Towards a Responsive Understanding of Sustainable School Architecture

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Abstract. Current international strategies admit the vital importance of education as the development engine for our knowledge-based society, where sustainability is the all-encompassing vision. In this context, a school building project should not begin with a design solution. This study aims to investigate the ways in which architects can better understand sustainable strategies and also how can they translate the real users’ needs into architectural design solutions. Sustainability may be implemented both inside the school’s curricula – knowledge, skills, critical thinking, attitudes, way of life – as well as into the design approach, construction, operations and maintenance of the school building. Not only the school building in itself should be a tridimensional textbook which offers sustainability lessons, subtly, attractively and interactively, but architects can become teachers of sustainability. Education for Sustainable Development has become a long-term strategic objective across the world. The strategy adopted by The United Nations Economic Commission for Europe in 2005 aims for integrating sustainability as a central nucleus within the educational curricula by 2040. This research applies a double filter in analysing the architecture of educational facilities: “What qualifies as sustainable?” and “What could educate?”. In other words, the study answers an original filter of analysis, “What is it in the sustainable architecture of a school that has the power to educate its users?” and defines major interconnected elements of a sustainable school building: Site, Transportation / Mobility, Safety & Security, Energy, Lighting, Indoor Air Quality, Acoustics, Water Management, Waste Management, Materials & Resources, Structural Systems, Modularity & Prefabrication, Accessibility / Universal Design, Image / Awareness / Local Footprint, Interior Design & Furniture, Orientation & Signage, Health, Nutrition & Physical Activity, Operations & Maintenance, Building services, BMS, Smart / Intelligent Buildings, Information and Communications Technology, Costs & Financing, New or Rehabilitated, Innovation. An 8-boxes matrix type SWOT Analysis have been applied for each specific component, investigating the situation of existing Romanian schools. The SWOT Analysis details the Strengths, Weaknesses, Opportunities and Threats and put forward sustainable and educational strategies. Following this study, architects may benefit from new open paths, landmarks and a research toolkit for generating original design solutions. New designed schools should be able to offer a wide range of dynamic methods of teaching architecture, engineering and environmental sciences. Therefore, Education for Sustainable Development is shaped through sustainable school architecture. If we offer users the opportunity to learn and work in educational spaces which are able to capitalize on the creative potential, in schools strategically placed within the environment and deeply rooted in their context, then children, adolescents and adults can all be proud of schools where they feel valorised, they all will be able to evolve, innovate and develop sustainable behaviours. Applying the filter of sustainability to educational purposes, architects can develop a responsive process of integrated design, based on evidence and looking towards the future.
1. Introduction
Schools are true landmarks of their communities. Nowadays, we witness a major prioritization of education embodied in programs of rehabilitating existing schools and building new ones, towards sustainability.

Ideally, any space contains learning opportunities. The key to the problem is to find out what, why, where, when and in what ways can a designed space help a learner develop. By combining academic research with personal experience, visits to newly built sustainable educational facilities and observations drawn from conversations with others, architects can reach a different level of understanding of how design can affect expected outcomes.

In the same way that knowing specific legislative requirements for educational constructions is essential for architects, so is the acquisition of knowledge about the educational process. Building a receptive design culture is not just about being up to date with the latest research in the field of education, but more than that, understanding how this information can be applied to a specific project and how it can be integrated into a certain educational facility.

In 1972, William Richmond bet his readership that the level of originality of any new published work on education is of maximum 5% [1]. Therefore, one of the objectives of this paper when reviewing the specialised literature was to track the originality “islands” in the studied works.

The present research paper puts forward a new structure, in keeping with the stated objectives, concerned with encouraging learning experiences with the aid of sustainable school architecture.

2. School architecture can facilitate learning experiences
The relationship between the space of the school and the educational process is based on a strong foundation stone: intrinsic motivation – a vital link between students, teachers, teaching and learning methods, curriculum, school environment, community and educational system.

Abraham Maslow introduced in 1971 a different way of perceiving education: the ultimate aim of education should be learning that life is precious [2]. This perspective opened new directions of approach. In other words, all subsequent debates regarding educational relations have taken place only in terms of authenticity, two-way knowledge sharing, determination, understanding, security (consistency, stability and suitability), equity, empathy, continuity and agreement.

In March 2000, The European Council elaborated at Lisbon the Memorandum of Lifelong Learning, which grounded the most important directions of action for educational public policies within its members. From the Memorandum strategy, six action principles came out: new basic competencies for all, investment in human resources, encouraging innovation, valorising learning, reorientation, conciliation and home learning.

New learning principles – self-centred learning, network learning, experiential learning and collaborative learning – have a profound impact on the functional configuration of contemporary schools. Moreover, every school design approach should take into account all 8 types of human intelligence, which all assume different aptitudes, abilities and learning modalities (verbal / linguistic; logical / mathematical; visual / spatial; musical / rhythmical; kinesthetic / bodily; interpersonal; intrapersonal and naturalist).

Educational specifications (ed specs) are meant to provide a working foundation for organizing the initial representation diagram of the architecture typology of school buildings, tracking specific functional areas for elementary schools, secondary schools and high schools [3]. Three sets of patterns were identified in the spatial configurations of contemporary school buildings:
- *primary patterns* concerns 7 functional zones: *Administration, Athletic, Science, Arts, Media, Cafeteria, Neighbourhoods*;
- *secondary patterns* unite 5 elements defining the areas: *The Streets, Common Areas Outside the Home, The Porch, The Home, The Main Entrance*;
- *tertiary patterns* define the essence of the educational facility and are comprised of elements that detail the specificity of secondary patterns: *fixed features, sociohistorical resources, transparency, ceiling heights*.

Other four types of schools, which distinguish themselves from the general analysis criteria are: *the urban bridge school*; the school that occupies *several stories of a multi-storey building*; *the floating school* and *the underground school*.

One cannot talk about the schools of the future without taking into account the exponential explosion, beyond any possible imagination, of the level of technology intrusion in everything related to knowledge. *What is not going to change in the future?* The answers to this question may be found if we go back to Maslow’s pyramid. Human needs (*Physiological, Safety, Love and belonging, Esteem, Recognition and respect, Cognitive, Esthetical and Self-actualization*) will most likely stay the same. The nature of the learning content, the nature of the needed skills and the diverse nature of the information sources will certainly come against a profound change.

3. An integrated approach through cross-disciplinary teams and dialogue

Studies have revealed two of the significant factors that cause a decreased building performance, lowered by 30% during building occupation, compared to the estimated performances from design stage: lack of active involvement of building users in design, operations and maintenance together with the poor quality of handovers of building projects to facility managers [4].

Buildings are merely a frame for the activities that take place inside, and this frame can help, or can restrain the specific ways in which these activities take place. An architect needs to develop the capacity to discover, not only the types of specific actions that a new building will host, but more importantly, the way in which the building's occupants will develop their activities in the future, and the possible internal relationships they will develop.

Through dialogue, an architect may discover design requirements [5] unexpressed clearly by the client by maintaining opened collaboration relationships between all interested parties: young scholars, students, teachers, school directors, community members, politicians, designers, research institutes. Solutions that fit all these needs may transform the project in a radical manner.

*What should we, as architects avoid when designing a new sustainable school building? What are the possible design traps in educational architecture?* During this research we identified 5 possible misleading features encountered in architectural practice [6]:

- *the knowledge trap*: not asking enough questions; accept opinions of the experts without considering the practical applicability of their recommendations;
- *the model trap*: the application of old solutions (which went well in several projects) to a new project; the examples considered to be the "best to put into practice" are not questioned; it is not examined why certain solutions worked in one context and why the same solutions did not work in another context;
- *the puzzle trap*: the idea that a good project will be obtained when using graphic patterns that incorporate the entire list of required criteria;
- *the figurative trap*: configuration of spaces and dimensions result directly from normative theories;
- *the image and symbols trap*: anchoring in predetermined spatial typologies.
The analytical avoidance of the trap network within an integrated design process will be able to form a conscious architect, armed with the presence of spirit. Regarding recently built sustainable schools, architects may face the following matter: How do we know if our intentions from the design stage have succeeded and how do we find out if the school is really being used properly? [7] The answers to this question can be found through in-depth comparative analyses of the results obtained from post-occupancy evaluations.

In the chapter entitled, in an evocative way, "Designing as if People Matter" [8] the authors recommend that we should aim for an architecture with an aesthetic role precisely because it suits, protects and enchants people. Analysing this urge, we have analysed, during this research, new questions, which can find their answers only in the dialogue with the school’s users: What detail configurations match, what details offer the feeling of protection and what is enchanting in the architecture of a school? In order to find solutions, an interactive design approach is required, which involves a deep research of the transitions: between users and architect, between building and context.

4. Sustainable school buildings as a normal architectural approach for education

"All education is environmental education [...] by what is included or excluded we teach the young that they are part of or apart from the natural world".

Education for Sustainable Development has become a long-term strategic objective across the world. The strategy adopted by The United Nations Economic Commission for Europe (UNECE) in 2005 plans integrating sustainability as a central nucleus within the educational curricula by 2040 [9]. In a cross-disciplinary approach, the school building, the schoolyard, the school garden, the school schedule come to be an integrating part of an educational system grounded on the vision of sustainable development. ESD corroborates 5 key-characteristics: cross-disciplinary curriculum; experiential learning; the study of policy influence on ecosystems; collaborative learning and intensification of public connections; action research, with the intent of serving local and global communities.

Sustainability is a live, regenerative, dynamic concept, which will further develop in time. Taking into account the current worldwide situation (the restrictive measures taken against the pandemic), both resilient design as well as sustainable design should represent a normal design approach, cultivated within academia and normally engaged in the architectural practice. A deep understanding of the concept of sustainability may be achieved exclusively upon embracing all nuances.

Exploring theories, legislative frames, building evaluation standards and good architectural practices, we can polish the multiple facets of the complex concept of “sustainability”, in order to promote a pragmatic approach. A thorough analysis highlights one of the less talked about facets, the risk of sustainability redundancy: a vast concept may very easily fall into the trap of rigid language through its vague and inadequate application. The concept of greenwashing speaks about a way of “money laundry” practiced by companies, purposely declaring to agree with being green, but really abusing its consumers’ ecologic profile in order to draw profit. Reducing the complexity of sustainable architecture to a few key-words, as efficient, solar, green, ecological, healthy, passive, reused, recycled can follow a proverbial pulling of the green wool over someone’s eyes.

Simply getting a good score within a checklist of a certification system does not guarantee the actual implementation of a good practice. Therefore, the issue of periodic recertification of sustainable buildings must be considered, in keeping with the evolution of technologies and design theories.

Following the idea that an architectural object exists only in relation to its users, the logical thread we further pursue explores deciphering the ways in which school architecture could better answer its
users’ needs. How can a school building teach? The answer to this key-question defines 4 levels of encouraging learning experiences [10]:

1. **multisensorial** – influencing the learning experiences of the school users through tactile, visual, auditory and olfactory interaction with the school building and site;
2. **dissemination** – communicating information concerning the school building, the active engagement of the community the school belongs to, educating the public (school occupants, community members, construction professionals);
3. **curricular** – integrating the school’s built environment in the curricula: school design project, building envelope, site, building services, equipment, they all can become subjects of study
4. **research** – analysis of the school building design project, of its incorporated technologies, analysis of building performance and its impact on the users.

Specialized literature contains heterogeneous definitions of categories and priorities. In this matter, a filter of analysis was necessary. Table 1 below introduces 25 “puzzle pieces” which deconstruct the sustainability of a school building and are grouped into 5 original thematic categories: **Settled Schools**, **Balanced Schools**, **Comprehensive Schools**, **Calibrated Schools** and **Grounded Schools**. Each of these components arguments in favour of the importance of a specific component of a sustainable school and synthesizes a series of design recommendations.

| 25 interconnected defining elements of the sustainability of a school building, grouped in 5 thematic categories, which answer an original analysis filter: |
|---|
| 1. Site |
| 2. Transportation / Mobility |
| 3. Energy |
| 4. Lighting |
| 5. Safety & Security |
| 6. Materials & Resources |
| 7. Structural Systems |
| 8. Modularity & Prefabrication |
| 9. Water Management |
| 10. Waste Management |
| 11. Image |
| 12. Orientation & Signage |
| 13. Accessibility / Universal Design |
| 14. Interior Design & Furniture |
| 15. Health, Nutrition & Physical Activity |
| 16. Operations & Maintenance |
| 17. Indoor Air Quality |
| 18. Acoustics |
| 19. Building services, BMS, Smart schools |
| 20. Information and Communications Technology |
| 21. Awareness |
| 22. Local Footprint |
| 23. Costs & Financing |
| 24. New or Rehabilitated |
| 25. Innovation |

Grouping these 25 items into 5 thematic categories is not aimed at being fully comprehensive. In keeping with future research priorities, the 25 puzzle pieces may be regrouped on different premises and may thus make the subject of new “pictures”. Two possible examples are grouping these components under the umbrella-notion of comfort or of building envelope.
The hypothesis launched in this paper can be summarized in the following manner: a school building is sustainable when it becomes a 3D interactive textbook of Education for Sustainable Development. In order to discover ways through which this hypothesis may be applied in the case of Romanian school architecture, we put the following instrument to use: an 8-boxes matrix type SWOT Analysis. This instrument brings about – apart from the well-known SWOT Analysis – the generation of strategies in the 4 intersection resulted fields.

![Diagram of SWOT Analysis]

**Figure 1.** Explanatory scheme for the 8-boxes matrix type SWOT Analysis model

25 SWOT Analysis have been applied, investigating the situation of existing Romanian schools. They put forward sustainable and educational strategies for Romanian schools integrate design measures recommended for architects, programming, using, and planning strategies, addressed for the decision factors and strategies connected to the other levels by which a building is able to educate: integration in the curriculum, research, communication and dissemination of results.

5. Results and discussions
Following a cross-analysis of the current undergraduate educational system, the research puts forward sustainable and educational strategies for Romanian school functioning, which corroborate the 4 levels on which a school building is able to educate: multisensory, curricular, research, dissemination.
On a close inspection of the results derived from this work, it is possible to extract the following barriers (listed with black bullets) and catalysing factors (listed with white bullets) for implementing educational and sustainable strategies in Romanian schools:

- The correlation between the following statistical data in Romania: the low level of motivation for the Romanian students (according to latest PISA tests conducted); the highest dropout rate in the European Union (19% among the 15-18 age group); very low rate of educational accommodation among disabled children; infantile mortality rate (the highest in the European Union); poverty degree among children (over 34%); high unemployment rate among young adults (over 23%).

- The built environment of Romanian schools falls behind when compared to the educational process it hosts. There is no official database of schools built from 1990 onwards but it is estimated that over the past 26 years fewer than 400 schools have been built (2% of the total number, estimated at 21,000). Over 80% of the existing Romanian schools have been built before 1970.

- Lack of correlation between legal documents. The national strategies concerning education and sustainable development are aligned with the levels of the European Union, leaving behind the existing norms and the architectural practice of educational facilities. Although assumed as a strategic objective, sustainable development is not part of the national curriculum and is still subject to extra-curricular activities.

- School projects are about attaining minimal safety, health, comfort rules, while sticking to an also minimal budget, without quoting optimizing its users’ health and comfort as an objective. Due to the lack of ensuring basic needs (protection against wind or rain, plumbing, electrical and thermal systems, security and comfort, transport), many schools face yearly short-term decisions.

- The new building and rehabilitation are ordered by the public local authorities without consulting with decision factors experienced in the educational field or with schools leadership. There are tenders but there are no architecture contests. Therefore, the price continues to be the most relevant criterion during a tender. The execution works are often subcontracted by third parties. Materials and finishing are inferior in quality when compared to the characteristics required in the initial project and there are no quality checks for installed products.

- The generalized practice of improvised works is designed to meet initial requirements which have been ignored and later discovered; the works are generally the result of external pressure: school year beginnings, inspections, external evaluations, fines, press alerts.

- Lack of involvement on the professionals’ part (designers, builders, suppliers) in (in)forming the teaching and administrative staff of a school after finalizing a project.

- Central and local authorities appear to be completely oblivious to the complementary services that accompany these projects on mid and long term (costs, trainings, operations and maintenance).

- The greatest opportunity is embodied by some local communities who are promoting projects and numerous activities towards sustainable development within the school environment, in association with NGO’s or private companies.

- The voice of the civil society on the one hand and the need to adapt and harmonize the legal frame on the other will attract the need to transform the educational built environment.

- Keeping a high banner for educational architecture, to the detriment of attaining a minimal threshold (survival, ensuring basic needs).

- Maximizing the time and resource investments during the design, research and evaluation stages.

- Taking into account the evidence that can be obtained from comparative analyses, benefitting from a ground base of best practices, the institutional leadership of our schools may be able to think long term plans. Being involved in the dialogue and understanding that their feedback makes a difference, the decision factors will end up wanting for the school they are managing to become a landmark playing the part of a magnet for the community it belongs to.

- The correlation between the very good quality of Information and Communications Technology (ITC) professional skills and the medium internet speed in our country, situated in top 6 countries.
worldwide over the past years. An intelligent ITC integration will not separate the education institution from the community. Instead, it will facilitate access to cultural, social, therapeutic, family and support services.

Finally, we would like to emphasize some further research directions opened by this research:

- Implementing a POE in an existing school building in Romania, with an existing school population, with the help of building performance research institutes and with the help of educational research institutes.
- Extended implementation of POE, on a representative sample of schools, from each type of standard school projects, with the intent of exploring rehabilitation opportunities for Romanian schools in the direction of sustainability.
- Revision of NP 010 / 1997 – Normative regarding design, construction and utilization of school buildings and high school buildings currently in force in our country.
- Research on pre-primary school education, based on learning by playing. The results of such a study can drive to realize a reviewed normative for kindergartens and also to create guides for exterior playing design features.
- Initializing practical activities in faculties where built environment is studied and promoting students’ activities by according credits: students in architecture, engineering, building services can participate in construction workshops in rural schools with various construction techniques, involving the local communities;
- Initializing teaching programs for administrative school staff, based on sets of techniques incorporating users’ complaints analysis, as diagnostic tools over the problems of a school building;
- Creating websites like “teacher’s toolbox” containing abstracts, presentations, questionnaires, checklists, application guides followed by successful examples of project lessons for each of the 25 components defining a sustainable school building, detailed on specific thematic areas;
- Creating a digital Map of all Romanian schools involved in programs, projects, competitions or other activities following a sustainable direction, based on existing and on future studies.

Figure 2 below explains the process recommended for future responsive architectural approach in regards of Romanian educational facilities: an Evidence-based Design approach (EBD) through Post-Occupancy Evaluation method (POE) in order to sustain Romanian education with the help of sustainable school architecture.

When sustainability will be truly integrated within the curriculum on all education levels, and the educational system truly becomes – not just on the legal documents – a system promoting Education for Sustainable Development, from that moment on we might witness a paradigm shift. In other words, experiences would be turned into knowledge through guided reflection, critical thinking would have a sustainable ground base and thus, sustainable behaviours would catch shape.

Today’s students may become tomorrow’s architects and the day after tomorrow’s project coordinating architects. The aces up their sleeves will be: sustainability as interpretation key, a baggage of evidence, and design experiences in cross-disciplinary teams. Responsive architects in dialogue with their users can turn the constraints into innovation and expressivity opportunities.
Figure 2. Explanatory diagram presenting the practical applicability of the results for the cyclic process of evaluation – research – design – use for a school building.

- **What qualifies as sustainable in a school building?**
  - Multisensorial
  - Curricular
  - Research
  - Dissemination

- **What has the power to educate?**

- **Double analysis filter over school buildings:**
  - Generating national evidence from international research on schools
  - Design integrated, responsive participative based on dialogue cross-disciplinary teams

- **25 SWOT Analysis**
  - **S** (Strengths)
  - **W** (Weaknesses)
  - **O** (Opportunities)
  - **T** (Threats)

- **Sustainable school buildings in Romania (new / rehabilitated)** playing the role of interactive and attractive 3D textbooks of Education for Sustainable Development (ESD)

- **< 1970**
  - Approximately 80% of school buildings

- **1990 – 2020**
  - Less than 2% from the total number of school buildings

- **POE (Post-Occupancy Evaluations)**

- **Settled schools**
- **Balanced schools**
- **Comprehensive schools**
- **Calibrated schools**
- **Grounded schools**
6. Conclusions
Transition to the information society will attract an innovative sustainable school architecture, which will help develop new learning modalities. There is a powerful need of adequate educational buildings, able to invite, encourage and inspire. The existing infrastructure of school buildings can be utilized to form community’s centres. As regarding new buildings, the modalities of teaching and learning should shape the form of the building and not backwards.

The built environment of an educational facility bears a great responsibility towards those who learn within. However, creating a habit of permanent dialogue between the design team and the school users is essential. Current practice, where design solutions emerge as a result of successive suggestions coming from other disciplines, is not just obsolete, it is also very hazardous. The current national context depicts the following situation: the school users are completely absent from any dialogue with the design teams. Moreover, the architects expect the users to be content with the solutions they got. Instead of blaming the ulterior modifications users have operated after building occupation, the architects need to be made aware of the fact that a school project does not begin with a solution.

On the contrary, it is only the receptive architects, as moderators of the dialogue between all involved actors in the design and construction process, that are able to develop a design brief fit to serve the current educational act. Architects must train to develop connections and read between the lines. Starting from these premises, this research has investigated ways through which an architect can translate sustainable criteria and the needs of the school users into architectural design solutions.

With the intent of creating a unitary vision for new sustainable school buildings which encourage learning experiences, this research paper supports an integrated, responsive, evidence and dialogue-based design approach, created in cross-disciplinary teams: professionals responsible of designing and realizing the project, consultants, school users, public authorities and local communities.

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