QUALITY IN BUILDING DESIGN: A CASE STUDY

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There is evidence that designers begin the design process with some presumptions about the potential users and their expectations. Therefore, a better understanding of how users perceive their physical environments is essential to provide the right framework for a more user-friendly design. This will provide the means to the effective control of client expectations from the earliest stages of the project.

It is hypothesized that more effective user involvement in design leads not only to better adapted spaces, but also to more satisfied users. The aim is that by dealing with both expectations and design output, client satisfaction is more likely. In order to achieve the research aim, the case of classroom design is used as an example for data collection and analysis.

An exploratory survey has been undertaken to understand the most important quality characteristics of a classroom, from the users' point of view. Data were collected from both staff and students.

Repertory Grid method was used to elicit users' perceptions in nine classrooms. Data were input to Generalised Procrustes analysis to obtain a consensus map where the principal components are the important perceptual attributes. The results of the main study confirm the results of the previous survey.

Keywords: building evaluation, quality design, repertory grid method, user perceptions.

INTRODUCTION

In the 1980s, the perception and use of the physical environment and its resources had matured into a major area of concern and research, which implicitly entailed a public and media increasing interest with architectural and design issues.

The present debate has firmly rooted environmental issues as an important consideration in building design (Cole, 1998). In fact, the design product does not exist in a vacuum, it becomes meaningful only in relation to a user. In order to realise a more user responsive design, the design process must begin with an explicit consideration of user activities and perceptions, enabling the control of the behavioural effects of the design decisions they have to make.

Our perception of the world is learnt, selective (implicit evaluation), dynamic, interactive and individual, we each structure the world we live in (Lee, 1973). Perception of the environment is a complex interaction of both physical and social factors. Studies of meaning, using approaches such as Kelly (1955) seem crucial to further understanding of the complex man-environment relationship. To Honikman (1980), a personal construct approach combined with a participant observation method facilitates the awareness of the way the physical environment and its cognition are associated.

An exploratory survey has been undertaken to understand what are the most important quality characteristics of a classroom, from the users' point of view. Data were

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collected from both staff and students. This pilot study for an ongoing project has revealed that quality characteristics actually affect users' behavior.

A version of Kelly's Repertory grid (Kelly, 1955) was used to elucidate the attributes (constructs) perceived in a range of nine classrooms. Subjects then scale the individual classrooms with respect to each of the constructs, which they have described. Data were input to Generalised Procrustes Analysis (Gower, 1975) to obtain a perceptual map of the classrooms for each subject and a consensus classroom map. The principal components of the consensus map, and hence the important perceptual attributes, are interpreted by identifying the constructs which are most heavily weighted by individual subjects.

BUILDING EVALUATION

In the early 1960s the concept of building performance appraisal started to develop in the USA as architects searched for rational methods of predicting the outcome of building designs. The increasing research, on the relationship between human behaviour and building design, led to the new field of environmental design research and to the formation of interdisciplinary professional associations, such as the Environmental Design Research Association in USA.

Environment-behaviour studies focused essentially on the application of methods from the social sciences to an analysis of the man-environment phenomena. Interviews, questionnaires, and laboratory experiments were the most usual environment-behaviour research techniques.

However, environment-behaviour research was highly criticised for being too theoretical, and for failing to improve the design process. Mitchell (1993) described it as an academic exercise with no relevance to the design process, as the design process was not affected by their efforts. Less radical, Holgate (1992) thinks that the so-called "psychology of architecture" offer many valuable insights on the appreciation of architecture.

To Mitchell (1993), design research, to be effective, must not consist of ideas about design, as is the case of environment-behaviour studies, but rather must be design itself. Moreover, to make design more responsive to people, it is fundamental to implement structural changes into the design process itself.

Another approach emerged in UK concerning the design process, the design-methods movement, since early 1960s. Christopher Jones and Christopher Alexander were the two most influential designers in this movement. Jones developed his initial views on design methods, while in industry, as a means to incorporate the results of his ergonomic studies into the design process (Jones, 1992). Christopher Alexander books on a pattern language in architecture introduced the notion of design requirements and patterns into the design process, based upon the evaluation of the needs of those for whom the designs were intended (Preiser et al, 1988).

According to Jencks (1987), the central purpose of design methods was to permit collaboration in the design process, rather than being limited to the intuitive decisions of individual designers. In other words, Jones attempted to redesign the design process itself in such a way that all those people affected by designing could become involved in decision making (Mitchell, 1993).

In the 1970s, the first attempt to a systematic building evaluation was made at the Building Research Performance Unit (BPRU), at the University of Strathclyde.

Markus (1972) proposed a cost-based building evaluation model that outlined the interacting elements of building systems, environmental systems and activity systems, as well as the ultimate goals and objectives of owners and occupants to be achieved in building performance.

In 1976, the results of systematic evaluation research, mostly in USA, were developed into design criteria and guideline documents to assure future better quality-buildings (Preiser et al, 1988). In the 1980s, standardised terms were already being used in the so-called Post-occupancy evaluation (POE).

Post-occupancy evaluation is defined by Preiser et al (1988) as the process of systematic data collection, analysis, and comparison with explicitly stated performance criteria pertaining to occupied, built environments. In fact, POE is actually a measure of user satisfaction in relation to built environment. It relies on confirmed behavioural science techniques to perceive the behaviours and attitudes of building users, alongside with technical and functional aspects of building performance. There appears to be a growing commitment towards the inclusion of POE in the building process, just as the activity of programming has been accepted as one of the critical steps in the pre-design phase of the building process (Building Research Board, 1987).

DESIGN RESEARCH

A more user-responsive design implies the adoption of a new attitude towards design. The relation of products to users has become a central theme of design discourse, though users still remain little understood by designers (Margolin, 1997).

Designers must know for whom they design and why, to know how their work will affect users. They need to enrich their understanding of the product milieu (Margolin, 1997), in order to make choices regarding characteristics, such as shape, size, proportion, materials, color, texture and how to mix these elements and determine the level of coherence that should exist among them.

Then, how do designers improve their awareness of users? Designers employ market research about user motives and behaviour, to generate data on how people relate to products (Margolin, 1997). New research techniques are important in improving product quality, which can provide a direct input to the design process.

There are a wide variety of market research procedures that can be used to elicit information about product attributes and to measure attitudes and beliefs. These include unstructured spontaneous techniques, such as interviews and projective methods, through to highly structured methods, where appropriate statistical procedures are used to obtain product maps and to identify salient product dimensions (Hughes, 1975).

Interviews can be held at the individual level, or with a group where each member acts as a catalyst for eliciting ideas and thoughts from others (Hughes, 1975). However, this type of unstructured technique has been criticized for its lack of efficiency in identifying the salient product attributes (Payne, 1965). Furthermore, they inevitably suffer from bias due to the interviewer or dominant personalities within the group.

In projective methods (Kassarjian, 1974), subjects are presented with incomplete or vague product ideas to explore. This way, beliefs, attitudes and perceptions are expected to come forth (Hughes, 1974).

REPERTORY GRID METHOD

Repertory grid method is a partially structured technique also used in market research. A version of Kelly's repertory grid is used on this research to elucidate the quality attributes perceived by classroom users, students and staff, in a range of nine different university classrooms.

Grid method is a technique based on a sound psychological theory, George Kelly's theory of personal constructs (Kelly, 1955; Bannister and Fransella, 1986). Repertory grid was originally developed by Kelly (1955), to identify the constructs that people use to structure their perceptions of the social world, where a construct is defined as the way in which two things are alike and, in the same way, different from a third. Kelly's model was developed in the field of interpersonal psychology, as an approach to the study of complex patterns of people and events.

In Personal Construct Theory (PCT), people evaluate the world around them in a very scientific way: formulating, testing, verifying, updating hypotheses on the world and its relationship with themselves (Kelly, 1955). These hypotheses are the constructs, or bipolar dimensions, which describe two contrasting poles, hierarchically arranged into networks of constructs related to each other.

Grid method allows for the assessment of both the content and the structure of an individual's construct system, where the term content refers to the things which interest any particular person, and structure implies the type of organization he has erected to deal with these things (Bannister and Maier, 1968).

According to Hughes (1974), the repertory grid technique is a more rigorous methodology for researching issues, as the triadic elicitation proposed by Kelly eliminates interviewer bias by allowing respondents to identify their own constructs, reflecting the differences they perceive between the objects under investigation. Further, if the terms elicited are subsequently used in questionnaires, they are likely to be more meaningful to other subjects than terms generated by the researcher.

Repertory Grid is a triadic sorting technique. The sorting procedure starts by the subject being shown triple combinations of the elements concerned. For each triple combination, the subject is repeatedly asked for an important attribute on which two of the elements are alike and at the same time different from the third. All the elements are then rated for each construct, by the subjects. For each subject, responses are then put into the form of a grid, a matrix of cells with rows representing constructs, and columns representing elements.

GENERALISED PROCRUSTES ANALYSIS

In fact, repertory grid technique is fundamentally a qualitative technique. However, Kelly (1963) also outlined that the internal cognitive relationships between objects, in the form of constructs, represent a form of multidimensional space, for each individual. Slater (1977), who used principal component analysis to analyse differences across repertory grids, introduced the idea of a mathematical space. In truth, to understand how people perceive a set of elements, it is fundamental to be able to identify common dimensions of perception and experience, across groups of subjects, through the geometric similarities in the mathematical spaces.

Generalised Procrustes analysis (GPA), works by iteratively matching each set of configurations to a consensus configuration, maximising the geometric similarities between them, through the mathematical operations of translation, rotation/reflection

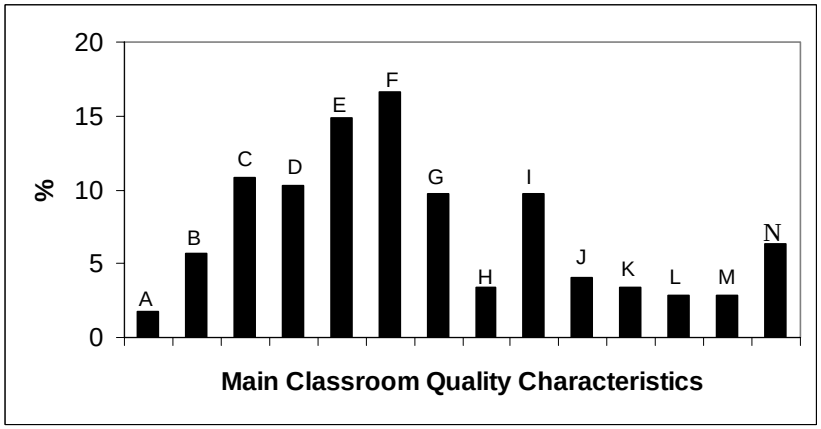

Figure 1: Main classroom quality characteristics
(Key: Classroom quality characteristics: A = noise; B = layout; C = acoustics; D = board visibility; E = lighting; F = comfort; G = temperature; H = ventilation; I = space; J = furniture; k = aesthetics; L = shape; M = teacher presentation; N = facility aids)

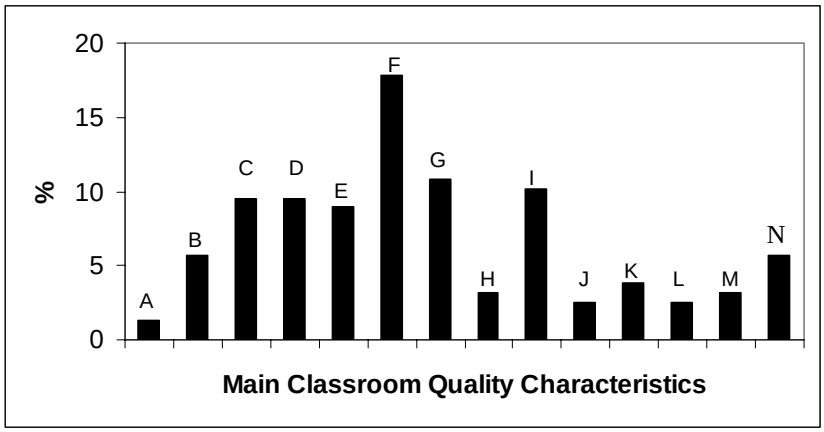

Figure 2: Main classroom quality characteristics for staff
(Key: Classroom quality characteristics: A = noise; B = layout; C = acoustics; D = board visibility; E = lighting; F = comfort; G = temperature; H = ventilation; I = space; J = furniture; k = aesthetics; L = shape; M = teacher presentation; N = facility aids)

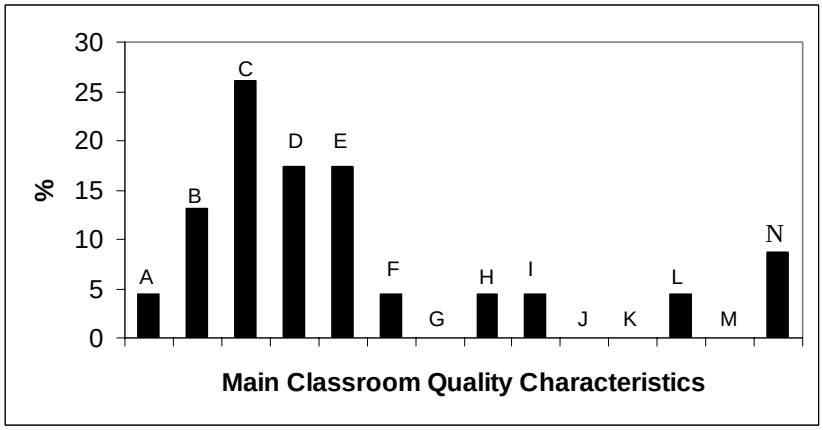

Figure 3: Main classroom quality characteristics for students
(Key: Classroom quality characteristics: A = noise; B = layout; C = acoustics; D = board visibility; E = lighting; F = comfort; G = temperature; H = ventilation; I = space; J = furniture; k = aesthetics; L = shape; M = teacher presentation; N = facility aids)

and scaling (Gower, 1975). The result is a consensus of the elements in multidimensional space. This way, through the statistical procedure GPA, it is possible to obtain a perceptual space of elements in several dimensions, when the various subjects use qualitative different attributes.

METHOD

Firstly, an exploratory survey was undertaken, at the University of Reading, to understand the most important quality characteristics of a classroom, from the users' point of view. Data were collected from both staff and students in different Faculties, namely the Faculty of Urban and Regional Studies, the Faculty of Letters, the Faculty of Science and the Faculty of Agriculture and Food Science.

The recruitment of participants was ongoing throughout three months. Subjects were asked to complete a brief survey in order to specify the single most important feature contributing to their judgement of the quality of a classroom. On this pilot stage, no list of quality characteristic was supplied to subjects. Only 175 questionnaires were completed, namely 135 males and 40 females. The results, as shown in Figure 1, indicate that the most important quality attribute for users, in the classroom learning environment, is comfort, followed respectively by lighting, acoustics, board visibility, temperature, facility aids and the layout.

The perception of the most important classroom quality characteristic differed in relation to the participants' sex, as suggested by the results accomplished. For men, the most important quality characteristic is comfort (18.4 %), followed by lighting (15.4 %), acoustics (10.3 %), temperature (9.6 %) and layout, facility aids and board visibility (5.15 %). On the other hand, for women, the most important quality attributes are board visibility (17.95 %), lighting and acoustics (12.82 %), comfort, temperature and facility aids (10.26 %), space and layout (7.7 %) and furniture (5.13%).

Further differences on the importance of classroom quality features, for staff and students, can be detected in Figure 2 and Figure 3. While staff regarded acoustics as the most important quality attribute, immediately followed by board visibility and lighting, layout, and lastly facility aids. Students adjudged comfort as the most important characteristic, proceeded by temperature, space, board visibility and acoustics, lighting, layout and facility aids and aesthetics.

Moreover, there are some differences in the quality perception of classroom quality features, linked with the student age. Although students perceived comfort as the main quality attribute, the students with less than 21 also sensed lighting at the same level of significance, immediately followed by the temperature (15.35 %), space (12.31 %), facility aids (7.69 %), layout, acoustics, board visibility and aesthetics (6.15 %). On the side of the students with more than 21, the emphasis was on lighting and acoustics (13.64 %), board visibility (12.73 %), space (8.16 %), temperature (6.36 %), and at last the layout and ventilation (5.46 %).

One last comparison was made between users with a background in built environment, from the Faculty of Urban and Regional Studies (FURS) and the other University users, from other Faculties. To Furs users, the comfort and acoustics appeared in first place, as the single most important feature, with a percentage of 16.83, immediately followed by lighting (14.85 %), temperature (11.76 %), board visibility (8.91 %) and at last, space and layout (6.93 %). The other users outlined lighting (15.1 %) as the most important attribute in the classroom environment, the other quality attributes

mentioned as relevant were space (13.7 %), comfort and board visibility (12.3 %), facility aids (9.6 %), and lastly temperature and the layout (5.5 %).

MAIN STUDY

The first procedure was to pick up the nine elements. The classrooms were selected by three subjects, from a total of 18 classrooms, spread through five different buildings on the campus of Reading University, previously chosen and photographed. The recruitment of participants for this study was carried out during the survey, according to their familiarity with chosen classrooms. Prior to the interview, each participant has been asked to walk through each classroom, together with the interviewer, in order to get an overall perception of each classroom environment. The nine classrooms (A, B, …, I) are briefly described in Table 1.

Thereafter, the repertory grid method was used to elucidate the quality attributes (bipolar constructs) perceived by each subject, in terms of the learning environment. Subjects were presented with the first triad, which comprised three photographs of the first three classrooms (A, B and C), laid in front of them on a table. On the basis of their knowledge of the classroom environment, subjects were asked to describe the ways in which two of the selected classrooms, from this first triad, were similar to each other, and in the same way different from the third. The interviewer recorded responses (constructs) as they were identified, and when no new construct was forthcoming, subjects were then asked to rate each of the 9 classrooms, with respect to each of the characteristic outlined for this first triad, in a five-point scale. There is evidence to suggest that a scale much above five points is very difficult to distinguish visually. This procedure was repeated for the remaining 8 triads. These rating scales, unique to each subject, were later used to quantify the perceptual characteristics of the nine classrooms.

After the completion of the grid, each subject was asked to rate each classroom, in the same five-point scale, in terms of the overall environment. Subsequently, they were also requested to describe their ideal classroom and some relevant past experience, positive or negative, in a classroom environment.

DATA ANALYSIS AND RESULTS

The matrix grids, from ten classroom users, three University lecturers and seven students, were input into a statistical programme, named Genstat, in order to apply GPA. This way, GPA is applied to all the individual repertory grids (data matrices), to produce a consensus configuration and a matrix of distances between every individual data matrix. The consensus configuration is interpreted by relating all constructs to the dimensions of the configuration for each individual subject in turn. Those constructs most highly correlated with each dimension for each subject are then listed, and each dimension may then be interpreted on the basis of this list.

Table 1a: Details of rooms in the sample

Room	Width (m)	Depth (m)	Height (m)	Style	Window Orientation	Window/floor area (%)[1]
A	6.26	8	5.5[2]	1990s	SE	17.2
B	11.68	9.5	3.5	1970s	NE	13.3
C	9.64	9.64	3	1960s	N	40
D	8.10	12.2	3	1970s	SE	30.4
E	5.37	7.92	2.5	1990s	NW	19.8
F[3]	14	6.5	3.1	1990s	SW	6.4
G	10.55	5.14	2.5	1990s	SW	17.6
H	9.34	8.15	3.35	1960s	W	27
I	9	7.05	2.85	1970s	NW	17

[1] Window as a proportion of floor area. [2] Sloping ceiling (max.=5.5 m; min.=4.3 m). [3] Odd shape

Table 1a: Details of rooms in the sample

Room	Artificial Lighting	Floor Covering	Wall Finish	Ceiling Finish	Layout
A	Suspended incandescent	Blue linoleum	Plaster[4]	Metal[5]	Formal desk rows
B	Fluorescent	Greyish linoleum	Painted blocks	Painted concrete beams	Formal desk rows
C	Suspended fluorescent	Brown Linoleum	Wood panels	Coffered	Formal desk rows
D	Yellow tungsten bulbs	Carpet[6]	Wood panels and plaster	Suspended	Informal, easy chairs randomly distributed
E	Incandescent	Blue carpet	Plaster	Plaster	Informal, desks in a square shape
F[7]	Incandescent[8]	Violet carpet	Plaster	Suspended	Formal curved desk rows
G	Incandescent	Blue carpet	Plaster	Plaster	Formal desk rows
H	Fluorescent	Greyish linoleum	Dark bricks	Unpainted concrete beams	Formal desk rows
I	Fluorescent	Wood	Brown bricks	Suspended	Formal desk rows

[4] Visible pipes. [5] Not finished. [6] Carpet with floral design. [7] Odd shape. [8] Control of lighting

Individual subject's perceptual spaces and a consensus space for the 9 classrooms were obtained. The percentage of variation explained by the first four principal components, represent 82 % of the total variation, where the first dimension (D1) embrace 41.09 % and the other dimensions comprehend, respectively, D2 (18.15 %), D3 (13.23 %) and D4 (9,91 %). Those principal components were identified by examining the weightings associated with each construct. The first principal dimension D1 is linked with comfort, the second principal dimension D2 is connected with lighting, the third principal dimension D3 is interrelated with space, shape and size, and finally the fourth principal dimension D4 is associated with the layout.

According to the results of the statistical analysis, the most important quality features in a classroom learning environment are comfort, lighting, space, shape and size, and finally the layout. Although restricted to ten classroom users, a small sample, this analysis is corroborated by the results of the exploratory survey previously undertaken.

Afterwards, an analysis of each individual grid is carried out, in order to detect common attribute perceptions.

For students, the first perception of comfort is related with ergonomically comfortable, padded chairs, in order to "seat down for a long lesson without feeling tired or feeling your back " and spacious desks " it gives more room, more space for your arms and papers".

Matching and varied ambience colours are also a very relevant attribute, "uniform and comfort colours, more appealing, more attractive, more colour variance is sometimes necessary". Students' surroundings created by subtle colours like beige and pale enhances the ability to concentrate. Pretty neutral, light coloured, plastered walls and finished ceilings, contrasting floor carpet and tables are the preferred ones.

Good daylight is very important for students too, with lower windows to get a view outside, a green view being the most sought after ("lighter rooms with lower windows; not to feel trapped inside"). Artificial light, "more diffusing, the more natural the better", positioned in order to avoid glare. No glare is important to get a better board visibility. Good daylight and no glare are also a very important issues for lecturers.

Temperature control and "a good, all round, natural ventilation" are very important for both students and lecturers. Good acoustics is essentially an important lecturer concern.

A well-proportioned room, with a good ratio length/width, supplied with "a modern and proportioned board" and "equipped with all those aids for a quality teaching" are also relevant requirements to most of the users. Most of the students require a high ceiling to provide enough space, more freedom "specially in big rooms with large groups, a low ceiling makes you feel claustrophobic".

Finally, a more flexible layout is perceived by students and teachers as enabling more interaction, "more space to move around, more connection between students and lecturers", this way facilitating learning and communication.

CONCLUSIONS

An underlying purpose of this ongoing environment evaluation is to develop a better understanding of how the physical environment contributes to a better man-environment interaction. Moreover, it is our intention to clarify what is currently known about specific attributes of physical environment and how they relate with people's behaviour and subjective responses to that environment.

Repertory grid method provides a technique sufficiently flexible and adaptable to the needs of each study, and at the same time sufficiently structured to help users to verbalise their perceptions of classrooms. Allied with GPA it can offer a reliable way to understand users perceptions.

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