in educational buildings by correlating different *'Assessment Approaches'* to *'Evaluation Methods and Techniques'* (Table I). The former is classified under the previously mentioned five categories, while the latter is divided into two categories; qualitative, and analytical. The developed framework rates the interrelationships between the aspects of these two groups into three scales; strongly related, related, and not related. In this framework, the 'Wish Poem' stands at the heart of the user-centered qualitative assessment techniques. It is highlighted as a bendable technique that could be manipulated differently according to each evaluation case.

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