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School Architecture of the Future Supported by Evidence-Based Design and Design Patterns

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***Abstract*—**Trends in education affect schooling, needing incorporation into design concepts to support desired learning processes with appropriate and stimulating environments. A design process for school architecture demands research, debates, reflections, and efficient decision-making methods. This paper presents research on evidence-based design, related to middle schools, based on a systematic literature review and the elaboration of a set of architectural design patterns, through a graphic translation of new concepts for classroom configurations, to support programming debates and the synthesis phase of design. The investigation resulted in nine patterns that configure the concepts of boundaries, flexibility, levels of openness, mindsets, neighborhoods, movement and interaction, territories, opportunities for learning, and sightlines for classrooms. The research is part of a continuous investigation of design methods, on contemporary school architecture to produce an architectural pattern matrix based on scientific information translated into an insightful graphic design language.

***Keywords*—**School architecture, design process, design patterns, evidence-based design.

I. Introduction

EDUCATION is changing globally. Transformations impact teaching methods and materials, as well as the physical learning environment. School architecture needs to follow suit, with design concepts and solutions supporting new and desired learning processes with appropriate and stimulating physical environments. A new design process is envisioned based on research, evidence, debates, reflections, and efficient decision-making methods [1]. To prepare for this future, specific investigations are necessary. This paper presents research on evidence-based design, related to middle schools. Through a systematic literature review, we elaborate on a set of architectural design patterns to support the programming debates and the synthesis phase of a design process.

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Our research questions are on two fronts. How are the changes in education impacting the school environment and can evidence-based design investigations support design decisions. We also examined the kind of support the architectural design process demands to respond positively to the new requirements of school communities with appropriate and uplifting settings for teaching and learning.

II. Design Patterns

Traditionally three phases make up an architectural design process: analysis, synthesis, and evaluation. The analysis-phase is a data collection and reflective moment, when facts and previous examples, as repertoire, are examined. Design goals and needs determine an architectural brief, and to measure proposals, and the final product indicators are necessary.

A well-structured design process is recommended based on the analysis of accumulated knowledge to ensure architectural quality for new projects or reforms of existing buildings. The collection of knowledge from literature is, however, hampered by scattered data, often written in a language difficult to translate into design solutions. Graphic representation, the language of architecture, is missing. Design parameters or patterns are essential to give the design process efficient support. As well, accumulated knowledge needs translation into a language appropriate to the synthesis phase. Transforming design information into design patterns increases efficiency and the quality of decisions in the synthesis phase.

Alexander et al. [2] developed the concept of patterns for general design considerations intending to humanize the built environment. Shared experiences and values are the basis of this concept. Design patterns transform design concepts for human needs to support problem-solving, solution explorations, and justifications of proposals [3].

According to [2, p.X]: "Each pattern describes a problem that occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice." As such, design patterns are not guidelines, but rich stimuli for the cognitive design process. A set of values prescribes solutions, determining a common pattern language.

III. Developing School Design Patterns

For school design, [4] analyzed 29 patterns of Table I and investigated their occurrence in specific schools. The results of the study showed that school buildings and grounds, in many

cases, lack the inclusion of essential patterns. Most of the school buildings analyzed in that study were based on a sterile model of architecture as a result of purely functional analysis, stipulated in a rigid brief. The design process of these buildings also lacks participation of the leading players of education and the daily workings of schools. Students of various ages, teachers, staff, parents, community members, pedagogues, psychologists, and design professionals, for instance, should give briefing inputs.

TABLE I
DESIGN PATTERNS FOR SCHOOL BUILDING DESIGN [5]

1. Classrooms, Learning Spaces
2. Welcoming Entry
3. Student Display Space
4. Home Base and Individual Storage
5. Science Labs, Arts Labs and Life Skills Areas
6. Art, Music and Performance
7. Physical Fitness
8. Casual Eating Areas
9. Transparency
10. Interior and Exterior Vistas
11. Dispersed Technology
12. Indoor–Outdoor Connection
13. Soft Seating
14. Flexible Spaces
15. Campfire Space
16. Watering Hole Space
17. Cave Space
18. Design for Multiple Intelligences*
19. Day-lighting
20. Natural Ventilation
21. Full Spectrum Lighting
22. Sustainable Elements and School as 3D Textbook
23. Local Signature
24. Connected to the Community
25. Home-like bathrooms
26. Teachers as professionals
27. Shared learning resources and library
28. Safety and security
29. Bringing It All Together

School design patterns should depend on research, which examines how pupils, staff, and parents learn through their engagements with the school environment [6]. The new trends in education have been translated into recommended learning modalities, as shown in Table II [7]. These, in turn, need graphic translation to incorporate these into design decisions efficiently.

Patterns are building blocks for the design of schools and provide a framework able to be used across diverse settings with positive results. Nair et al. [5] developed the 29 patterns of Table I.

Evidence from design and Post-Occupation-Evaluations (POEs), as well as specific research on the learning environment, education as a whole, and teaching methods determines school design patterns. These building blocks reflect on a design problem as an if-then statement. If a specific recurring problem exists, then the solution should be sought through a particular reflection on evidence on spatial configurations and their impact on human behavior. Diagrams describe both the problem and solution realms visually. Patterns, in turn, are part of a set of design questions. A pattern will gain a title and an indication concerning its position in the set. The translation of design problems and its solution realm into graphic diagrams is an essential part of the development of patterns.

TABLE II
18 LEARNING MODALITIES WITH GRAPHIC SPATIAL TRANSLATIONS [7]

Learning Modality
1. Independent study
2. Peer tutoring
3. Team collaborative work in small and mid-size groups (3–6 students)
4. One-on-one learning with the teacher
5. Lecture format with the teacher or outside expert at center stage
6. Project-based learning
7. Technology-based learning
8. Distance learning
9. Research via the Internet with wireless networking
10. Student presentations
11. Performance and music-based learning
12. Seminar-style instruction
13. Collaborative and interdisciplinary learning
14. Naturalist learning
15. Social/emotional learning
16. Art-based learning
17. Storytelling
18. Learning by building—hands on learning

IV. GRAPHIC REPRESENTATION

Graphic representation of concepts is a specific area of research with particular importance for studies in design methods. Visual languages are part of design, expressed through diagrams, sketches, drawings, models, and other varied illustrations. Gombrich [8], Jacobson [9], Krum [10], Lankow et al. [11], Laseau [12], Malamed [13], Nair et al. [5], O'grady & O'grady [14], Peña & Parshall [15], Tufte [16], and White [17] are essential authors of studies in this knowledge area. Deliberator [18] presents a systematization of these methods through principles of graphic translation, as expressed by organizing perception, directing sight, reducing realism, making the abstract concrete and the complex clear, and finally putting emotion into visual images. These principles were applied here to develop nine new patterns for school buildings of the 21st century, based on a Systematic Literature Review (SLR). This SLR method followed [19]-[21].

V. RESULTS

The SLR identified six recent articles specifically on the teaching environment and new evidence on the configuration of classroom spaces. These were [22]-[27]. The analysis of these articles revealed evidence that permitted the creation of nine parameters or patterns to configure the classroom of the future, called the teaching environment in the majority of research evaluated. These patterns are Boundaries; Flexibility;

Levels of Openness; Mindsets; Neighborhoods; Movement and Interaction; Territories; Learning Opportunities; Sightlines. For each pattern, a symbol is its visual identity, and design issues describe the parameter. The original references that brought to light the evidence are part of a pattern, to permit more detailed reflections.

1. Boundaries

The learning environment must have both internal and external flexibility, through architectural elements and furniture that allow for change and adaptation. Boundaries between interior and exterior spaces are essential but need to have control. The perception of learning environments in themselves is different for students and teachers. A poorly delimited boundary will disrupt students' concentration and the organization of a classroom setting [24]. The inclusion of this pattern is paramount, as it deals with spatial definitions of architectural elements such as area and helps teachers with their responsibility for student groups. Other types of school spaces with different but complementary functions can apply the concept of boundaries as well [28].

2. Flexibility

Flexibility is a crucial element for classrooms because learning processes need interaction between internal and external spaces, and between users and space. Flexible layouts promote freedom of movement, functions, and activities. Equipment and furniture need diversity and mobility to permit flexible use [27]. Flexibility in the classroom impacts spatial definitions of architectural elements.

3. Levels of Openness

The interrelation of spaces in a building determines different levels of openness. Flexible elements can enhance openness. Space with diverse openness can accommodate different types of activities and users (students). Interactivity during learning activities can improve relationships between students, resulting in a positive learning environment [29]. This parameter deals with spatial definitions and their architectural elements.

4. Mindsets

Students reach Middle School accustomed to a specific form of teaching, based on a particular pedagogy. At this level of schooling, teachers must pay special attention to this. Existing practices of both students and teachers need constant reflection [30]. Current and previous teaching methods have a strong influence on how spaces are used [27], [29]. To ensure that the use of innovative solutions is successful, students and teachers need to understand their potential. This parameter deals with behavioral and human factors.

5. Neighborhoods

Well-functioning social student groups are the basis of a positive learning environment. A healthy relationship between different groups of students and students with teachers is an essential part of this environment. Students with different pedagogical requirements demand pedagogical monitoring of their academic development. Under such situations, the concept recommends optimal student groups. The physical environment must accommodate such communities adequately [23]. This parameter addresses behavioral definitions and the human element.

6. Movement and Interaction

Freedom of movement and ample interactions within space are essential in a positive teaching environment. Enabling freedom of movement for both students and teachers increased social interactions and knowledge exchange between students during classroom activities, as well as teacher monitoring [27]. This parameter deals with behavioral definitions and the human element.

7. Territories

Territoriality of a teaching environment encompasses not only the relationship between the user and space but also how users appropriate space. Attention to place-making is essential. A territory consists of student communities or groups, as well as the whole school community. An environment that becomes the territory of a class becomes a "communal possession" among students, which produces a healthy relationship between students [27]. This parameter deals with place definition and the relationships between space and user.

8. Opportunities for Learning

Positive teaching environments provide students with a wide range of teaching opportunities. These encompass multiple forms of learning and teaching, enabling different activities in spaces and different groupings. Fixed and flexible elements and supporting materials should guarantee the diversity of opportunities [25]. This parameter deals with place definitions and the relationships between space and user.

9. Sightlines

User experience and perception of space occur mainly through sight. Sightlines are crucial in a learning environment. Teachers must be able to observe all students with a degree of privacy [28]. Space dimensions and proportions, as well as the placement of visual barriers, need adequate definitions. This parameter deals with place definitions and the relationships between space and user.

VI. Discussion and Conclusion

This paper describes a study on school design patterns created through the application of evidence-based design. Nine patterns are defined to configure the teaching environment as it emerges from research on education in the 21st century at the middle school level. Evidence on teaching methods and their environmental design needs are primarily the results of building evaluations and POE studies. Many of these studies present specific research on the learning environment, classroom settings, education as a whole, and teaching methods. Our study organized and translated this type of information into design concepts, graphically translated into design patterns. Two types of diagrams are part of this process. At the moment, symbolic graphic descriptions

represent evidence-based design conceptually.

Further development is in the form of diagrams embodying the evidence information to support the design process and problem solving. Changes in education also impact socialization and the recreational area of school buildings. Contemporary school architecture must integrate outdoor and urban areas into educational activities. The development of new patterns that deal with these issues is underway.

The product of this research will be an architectural pattern matrix for the design of middle schools as a tool to support the design process. This tool should stimulate school building design of diverse contexts, and support solution analysis and validation. The research is part of a continuous investigation of design methods and especially on contemporary school architecture. The collection and organization of new knowledge (evidence) will provide future school design processes with scientific information, translated into an insightful and clear textual and graphical language as design patterns. Finally, our contribution should inspire the design of school buildings appropriate to their context and able to motivate positive learning results.

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