

## Systematic Investigation into the Development of an Architectural-Pedagogical Concept for Schools as a Hybrid System

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**Citation:** Sedighi M (2026) Systematic Investigation into the Development of an Architectural-Pedagogical Concept for Schools as a Hybrid System. American J Sci Edu Re: AJSER-197. <https://doi.org/10.71010/2835-6764/ajser-e297>.

**Received Date:** 07 January, 2026; **Accepted Date:** 13 January, 2026; **Published Date:** 19 January, 2026

### Abstract

*School as a hybrid system is a hybrid architectural-pedagogical model for future-proof school buildings, which stands for a variable and agile solution for the current challenges in the school and adult education sector. With its motto from education to edu'action' [1] school as a hybrid system is also an ideal basis for the implementation and realization of the ESD (Education for Sustainable Development) goals.*

*School as a hybrid system transforms school into a hybrid space that includes different user groups and integrates the school and its educational mission into the socio-cultural and socio-economic environment. With an expanded range of spaces and an optimized spatial concept, it offers variable possibilities for the implementation of diverse digital learning formats and hybrid learning concepts with tech labs or maker spaces as well as informal digital learning environments.*

*For the architectural transformation of a classical school into a hybrid school, the functional, structural and design potential of a hybridization must be considered holistically, taking into account the educational mission statement of the respective school and the characteristics of the environment of the school. In doing so, a hybrid utilization scenario developed participatively is transferred into spatial-architectural requirements.*

*The extent to which this transformation to a school as a hybrid system takes place depends on the degree of hybridization, which is determined by the parameters of Variety, Diversity, Ambiguity, and Variability (VDAV principle) [2,3]. To coordinate the effects in the different categories of hybridization and to strengthen the effectiveness of the measures, a model matrix (modular system) for the design of the degree of hybridization is developed and presented based on the principle of the VDAV parameters. The concept is transferable to universities, colleges and research institutes.*

**Keywords:** Hybridity, Architectural-Pedagogical Concept, New Architecture for Educational Buildings, Education for Sustainable Development, Lifelong Learning, Hybrid School.

### Introduction

Demographic change, migration, disruptive technologies, and innovative teaching and learning formats require school spaces that can cope with current developments. However, many schools are reaching their limits in terms of the space, spatial concept and interior design regarding today's requirements.

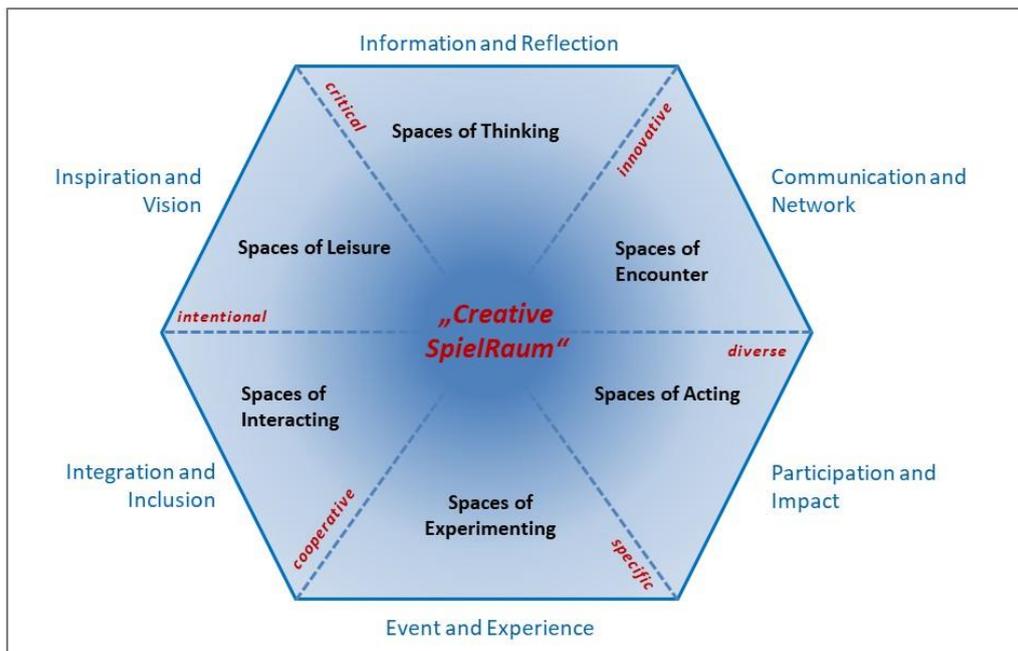
In addition, schools must increasingly prepare today's children for complex and rapidly changing working environments which rely on a sense of responsibility, creativity, and above all on self-reliance, as well as for future professions that do not even yet exist. The *4C's Learning Model*<sup>1</sup> summarizes the development of four most important competencies-communication,

collaboration, creativity, and critical thinking – as educational goals in a digitalized world with ubiquitous access to information and knowledge.

Acquiring these skills requires innovative and creative educational spaces, spaces of change, spaces of development, addition and overlap, simply multidisciplinary spaces. Hybrid spaces make it possible to link all these aspects architecturally as well as pedagogically, economically, socially and legally in a dynamic process.

A sustainable and participatory development of our world needs space for a targeted transformation of education and its environment and for shaping our future. This *Creative SpielRaum* is multifaceted, experimental, participatory, locally and globally integrative [4].

<sup>1</sup> s. Basińska (Basińska, 21.04.2021)



**Fig. 1:** School as a hybrid system: scientific model of the Creative SpielRaum [4].

Schools could be the first institutions and offer ideal architectural spaces for this development. They play a decisive role both in rural areas and in the urban context, as they can take on many tasks in society as a kind of large social space (not only for students) and as a place of (everyday) living and learning. New pedagogical models and socio-cultural demands on schools require new concepts for room structure, room program, room use and room design in order to meet the above-mentioned objectives. Therefore, architects are facing new challenges in design and planning of modern schools and educational buildings:

- School as part of the urban quarter or rural environment
- Innovative/new teaching and (digital) learning environments
- Rooms for all-day activities
- Rooms for inclusion
- Multifunctional areas and differentiation areas
- Flexible, variable and individual floor plan design
- Hygiene concept and pandemic resilience
- Environmental and climate protection.

The architectural-pedagogical concept of *school as a hybrid system* includes various user groups by transforming it into a hybrid space. For example, spaces available in the building for colearning or coworking, a cafeteria and restaurants, sports and health offers, leisure, startups, workshops, and art studios integrate the school and its educational mission into a realistic socio-cultural and socio-economic environment. With an expanded range of spaces and an optimized spatial concept, it offers variable possibilities for the implementation of diverse digital learning formats and hybrid learning concepts with tech labs or maker spaces as well as informal digital learning environments. In this way, school becomes a diverse learning space and *creative SpielRaum* in a dynamic process: according to the motto *from education to edu'action*'.

## Approach and Method

### School and Pedagogics

An in-depth understanding of the school as an organizational form is an indispensable basis for the subsequent development of potential pedagogical-architectural concepts for *schools as hybrid systems*. Many existing research and practical projects in this field have been investigated and analyzed both architecturally and pedagogically. The complexity of the topic at the interface between social sciences and engineering also requires a well-founded scientific analysis.

### Hybridity

The classification of hybrid forms in architecture is analyzed and further expanded in order to recognize, explain and apply the systematics, possible form variants and transfer possibilities for the hybridization process of school buildings. Principles and key elements for the architectural hybridization are identified and described.

Scientific approaches to the analysis and representation of the complexity of hybrid systems as well as their interpretation and design are examined and applied. Reiß's *VDAV-model*<sup>1</sup> for the description and design of hybrid systems (organizations, organizational forms and organizational dynamics) [2,3] is adapted and applied as a possible scientific approach for the design of architectural concepts for the intended transformation of schools into *schools as hybrid system*.

### Architectural Development of School as a Hybrid System

The typologized architectural school forms are fundamentally analyzed to find out which basic forms and building types are suitable for a hybridization. As a result, principles and appropriate key architectural features and elements for hybridization reveal.

It is shown how integrative usage models can be developed architecturally, taking into account the school location, the socio-cultural and socio-economic background, the acceptance of the stakeholders and the preferred pedagogical and didactic

concepts, and how the interfaces of the jointly used areas can be consciously designed.

**Systematic planning and implementation process of a hybridization**

A participatory hybridization process is outlined for architectural planning and implementation and the methodology of combined modular hybridization, refurbishment and modernization is established and described for existing schools.

**Results**

In principle, all schools and common school types - elementary school, secondary schools, secondary modern schools, grammar schools, vocational schools, etc. - are suitable for hybrid concepts to varying degrees. As part of a context-appropriate hybridization of schools, aspects of the three thematic clusters "school and architectural space", "school and pedagogy" and "school and society" with their interfaces, their problems and their challenges and synergies must be considered in detail and as participatively as possible (see Table 1).

The school hybridization, transformation and development take place in multiple dimensions and on several different levels. A classical school grows into an innovative, hybrid system with new structures, which not only integrates technologies,

processes, and stakeholders and protagonists, but also acts as an active designer and integrator ("*classroom as 3rd teacher*", Loris Malaguzzi). In this way, a construct of interrelated parts emerges that demands and promotes the relationship, connection, interaction, and interdependency of the students and stakeholders and at the same time forms one common whole.

The number and diversity of school and non-school actors and stakeholders changes during the development of a *school as a hybrid system*. This leads to a diversity of functions, which requires an adaptation and, if necessary, an expansion of the space available at the school from a classic to a multi-optional and multifunctional space concept with flexible usage structures.

For the holistic architectural transformation and conversion of a traditional school into a hybrid school, the functional, structural and design potential for hybridization must be considered, taking into account the pedagogical mission statement. A hybrid usage scenario developed for the respective school is translated into spatial and architectural requirements. New functional spaces can be implemented based on a specially developed spatial concept and room catalogue in accordance with appropriate hybridization principles and using suitable construction methods.

| School and Architectural Space                             | School and Pedagogics                                    | School and Society  |
|--|--|---|
| Building type  | Type of school (elementary school, grammar school, etc.) | Socio-cultural background of the students and stakeholders                    |
| Building form, and size                                    | Type of school (e.g. all-day school)                     | Multiplicity and diversity of the teachers, students and further stakeholders |
| Usable floor space   | School concept   | Social and economic status of parents/guardians/families                      |
| Gross floor area   | Educational mission statement                            | Usage profile of the urban quarter (e.g. residential, urban, mixed)           |
| Space available, room concept, room structure, room design | Number of students                                       | Population density  |
| Functions and use of space                                 | Sponsorship  | Development plans   |
| Accessibility and mobility concept                         | Teaching and learning formats, learning processes        | Safety concept  |
| Open space and exterior design                             | Education for the use of digital media                   | Equal opportunities   |
| Accessibility  | Education for sustainable development (ESD)              |   |
| Building design  | Inclusion and special educational focuses                |   |
| Barrier-free accessibility                                 | Teaching materials, (digital) school equipment           |   |
| Building security  | Digital learning platform                                |   |
| Technical equipment, IT infrastructure                     | Networking with external stakeholders                    |   |
| Material concept and construction                          |  |   |
| Site analysis, location                                    |  |   |
| Public transport connections                               |  |   |
| Spatial embedding in the built environment                 |  |   |
| Energy efficiency concept                                  |  |   |

**Tab. 1:** Important aspects for the analysis of a (planned) school in the three thematic clusters School and Architectural Space, School and Pedagogy, School and Society.

**Functional Hybridization**

The functional hybridization of a school means a targeted expansion and optimization of use against the background of the needs of all stakeholders in a neighbourhood, urban quarter or municipality through a deliberately chosen combination of different functions to suit the respective location.

By superimposing and overlapping the spatial program of a school and the spatial requirements of the neighbourhood/community which are evaluated e.g. from interviews, surveys, discussions, urban and neighbourhood planning, a new catalogue of uses or usage scenario is created as the basis for a context-appropriate hybrid spatial program for the

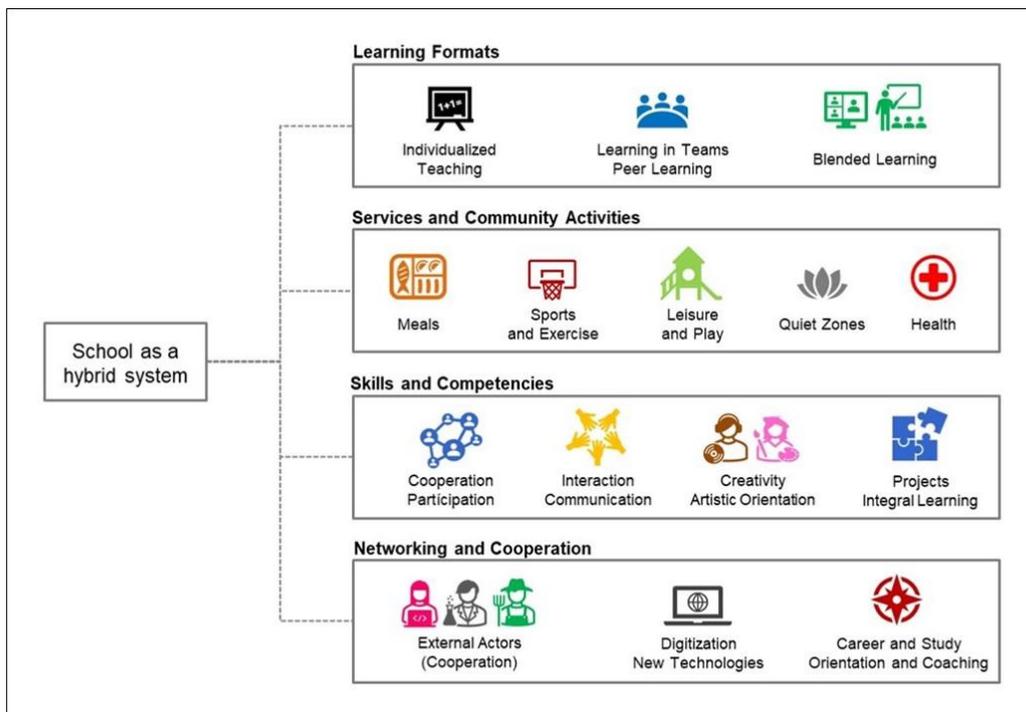
school.

Thus, the functional hybridization takes place through active and participatory involvement of the stakeholders, which leads to an agile development of a site-specific usage scenario, and it can be specifically controlled and architecturally implemented through the design of the parameters of variety and diversity.

In summary, hybridization increases the number and variety of functions and systematizes them according to their functional fields (Fig. 2), expands the range of uses, supplements usage concepts and develops a new spatial program. It is not only the

number and size of the existing (learning) spaces, but much more their (open) accessibility and thus their allocation to certain building areas or sectors, levels, layers or episodes that

determine the options with regard to an expansion of use and/or use for new actors.



**Fig. 2:** Hybridization process: Exemplary categorization of functional fields for the creation of an individual and specific usage scenario for “school as a hybrid system” [5].

### Structural Hybridization

The participatively developed hybrid utilization scenario of a school is in the next step transferred into spatial-architectural requirements. For architectural hybridization, new functional spaces can be implemented based on a specially developed spatial concept and room catalogue in accordance with appropriate hybridization principles and using suitable construction methods.

Structural hybridization is based on certain hybridization principles, such as *addition, adaptation, transplantation, grafting, addition of stories or superimposition* [4] which lead to the creation of a hybrid construct. These principles can be implemented in different combinations and in different processes in both vertical and horizontal form or in a mix of both using key architectural elements.

A functional hybridization requires an expansion of the available space and in parallel an adaptation of the spatial structure and design, which can be implemented structurally on the basis of the above-mentioned architectural hybridization principles. In this way, *fabric hybrids, graft hybrids, agglutinate hybrids, chain hybrids, sector hybrids and monolithic hybrids* are created<sup>2</sup>.

Here, not only form follows function, but also their development (spatially, in terms of design, arrangement and structure of the rooms). A smooth transition between the different functional areas leads to efficient and high-quality spaces with maximum

utilization possibilities. This type of hybridization takes place both horizontally and vertically.

As a result, the traditional, hierarchically organized spatial concept of school buildings is replaced with decentralized, changeable and multiply activatable spaces and areas, both in the entire school and in the individual classrooms.

The mobility of the students and further protagonists is one of the decisive factors in the development of the hybridization and places high demands on the infrastructure and the accessibility and circulation concept of the building. The various rooms and areas of the *school as a hybrid system* should be arranged anatomically like the organs of a body, coordinated and interconnected, function perfectly and merge smoothly into one another, but at the same time be able to fulfill their function independently and ensure the safety of all stakeholders.

Therefore, a distinct and varied range of circulation and access elements is required, e.g. in the form of staircases, stairwells, elevators, bridges, arcades, covered entrance rooms/halls and courtyards. Separate, multi-variant circulation and access levels and sectors enable the separation/segregation into private, semi-public and public areas essential for hybridization. Sections with restricted circulation, quiet zones, and “stroll” areas are just as important as meeting, “swarm” and communal spaces.

Structural expansion measures and space optimization are just as important aspects for the integration of new functions as the

<sup>2</sup> see the historical principles of hybridization [6], for example in the form of grafting or adding-on to create fabric hybrids, graft hybrids and monolithic hybrids.

creation of different atmospheres through the conscious design of functional areas, furniture, color and lighting concepts, and the use of sustainable materials (design hybridization).

### Key architectural elements and measures

Hybridization transforms the entire school into learning spaces and learning environments that, just like our living spaces, have a multifunctional and tangible character, create identity, stimulate curiosity, have an inviting effect and promote community.

It is crucial to eliminate any rigid usage structures of a school's traditional room program in favour of multifunctionality and to create opportunities for optimal use of the areas and rooms as well as to enlarge, link and change the areas while retaining the learning spaces.

Some of the most important architectural characteristics and features of a hybrid school therefore include

- Presence of macro development and micro development
- Variety of room layouts
- Multi-layered range of rooms
- Differentiation areas
- Variability, adaptability and flexibility of the rooms
  - Short-term (situational)
  - Long-term (conceptual)
- Versatility, multi-optionality
- Accessibility, spaces of inclusion
- Possibility of enlarging, linking and changing learning spaces
- Multifunctional and multi-optional spaces, common rooms
- Requirements and equipment for digitalization
- Systematization of functions
- Sectors, episodes, levels, layers
- Private, semi-public, public areas.

Differentiation areas can be designed both vertically and horizontally (e.g. by glazing or slightly raising the level, floor and/or wall surface). Separate access areas extend the existing infrastructure (separate stairwell, entrances). This also includes bridges, corridors, covered walkways and connecting

structures/separation zones. The presence of several entrances allows each wing to be used separately without crossing functions. It is particularly important that differentiation areas are developed or created as a buffer zone to the main area and can be extended if necessary.

The access is more than just a central connecting element. In this way, the school itself as a space for movement and action becomes a kind of “teaching aid” that encourages the curiosity of the actors, especially the students, stimulates their mobility and thus strengthens their identity because they can perceive the school ensemble better and holistically, but still step by step.

### Macro- and Micro-Hybridization

Hybrid spaces are created not only purposefully in new school buildings, but also based on redesign, addition, and adaptive expansion of existing schools as part of a holistic hybridization. Micro-hybridization involves adding and transplanting a new room module into the existing structure of a school. This results in a minimal structural change, but at the same time a functional expansion of the school is achieved. Such micro-hybridization can be implemented quickly and efficiently by using prefabricated modules, for example.

Macro-hybridization, on the other hand, changes the entire room structure, the arrangement of the rooms, the room concept and range and expands the school's room program. This leads to a significant overlapping and shifting of functions and uses, which in turn requires certain safety aspects (e.g. fire protection, hygiene) and a barrier-free infrastructure as well as an expansion and supplementation of the traffic concept and development. Like micro-hybridization, macro-hybridization can also take place both horizontally and vertically.

### Design of hybridization according to the VDAV principle (Variety, Diversity, Ambiguity, Variability)

The extent to which the transformation to a *school as a hybrid system* takes place depends on the degree of hybridization, which is given by the parameters of Variety, Diversity, Ambiguity, and Variability (VDAV<sup>1</sup>). The degree of hybridity is determined not only by the multiplicity of actors and functions in the school, but also by their heterogeneity and diversity.

|            |            | Parameter for the Adjustment of the Degree of Hybridization   |   |   |   |   |
|------------|------------|---|---|---|---|---|
|            |            | Variety   | Diversity   | Ambiguity   | Variability   |   |
| Categories |            |   |   |   |   |   |
| Functional |            | <ul style="list-style-type: none"> <li>Addition of new functions</li> <li>Extension of functions</li> <li>Reutilization</li> <li>Community areas</li> <li>Places for exchange and encounters</li> <li>Comfort zones</li> <li>Quiet areas</li> <li>Movement areas</li> <li>Accessibility and mobility concept</li> </ul> | <ul style="list-style-type: none"> <li>Meeting and encounter places</li> <li>Heterogeneity of functions</li> <li>Diversity of functions</li> <li>Variation of functions</li> <li>Multifunctionality</li> <li>Variability of functions</li> </ul>                                | <ul style="list-style-type: none"> <li>Connection</li> <li>Overlapping</li> <li>Superimposition</li> <li>Overlapping</li> <li>Differentiation</li> <li>Individualization</li> <li>Flowing transitions</li> </ul>  | <ul style="list-style-type: none"> <li>Interaction</li> <li>Dynamism</li> <li>Agility</li> <li>Interaction</li> <li>Synergy effects</li> <li>Transformation</li> <li>Metamorphosis</li> <li>Networking</li> </ul>   |   |
|            | Structural |   | <ul style="list-style-type: none"> <li>Rooms</li> <li>Forms</li> <li>Infrastructure</li> <li>Connecting elements</li> <li>Accessibility &amp; circulation area</li> <li>Principle of addition, vertical/horizontal</li> <li>Attachment, gap construction, conversion</li> </ul> | <ul style="list-style-type: none"> <li>Room structure</li> <li>Room available</li> <li>Variety of forms</li> <li>Diversity</li> <li>Differentiation</li> <li>Multifunctionality</li> </ul>  | <ul style="list-style-type: none"> <li>Variability</li> <li>Switch areas</li> <li>Turning points</li> <li>Separating zones</li> <li>Connecting sections</li> <li>Flowing transitions</li> <li>Linkage</li> <li>Overlapping</li> <li>Superimposition</li> <li>Multi-optionality</li> </ul> | <ul style="list-style-type: none"> <li>Adaptation</li> <li>Transplantation</li> <li>Agglutination</li> <li>Flexibility</li> <li>Modularity</li> <li>Situational spatial structure</li> <li>Development of the spatial profile</li> <li>Temporary and secondary structures</li> <li>Pop-up concepts</li> </ul> |
|            |            | Design  | <ul style="list-style-type: none"> <li>Material selection</li> <li>Material combination</li> <li>Colouring scheme</li> <li>Light- and colour components</li> <li>Optics, acoustics, haptic</li> <li>Furniture</li> <li>Mobile spatial elements</li> </ul>                       | <ul style="list-style-type: none"> <li>Colour concept</li> <li>Lighting concept</li> <li>Material selection and concept</li> <li>Variable equipment</li> <li>Interior design</li> <li>Design of exterior space</li> <li>Hybrid learning environments</li> <li>Variable design of usage areas</li> </ul> | <ul style="list-style-type: none"> <li>Flexible equipment</li> <li>Variable zones</li> <li>Various lighting concepts</li> <li>Room effects</li> <li>Multifunctionality</li> <li>Overlapping and superimposition</li> </ul>  | <ul style="list-style-type: none"> <li>Atmosphere</li> <li>Comfort and cosiness</li> <li>Room comfort</li> <li>Convertible areas</li> <li>"Stroll" areas</li> <li>"Swarm" areas</li> <li>Movement and rest</li> <li>Encounter</li> </ul>  |

Fig. 3: Model matrix for the design and control of architectural hybridization according to the VDAV principle [4].

To coordinate the effects in the different categories of hybridization and to strengthen the effectiveness of the measures, a model matrix (modular system) for the design and targeted control of the degree of hybridization is developed based on the VDAV principle [4] (Fig. 3).

As a result, an architectural catalog for *school as a hybrid system* is compiled for both new and existing buildings according to the principle of a matrix, which shows and contains important prerequisites as well as concrete proposals for room structure, room offer, room program, room design and also for the development and infrastructure as well as the overlapping of functions. The possibilities of hybridization are exemplified in the three categories *structural, functional, and design* and their interaction and reciprocal effects are illustrated in a model matrix (modular system), on the basis of which the degree of hybridization can be specifically controlled using the VDAV model.

The model matrix shows that each step of a hybridization in a selected category simultaneously causes interaction and coherence in all other categories but can be controlled in a context-appropriate and targeted manner using the VDAV parameters. This complexity and dynamic can be illustrated using the present matrix: *Variety creates diversity, diversity creates ambiguity, ambiguity creates variability*" [3].

**Example of a macro-hybridization to a hybrid atrium school: addition, adaptation and duplication**

By combining and linking two different basic forms with an access element, macro-hybridization can sometimes lead to new architectural hybrid building forms, as shown by the pictograms in Fig. 4. In the example shown, initially two basic building forms are linked, namely a corridor school and a school with a covered entrance area with a connecting building. In the next step, a hybrid atrium school can be developed by addition (duplication and extension) plus a further connecting building. In this way, the available space is expanded and a multi-optional, flexible usage concept is developed. The covered connecting elements play an important functional role as circulation and access cores, set strong architectural and design accents, and lead to the creation of a new architectural, hybrid atrium school.

The school is purposefully extended and has additional learning space, for example in cluster form. In the newly created hybrid building ensemble, the original basic forms have been retained and are still clearly recognizable, but the available space has been expanded and the use of space reorganized. The functional areas can be separated as required and at any time by inserting lockable sections. This allows new, extracurricular players to be integrated into the school. The atrium can be used as a n encounter area, break and exercise room or as an open-air classroom.

### Discussion

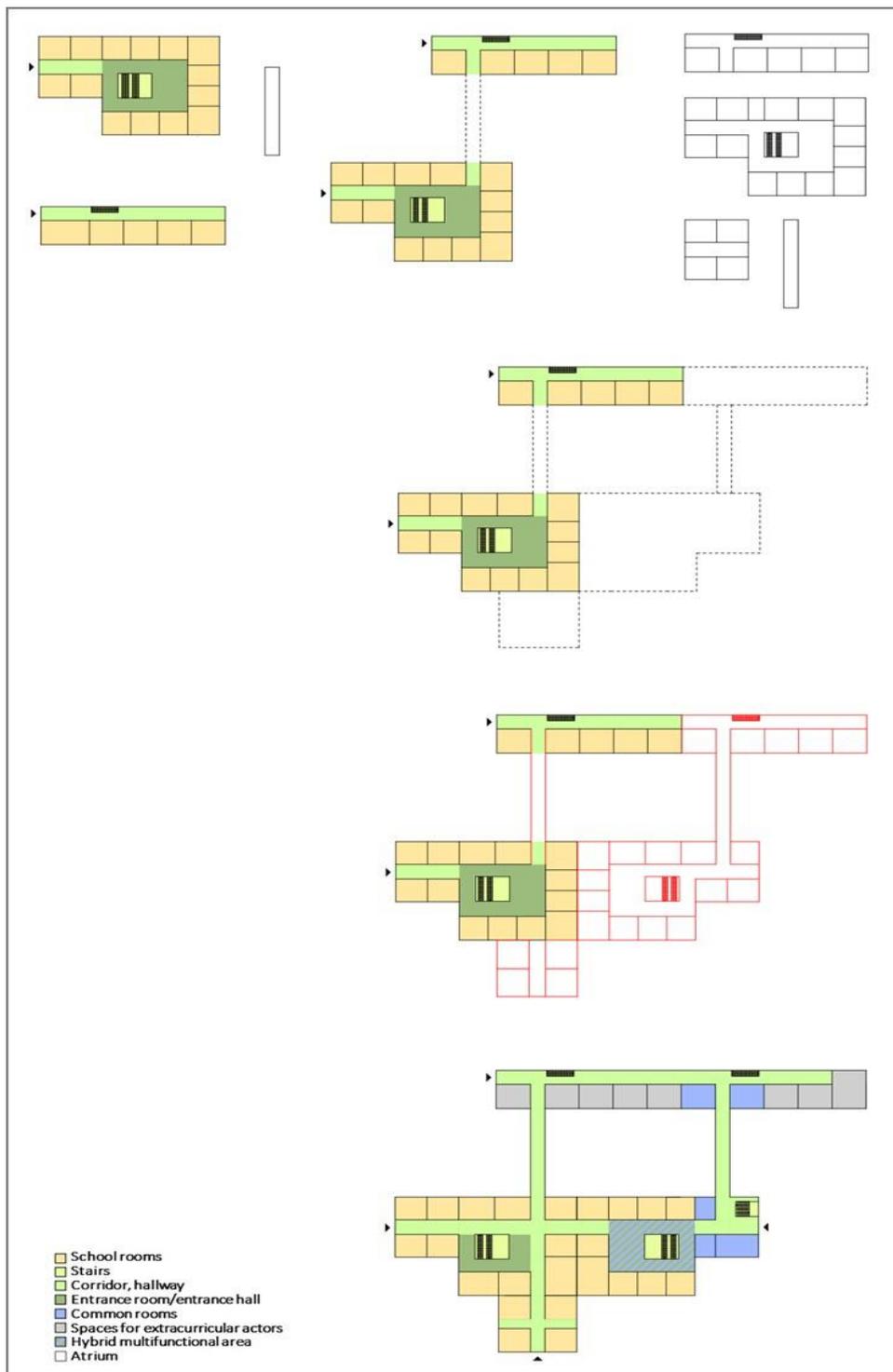
*School as a hybrid system* is an intentional form of hybridity and is based on differences and heterogeneities. It is variable, versatile, and surprising. Hybrid schools are not fixed to one pedagogical approach, but rather combine and complement the formal teaching mission of the school with non-formal and informal learning approaches in a practice- and action-oriented way.

The best-known pedagogical concepts all focus primarily on students and further school stakeholders, while *school as a hybrid system* with its multifunctional and creative spaces addresses the

various stakeholders in society in the current and global reality of life (climate change, pandemic, resource scarcity, social division, migration) and offers them the opportunity for lifelong learning and participation in the educational environment and environmental education in a dynamic process in the school.

### Digitalization

With an expanded range of spaces and an optimized spatial concept, *school as a hybrid system* provides variable possibilities for the implementation of diverse digital learning formats and hybrid learning concepts with tech labs or maker spaces as well as informal digital learning environments.



**Fig. 4:** Schematic representation of a macro-hybridization: combination of two basic forms (school with covered entrance hall(s) and corridor school) and creation of a hybrid atrium school.

*School as a hybrid system* offers new, integrative approaches for the innovative teaching of digital skills and user knowledge as a suitable learning space to promote inclusion in the provision of information and knowledge (e.g. AI tools to overcome language barriers), and also by facilitating exchange with different user groups, e.g. an IT company or digital experts in coworking spaces. The exchange of experiences and mutual learning effects can accelerate the familiarization, safe handling and meaningful application of new digital developments in the education sector. In this way, *school as a hybrid system* acts as a ‘catalyst’ for digital transformation in the education sector across generations. The relevance to reality and thus the interest and motivation of students will increase if practical examples and possible role models for the use and development of digital skills are available in the immediate vicinity. This appears to be an important advantage, especially regarding the transition from school to work.

### Equal Opportunities and Lifelong Learning

As an architectural-pedagogical concept, *school as a hybrid system* integrates formal, non-formal and informal education and thus not only provides excellent spaces for digital and hybrid learning concepts such as blended learning but can also help to include other dimensions such as intergenerational and interdisciplinary learning and to address broader groups of learners (network building).

In addition, students who live in restricted housing conditions and do not have a quiet place to learn or appropriate end devices at home could be offered appropriate alternatives at school, both in terms of their equipment and in terms of the physical learning location.

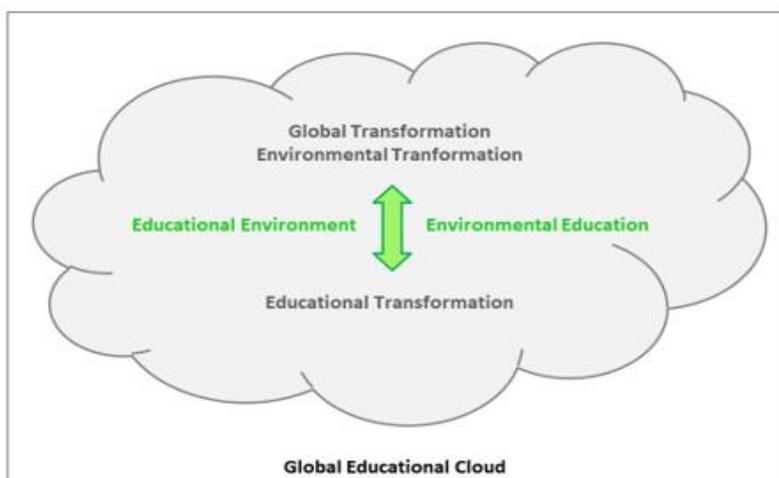
The involvement and engagement of various stakeholders in a participatory model act as an integration factor in relation to the education system. Thanks to the familiar networks created in *school as a hybrid system*, the barriers and obstacles in social, socio-economic and cultural terms are better perceived, addressed and, if possible, overcome through community and transparency. Hybrid architectural-pedagogical concepts can help to decouple school success from the social and economic background of the students and ensure greater educational equality, especially for disadvantaged children and young people and/or those with impaired participation.

### School as a Hybrid System and Education for Sustainable Development

*School as a hybrid system* is a suitable, open and overarching framework for the concept of *Education for Sustainable Development (ESD)*, which aims to provide all people with a platform for high-quality learning and for shaping the future of our world regardless of origin, age and any impairments to participation based on the 17 goals of the *United Nations 2030 Agenda* [7]. It can take on a decisive role as *integrator* and *facilitator* for the future of our society and provide the basis for the shaping of the *educational environment* and *environmental education* (Fig. 5). It is first activated, designed, and developed by its different user groups and includes the local setting, consciously creating networks and transitions from a pure learning space to a hybrid living space.

The educational concept for sustainable development is holistic and vision oriented. Openness, communication, future viability, networked thinking and learning, solidarity, inclusion and participation are its foundations [8,9,10] and its implementation requires not only knowledge, information, understanding, skills, values and attitudes, but also agile action. *ESD* targets to enable the students to learn, to think and to act in larger contexts by understanding complex systems, their interconnections, their mode of operation and impact, and communication and thus being able to act immediately - systems thinking is a key competence of *ESD* (Bollmann-Zuberbühler 2016: 368 f.) [11].

School as a hybrid system with its motto *from education to edu'action'* [1] forms the appropriate building space for the implementation of the *ESD* goals. The concept of school as a hybrid system is based on integration and change. It thus opens up multidisciplinary spaces that are participatory, dynamic and open to experimentation: A *Creative SpielRaum* [1] of hybrid structures and units that invite to designing and experimenting, and that is constantly evolving, never finished and never completed. Through the integration of new and external stakeholders and the combination and overlapping of different user groups and their interactions, students are motivated and empowered to develop into responsible members of our society and at the same time all stakeholders involved can experience a holistic sensitization to the topic of sustainability [8,12].



**Fig. 5:** The “Global Educational Cloud” [13,1].

## Conclusion

*School as a hybrid system* transforms school into a hybrid space that includes different user groups. With an expanded range of spaces and an optimized spatial concept, it offers variable possibilities for the implementation of diverse digital learning formats and hybrid learning concepts with tech labs or maker spaces as well as informal digital learning environments. In this way, school becomes a diverse learning space and *Creative SpielRaum* in a dynamic process: according to the motto *from education to edu'action*'.

By including external stakeholders in *school as a hybrid system*, the separation between a "school world" and the outside world is overcome in a targeted and controllable way using the VDAV parameters (variety, diversity, ambiguity and variety) and children are granted a role as shaping members of society from the outset in exchange with other stakeholders in the immediate school environment. Schools can come into contact and work with the applications of the latest digital technology in a building that also houses modern offices. Of course, buildings and rooms must be structurally prepared and infrastructurally equipped accordingly.

The architectural development of *school as a hybrid system* as a potential form of school of the future has to do with the aspects of modularity, flexibility, multi-optionality, multi-functionality, optimization of use, temporary or permanent densification, transformation, and digitalization. As a physical designer of social and cultural community, architecture creates a hybrid space for a new kind of teaching and learning combined with spatial comfort, convenience, and wellbeing.

*School as a hybrid system* opens up space for new experiences in dealing with diversity, complexity, uncertainty and ambiguity, you do not have to confront them, but deal with them naturally and experimentally (*Creative Spielraum, VDAV model*), it makes them a kind of integrated part of everyday life.

The concept of *school as a hybrid system* can become the starting point for a holistic architectural and pedagogical perspective on new school buildings and on the refurbishment and modernization of existing schools and provide architectural impulses on the topic of the *Education for Sustainable Development (ESD)*.

## Recommendations

When planning and implementing a *school as a hybrid system*, a large number of participating institutions must be included, different organizational forms of cooperation must be integrated, architectural-pedagogical, legal and infrastructural aspects must be considered as comprehensive as possible, and socio-spatial references must be set up. A detailed planning process in different phases is therefore required. The planning and implementation of the hybridization of a school is recommended to place in three phases, each of which takes place in a participative approach.

- Phase I: Preparation phase and site analysis comprising a site evaluation in the context of the urban district or community including all stakeholders in the relevant district or community.
- Phase II: Development of a hybridization scenario including the creation of a usage catalog as the basis for functional hybridization, and the prioritization against the background of educational, societal/social, economic and

architectural framework conditions.

- Phase III: Architectural hybridization by transferring the hybrid usage scenario into spatial-architectural requirements (spatial program), including the selection and definition of suitable structural hybridization principles and necessary architectural key elements.

## New Building or Renovation and Revitalization

The realization of *school as a hybrid system* can be planned holistically from the beginning of new school buildings and implemented in various participatory phases in agreement with the participating architects and as part of the development planning of the urban district/municipality.

On the other hand, the hybridization of schools and their revitalization into sustainable schools and, at the same time, into new centers for the district often involves not only an expansion but also the renovation and modernization of already built school buildings. It requires measures that can be designed step by step and in a case-specific manner within the framework of a holistic, modular, combined renovation and hybridization approach, while considering interactions and interdependencies (VDAV principle).

## School as a Hybrid System and Suggestions for Application

The presented research results provide the basis for a first experimental implementation and testing of school as hybrid system in pilot projects. A specific monitoring process with suitable tools based on a scientifically supported parameter matrix should be developed by an interdisciplinary team in order to further optimize the concept.

Concrete model projects could

- provide innovative and future-oriented impulses for new school buildings as well as for the renovation and modernization of existing schools in urban quarters in light of space scarcity and urban densification concepts
- serve as a revitalization especially of schools in rural areas to a *school as a hybrid system* as a new village center and part of rural development programme
- represent an interesting concept for the transformation of part-time schools to all-day schools in the sense of "Quality Education" - goal 4 of the 17 global sustainability goals of the UN,
- serve as a holistic and quick solution especially in disaster zones: to recover essential functions of affected cities and communities in a central, and, if necessary, temporary building, i.e. based on cost- and time-efficient modular construction methods
- contribute to the smooth integration of refugees coming to us from crisis regions.

## Acknowledgements

This research was supported by the Federal Institute for Research on Building, Urban Affairs and Spatial Development (BBSR) on behalf of the Federal Ministry of Housing, Urban Development, and Building (BMWSB), Germany.

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