Architectural Design Quality Indicators for Educational Built Environment in the Indian Context

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Abstract
Quality is one of the triple considerations in any project; the other two are namely time and cost. While there are measuring tools for both time and cost, quality remains unmeasured in an objective manner. The building is a product of design and the quality of building depends on the quality of design. It is important to measure the quality of design in different stages of the project life cycle to understand how the building is performing when in use. In India, several standards, codes, and different green building rating systems are used to judge different design aspects. However, there is a need for a unified framework to measure design quality objectively. The education sector in India has experienced growth in the last few decades. With different flagship schemes, Indian schools are all set for Information and communication technology-enabled education systems. Investment in the education sector has increased, therefore, there is a need for physical spaces to make this investment work efficiently. The purpose of this study is to identify the criteria affecting the design quality of educational built environment and to assess their relative importance. A quantitative approach using a questionnaire survey has been used to collect data. The survey intended to elicit feedback on the suitability of the significance of design quality indicators in the context of educational built environment in India.

Keywords: Design quality, DQI, educational built environment, Indian context

Introduction
Quality is one of the triple considerations in any project, the other two are namely time and cost, Figure 1. While there are measuring tools for both time and cost, quality remains unmeasured in an objective manner and remains as an individual's perception. Quality, as defined by Cambridge Dictionary, is ‘of a high standard’ or ‘the degree of excellence of something, often a high degree of it’. As per the Oxford dictionary quality is "the standard of something as measured against other things of a similar kind." Design quality can be defined as the value of design to its user. The design could be for any product, service, system or experience. Design quality could be the function of any combinations of usability, performance, aesthetics, reliability, predictability, stability, consistency, safety and security. The design quality is still in a very elementary stage in developing countries like India, though it has a great impact on the satisfaction of the end-users. The building is a product of design and the quality of building depends on the quality of design. ISO 9000 on Total Quality Management includes customer satisfaction in an organization's objectives. In the case of the buildings, the end-users are the primary customers of the product. The satisfaction or dissatisfaction of the end-users of the buildings determines the quality of design. A building can perform well once it is designed conforming to the local and national codes and standards. The quality of design improves the efficiency of the building. It is important to measure the quality of design in different stages of the project life cycle to understand how the building is performing when in use. The measure can be done during the briefing, predesign, construction, pre and post-occupancy stages. Also, all the factors in design might not have the same weightage in the measuring scale.

Figure 1 : Value of product or service as a function of quality, cost and time

Background:
The Construction Industry Council of the United Kingdom started the development of Design Quality Indicator (DQI) in 1999 and it was launched as an online resource in 2003. DQI engages end users in a structured interview in the briefing stage to know their requirements. This is a part of the design process itself. Further, it is tested through the design development stage, whether these requirements are met. This assessment is done to make sure that users’ demand and design supply are in the straight-line and having the same visions.1
For the last 16 years, DQI has been used on over 1400 projects. It has been successfully used for an educational facility, hotels, civic buildings, retail, and mixed-use buildings, sports and leisure and workplaces.

DQI focuses on the design and construction team on the needs of the end-user as it:

i) creates a sense of ownership by engaging users throughout the process;
ii) enables feedback and learning for future projects;
iii) generates a simple graphic profile that indicates the strengths and weaknesses of a design or existing building;
iv) provides an agenda for briefing and design reviews;
v) provides benchmarking information in the form of Facilitator’s Reports; and
vi) it helps to develop a more sustainable building.

Design Quality Indicator is based on Vitruvian Principles. The Roman architect Vitruvius in his treatise on architecture, De Architectura, emphasized that there were three principles of good architecture, they are as follow:

i) Firmatas (Durability) - It should be strong and remain in good condition.
ii) Utilitas (Utility) - It should be useful and functional for the people using it.
iii) Venustus (Beauty) - It should be beautiful and enhance people’s spirit.

The modern mind rewrote them as, Functionality (Utilitas), Build quality (Firmitus), and Impact (Venustas)

The DQI questionnaire is organized to address the issues under each of these three quality fields, they are as follow:

i) Functionality
   a) Use
   b) Access
   c) Space

ii) Build Quality
   a) Performance
   b) Engineering Systems
   c) Construction

iii) Impact
   a) Form and material
   b) Internal Environment
   c) Character and Innovation

DQI has 5 stages that are undertaken over the project's lifecycle.
Stage 1: Briefing
Stage 2: Concept design
Stage 3: Mid design
Stage 4: Ready for occupation
Stage 5: In use

Importance of Architectural Design in Educational built environment

Educational built environment like schools and colleges play an important role in human life. A child or a young adult spends most of his or her day time in these spaces. It helps in building the character of a person like self-esteem and a companionship. The design of educational infrastructure is a complex process as it involves complex human experiences such as spatial, psychological, physiological and behavioral (Nair, 2005). The overall experience helps in the students’ performance also. A good design provides a comfortable and responsive environment that helps in effective and efficient educational performance. It also reduces operational cost. In most of the educational spaces, especially in schools, safety and security come first while discussing the good design criteria.

A research carried out by RIBA in between the 2015 and 2017 in response to the UK Government’s and Education Funding Agency’s target to convert the locally controlled education system to a nationally controlled system. RIBA argued that the “one size fits all” system, which has been adopted by the UK government might have delivered projects in a restrictive budget and timeline but there was no scope for innovative design or local context. A total of 129 Post Occupancy Evaluation (POE) were conducted in primary, secondary, and Special Educational Needs and Disability (SEND) schools. The POE contained data like users' perceptions related to the environment as well as spatial layout, energy cost, etc. A
framework that the researchers developed was then used to identify the key beneficial impacts of good design, which were found to be: educational outcomes, teacher productivity, and potential cost savings in running and maintaining school buildings.

The good design defined in this research comprises the followings:

i) Good quality natural light, supported by good artificial lighting.

ii) Pupil sense of ownership. School design that creates dedicated social or self-directed learning spaces, incorporates child-centred furniture, and allows for the display of work or imagery pupils can identify with on the walls.

iii) Simple, natural ventilation systems or where that is not possible or appropriate, mechanical ventilation, which is simple to operate and quickly responsive to allow air quality to be easily maintained.

iv) Thermal comfort and control over temperature. Thermal controls should be easy to use and quick to adapt to changing uses of space.

v) The optimum amount of colour in learning spaces. To create interest but not become a distraction.

vi) An optimum level of visual interest in terms of design.

Figure 3: Outcome-based model for quantifying benefits of good design in schools, Source: Better spaces for learning, © Royal Institute of British Architects (RIBA) May 2016

Indian codes and bylaws to facilitate educational infrastructure design

Building bye-laws and codes provide a basic guideline for how a building has to be designed and constructed. While the state governments have laid down specific rules and regulations, they are following the National Building Code of India (BIS 2016). These rules and regulations are amended from time to time to facilitate and accept new changes in the building construction industry.

The Bureau of Indian Standard adopted Recommendations for Basic Requirements of School buildings (IS 8827 - 1978) in 1978 which provides the recommendations and specifications for the school buildings in India. Similarly, Compendium of Architectural Norms & Guidelines for Educational Institutions by Central Public Works Departments set forth the recommendations for different educational facilities like school, colleges, technical campuses, etc. while these bye-laws, specification, and standards are mandatory to obtain sanctions from the competent authorities, they only lay down the basic requirements and benchmarking, failing which a building design cannot justify itself to be fit for the purpose. The bye-laws are followed to maintain the basic requirements for health, safety, fire fighting, light and ventilation, universal accessibility, energy efficiency, sustainability, etc., they are not meant to judge building quality.

IS 8827 -1978: This standard lays down standards for the functional, spatial, and environmental needs of the basic classroom and allied spaces in primary to high school in the context of India.

This standard provides a guideline for the following:

i) Grouping of classrooms

ii) Spatial, environmental and anthropometric requirements of classrooms

iii) A tentative layout of the classroom and laboratories

iv) Furniture and fittings requirements

v) Guidelines for outdoor spaces and circulation spaces

vi) Detail of administrative spaces

vii) Site selection guidelines and site area

viii) Effect of landscape elements
ix) Exit requirements like the staircase, ramps, etc.

x) Fire protection requirements

xi) Water supply and sanitation requirements

Compendium of Architectural Norms & Guidelines for Educational Institutions by Central Public Works Departments of India

This is a ready reckoner for the educational infrastructure in India. The guideline covers architectural and engineering requirements of different educational facilities like Kendriya Vidyalaya, Jawahar Navodaya Vidyalaya, Norms & requirement for College of Architecture from Council of Architecture, Norms & Requirements for Engineering, Architecture, MBA & Pharmacy Colleges from All India Council for Technical Education (AICTE), etc.

For Kendriya Vidyalaya school buildings, this guideline shares the following details:

Land requirements

i) Space requirements for different facilities like classrooms, laboratories, activity rooms, computer room, art rooms, a medical room, PET room, etc.

ii) Drinking water, Toilets, and other Physical Facilities.

iii) Playground

iv) Brief specification of foundation, superstructure, door windows, flooring, electrical and other services

It also provides a checklist for construction to be checked by the architect.

National Building Code of India (BIS 2016)

As the buildings in India are becoming more and more complex, the need for a unified building code was felt. Due to large scale changes in the building construction activities, such as a change in nature of occupancies with the prevalence of high rises and mixed occupancies, greater dependence and complicated nature of building services, development of new/innovative construction materials and technologies, greater need for preservation of environment and recognition of the need for planned management of existing buildings and built environment, there has been a paradigm shift in building construction scenario. A comprehensive revision has therefore been brought out to address all these aspects and also reflect the changes incorporated in various standards which are considerably utilized in the Code.

Part 3 of NBC, 2016 talks about the Development Control Rules and General Building Requirements. It provides guidelines for the followings:

i) Land use classification

ii) Means of access

iii) Community open space and amenities

iv) Open space within a plot

v) Area and height limitations

vi) Off-street parking space

vii) Green belt, landscaping and water conservation

viii) Requirements related to different parts of the buildings

ix) Requirements for accessibility in the built environment for the elderly and specially-abled person

x) Fire and life safety

xi) Design and construction

xii) Lighting and ventilation

xiii) Electrical and allied installation

xiv) Air conditioning, heating, and mechanical ventilation

xv) Acoustic, sound insulation and noise control

xvi) Heat insulation

xvii) Installation of lift, escalator and moving walks

xviii) Information and communication-oriented installation

xix) Plumbing services including solid waste management

xx) Sustainability

xxi) Asset management

Data collection and analysis

Consolidation of design quality Indicators

A total of 41 indicators were consolidated from an extensive literature survey and doing a brainstorming on design quality applied for different types of buildings. They are grouped into three major heads of Design Quality Indicator, namely the Functionality aspect, Build quality aspect and Impact aspect. The criteria are as follows
Table 1: Functionality Aspect and Quality Indicators

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use</td>
<td>Accommodates users’ need: classroom sizes and anthropometric dimensions</td>
</tr>
<tr>
<td>Site selection</td>
<td>Easily accessible from the residential area, away from traffic, with good natural drainage</td>
</tr>
<tr>
<td>Parking</td>
<td>Provided with an adequate cycle, two-wheeler, and four wheeler parking</td>
</tr>
<tr>
<td>The layout of the building</td>
<td>Easily understood by the user</td>
</tr>
<tr>
<td>Access</td>
<td>Good and safe access to everyone</td>
</tr>
<tr>
<td>Space</td>
<td>Right size for function</td>
</tr>
<tr>
<td>Lighting</td>
<td>The lighting is efficient and allows for different user requirements</td>
</tr>
<tr>
<td>Open spaces</td>
<td>Appropriate for the breeze, sunlight and outdoor activities</td>
</tr>
<tr>
<td>Pedestrian walkway</td>
<td>User friendly</td>
</tr>
<tr>
<td>Service</td>
<td>Providing essential service to the users</td>
</tr>
<tr>
<td>Natural lighting</td>
<td>suitable position of the window</td>
</tr>
<tr>
<td>Natural ventilation</td>
<td>Position of window and door</td>
</tr>
<tr>
<td>Universal aspect</td>
<td>The building is easily accessed by all users</td>
</tr>
<tr>
<td>Circulation</td>
<td>Adequate circulation areas between habitable spaces</td>
</tr>
<tr>
<td>Fire exits</td>
<td>The building is provided with adequate fire exits as per norms</td>
</tr>
<tr>
<td>Acoustic comfort</td>
<td>The building provides acoustic comforts to the users</td>
</tr>
</tbody>
</table>

Table 2: Build Quality Aspect and Quality Indicators

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering system</td>
<td>MEP systems working properly</td>
</tr>
<tr>
<td>Security system</td>
<td>Safe environment for the children</td>
</tr>
<tr>
<td>Energy</td>
<td>The building is efficient in the use of energy</td>
</tr>
<tr>
<td>Green energy and sustainability</td>
<td>The building uses green energy</td>
</tr>
<tr>
<td>Landscape</td>
<td>The attractive landscape of the building</td>
</tr>
<tr>
<td>Finishing</td>
<td>Finishing of the building is durable and suitable</td>
</tr>
<tr>
<td>Structure element</td>
<td>The structure is efficient</td>
</tr>
<tr>
<td>Road width</td>
<td>Suitable for pedestrian as well as vehicular</td>
</tr>
<tr>
<td>Stability</td>
<td>The building is stable from natural elements</td>
</tr>
<tr>
<td>Indoor air quality</td>
<td>Free from smoke, CO, etc.</td>
</tr>
<tr>
<td>Hygienic condition</td>
<td>Proper drinking water and toilet facilities</td>
</tr>
<tr>
<td>Building maintenance</td>
<td>The building is maintained properly</td>
</tr>
</tbody>
</table>
Table 3: Impact Aspect and Quality Indicators

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>Gives building a distinctive character</td>
</tr>
<tr>
<td>Colour</td>
<td>Suitable for building</td>
</tr>
<tr>
<td>Form and material</td>
<td>Shape and materials following the functions</td>
</tr>
<tr>
<td>Comfort</td>
<td>Buildings provide comfort to the user</td>
</tr>
<tr>
<td>Internal environment</td>
<td>The atmosphere in the building, the relation between light and space and working climate</td>
</tr>
<tr>
<td>External environment</td>
<td>Conducive for mobility and activity</td>
</tr>
<tr>
<td>Character and Innovation</td>
<td>The impact of buildings on the character, thinking and human appearance</td>
</tr>
<tr>
<td>Urban and integration</td>
<td>Interaction with private and public areas and the impact of buildings on the city and community</td>
</tr>
<tr>
<td>Location</td>
<td>The positioning of the building in a good location</td>
</tr>
<tr>
<td>Visual effect</td>
<td>The scene of the building is attractive</td>
</tr>
<tr>
<td>Security</td>
<td>The building provides a sense of security</td>
</tr>
<tr>
<td>Natural disaster</td>
<td>Location of buildings survived from a natural disaster like floods or others</td>
</tr>
<tr>
<td>Noise</td>
<td>Surrounding noise of the building is not intrusive and affect human health)</td>
</tr>
</tbody>
</table>

Methodology adopted for data collection

A quantitative approach using a questionnaire survey has been used to collect data. The survey proposed to bring about feedback on the appropriateness of the significance of design quality indicators which are assembled under functionality, build quality and impact in the context of educational infrastructure in India. The targeted respondent of this survey was mostly architect either in practice or academicians. The questionnaire was distributed online. A total of fifty responses were received.

Data analysis

A five-point Likert-scale with options ranging from '1 = Not Significant' to '5 = Very Significant' has been adopted to elicit feedback on the indicators, table 4. To determine the level of significance of the indicators, average index (AI) analysis was carried out and the interpretation is as follows

Table 4: Average index value and interpretation

<table>
<thead>
<tr>
<th>AI range value</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.50 to 5.00</td>
<td>Very significant</td>
</tr>
<tr>
<td>3.50 to 4.50</td>
<td>Significant</td>
</tr>
<tr>
<td>2.50 to 3.50</td>
<td>Moderately significant</td>
</tr>
<tr>
<td>1.50 to 2.50</td>
<td>Less significant</td>
</tr>
<tr>
<td>1 to 1.50</td>
<td>Not significant</td>
</tr>
</tbody>
</table>

Perception of indicators of design quality

I) Perception of functionality

Under functionality, aspect fire exists scored the highest index (4.78) followed by use and access with AI of 4.68 for both, Figure 4. Whereas site selection and building layout have taken much back seat.

Figure 4: DQI Index for functionality aspect
II) Perception of build quality:

In the build quality segment, both stability and hygienic condition get the highest score of 4.7, followed by structural element (4.5) and security system (4.48), Figure 5. Landscape and road width get 3.8 and 3.86 respectively making them not very significant aspects.

III) Perception of Impact

Among the indicators under Impact, Comfort and natural disaster get the highest score (4.54) whereas colour and visual effect get the lower AIs, 3.52, making them only significant, Figure 6.

It is important to notice that where maximum indicators of functional aspects are between 4.5 to 5 AI, the indicators of impact mostly score AI between 3.5 to 4.5.

Conclusion

The undertaken in this research paper evinces that building design quality has direct relation with users’s satisfaction. Based on literature review and brainstorming sessions, this study consolidated 41 indicators (classified in three design quality field) to measure satisfaction towards design quality of buildings. A pilot survey was conducted to assess the suitability of the indicators in the context of the design of the educational built environment in India. From the survey, it came out that all the indicators are significant in measuring the design quality of Educational buildings in the context of India, Figure 7. No criteria have been scored less than 3.5 significant. The criteria like use, access, delighting, indoor air quality, hygienic condition, security systems, and comfort have scored more than 4.5, making them very significant in the context of educational buildings. Out of 50 respondents, 42 assign 5 points to ‘Fire exit’ making it the most significant indicator in educational infrastructure. The respondents of the above study were design professionals only. More criteria can be added to this list to a detailed understanding of the factors affecting design quality. All other stakeholders of the building construction can be included in the detailed and elaborate survey for more accuracy. Once relative ranking is established a framework could be formed to for the objective evaluation of the design quality for the educational infrastructure. Similarly this method can be used for other building typologies as well. The framework hence prepared can be used in different stages of the project lifecycle namely the briefing stage, design development stage, construction and post occupancy stage. The intent of using the framework in the briefing stage could be creating an aspiration of the users for the project, while in the design development and construction stage it could be for the monitoring of the quality. In the post occupancy stage the framework could be used to review, whether the project meets those aspirations of the users and the learning can be taken forward for the next project to come.
References:


[10] Compendium of Architectural Norms & Guidelines for Educational Institutions, 2019, CENTRAL PUBLIC WORKS DEPARTMENT,


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Architect Tanushree is a graduate from Jadavpur University, Kolkata with a master degree in Building Engineering and Management from School of Planning and Architecture, New Delhi, Currently pursuing PhD from DCRUST, Murthal. She has an experience of a decade in the field of Architecture, interiors and project management and Light Gauge Steel Frame structures and more than six years of teaching experience. She is an IGBC AP and GRIHA CP, and GRIHA Evaluator as Architect and Construction Manager.