RESONANCE BASED DESIGN METHOD FOR "PREVENTIVE" ARCHITECTURE
Learning from evolutionary principles and their key success factors

Abstract

The Resonance based Design Method (RbD_Method) is a tool that can be used to plan buildings that are fit for the future and retain their value over a long period of time. In analogy to evolution, resonance and cooperation play a decisive role. The model is based on the recognition that built systems are more than the sum of their building components. What distinguishes a building as a living space from the addition of all its individual elements is constant cooperation and resonance from the outside in, and the inside out. Examples of this are the interrelation of sub-systems within the building, interaction between the building and its users or its location, collaboration in planning teams etc. This approach leads to a systematic understanding of a building in which various tangible and intangible sub-systems are in constant interaction with each other. The building as "an active programme" calls for planning methods (interdisciplinarity, participation, etc.) based on cooperation and resonance. Developed using health care facilities as case studies, the RbD_Method offers future-oriented strategies for buildings. These strategies are adaptable to change, have high user acceptance and retain their value over a long period of time. With the help of the RbD_Method, buildings are recorded and compared with each other. Knowledge gained on their strategies may also be applied to other designs in a similar context.

Keywords: Evolution, Cooperation, Resonance, Adaptation, Flexibility, Open Building, Health care

INTRODUCTION

In architecture, change is a reliable constant. Dealing with this requires strategies in planning, constructing, and operating buildings. Demands for a building stock that is both attractive and functional over a longer time period call for its ability to adapt to new requirements. The aspired (not only monetary) long-lasting value retention of the building stock lies at the heart of sustainable construction.

For this reason, a project cycle was initiated at CCTP with the aim of creating a theoretical basic model to develop planning recommendations for adaptive, i.e. reactive, and "active" buildings and neighbourhoods.

To establish the essential theoretical fundamentals, evolution theories were intensively analysed and evaluated. Theories discussed by evolutionary and molecular biologists provide indications on the principle mechanisms of development and adaption. By taking the Darwinian evolutionary algorithm, comprising of variation, selection and reproduction, it could be proved in a preliminary study that the algorithm could in principle, also be applied to architecture. [1]. However, it also showed that important phenomena of changes relevant to architecture could not be explained:

In Darwin's theory, development occurs as an unfocussed, slow moving and seemingly random process, whereas architectural design is usually a deliberate and purposeful process in which knowledge is applied and passed on. Furthermore, Darwin's theory gives the impression that the species are in continuous competition and struggle for survival, and can only successfully occupy an ecological niche when the competition has been forced out. The latest research results in molecular and evolutionary science do not dispute the validity of Darwin's evolutionary algorithm, but contradict the "struggle for life" and random mutation as an evolutionary principle [2].

“Evolution is not the development of lone warriors, it is the development of biological systems" [3] and further: "The «behaviour» of living systems to try out new (…..) variations in a creative manner, and in doing so, become more and more complex, is inherent in itself.” Organisms are equipped with a biological sensorium that enables them to "adapt themselves and, triggered by changes in their particular environment («stressors»), change themselves”. [3]. In doing so, the biological principles of cooperation and resonance are applied. This process is contrary to Darwin's theory of natural selection, not random, but a controlled and creative activity.

LIVING SPACE BUILDING AS A COOPERATIVE PROJECT

Applied to architecture, according to Bauer, [3] it is apparent that the built systems are more than the sum of their building components. What distinguish a building as living space from the addition of all its individual elements are constant cooperation and resonance from the outside in and the inside out. Examples of this are the interaction between users and planning teams, reactions to the location, interrelation between building parts etc. This approach leads to a systematic understanding of a building, not as a static object, but as living space in which various tangible and intangible sub-systems are in relationship with each other. The building as an "active programme": According to John Habrakens "open buildings”, we must demand that our buildings "as a material form be brought to life"[4] and suddenly, a complicated building planning problem becomes a complex living space planning problem.

As an "open system", the architectural living space is an "adaptable" system, i.e. the behavioural possibilities of the system are variable and diverse. That is why a problem in this living environment cannot be finitely solved despite time and effort spent, and adequate knowledge. It is a complex system that can be planned and controlled only to a certain extent. Planners are faced with the dilemma, in spite of it being impossible, to achieve the highest possible level of certainty in their planning process. This uncertainty can only be overcome by gathering specific information. Core element in the design process is consequently to obtain correct information, and to evaluate and compare it. In the process, the entire planning team, including the users involved, is reliant on cooperation and resonance based planning method.

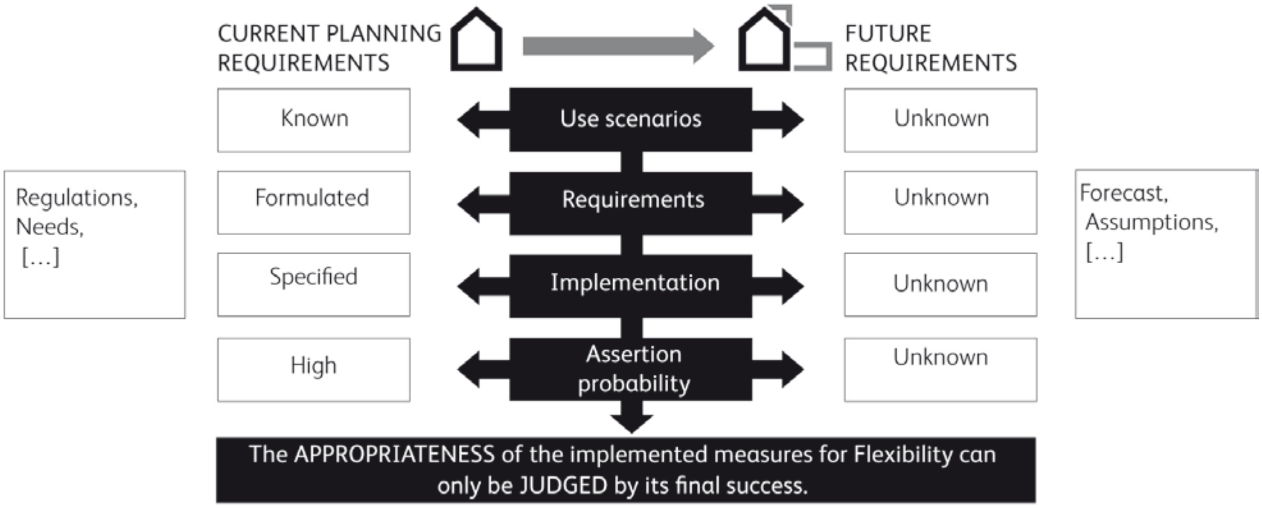

Figure 1: *Dilemma of evaluating flexible measures [8]*

BASIC EVOLUTIONARY PRINCIPLES OF COOPERATION AND RESONANCE IN THE DESIGN PROCESS OF PREVENTIVE BUILDINGS

Like genetic systems in evolution, buildings can also, "only fulfil their function in close cooperation with their environment" according to Bauer [5] and because of this, are significantly influenced by environmental factors. Changes in environmental factors trigger stressors that constantly pressurise our buildings to adapt. We distinguish between stressors at context level (e.g. a new road in the neighbourhood), at use level (e.g. the desire for more space), and at building element level (e.g. normal wear and tear - windows not sealed). The stressors are often combined and overlapped.

In the conception of adaptable buildings, we must take into account the interaction between the stressors and the entire building system. The pressure applied by the stressors on designed and constructed buildings requires cooperative planning understanding of teamwork and building combined with the target to achieve the highest possible resonance between the building and its users. In current evolutionary research, genetic systems are seen as a unit formed by "gene and environment, relationship experiences and physical biology" which is "part of a cooperative project" [5]. The building as a "cooperative project" is perceived by its users upon completion. This is when successful planning becomes evident. If the users succeed in establishing a positive relationship to the building and the architectural space develops into a living space, the measures have achieved a positive effect, i.e. a resonance. The question of effect is strongly linked to resonance.

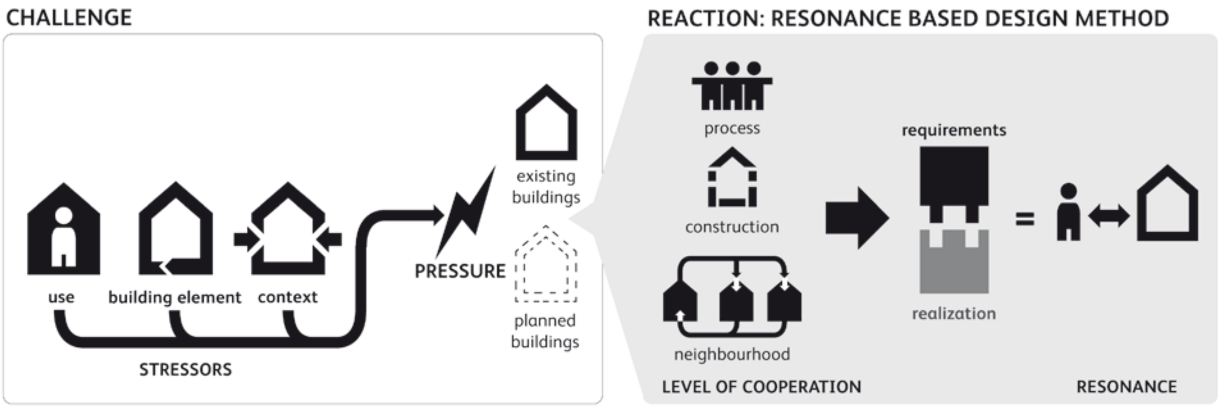

Figure 2: *The basic evolutionary principles of cooperation and resonance in the design process of preventive buildings.*

In a physical sense, resonance is defined on the one hand as *a) oscillation excitation of sound waves of the same frequency, reverberation of another object or other system capable of resonance (phys.); b) Amplification and refinement through vibration in the overtones (for every fundamental tone, scarcely audible, resonating, higher-pitched partial tones which produce a sound (mus.);* and on the other hand *reactions (e. g. discussions, remarks) that have been triggered or suggested by something and which relate to it; echo, approval, understanding, effect.* [6]

Applied to architecture, resonance should not only be seen as fulfilling a function in the sense of a reaction to the requirements, but also includes the viewer's subjective emotional perception. Both assume the presence of a sender and receiver, and the ability to establish contact with one another. Without these requirements, no resonance can take place between the sender (building) and the receiver (user). The aim of future-oriented architecture must be to generate positive resonance from the users in order to achieve highest possible acceptance. Special attention is therefore to be giving to activating and reinforcing the latent resonance potential during the planning process.

"The resonance potential of the senses can be best understood by considering our complex sense of smell. Our nose does not have a different cell membrane protein as receptor for every conceivable molecular structure of a scent. The perception of scents overlaps in a similar way to the characteristics of waves. Human beings perceive scents as positive or negative according to personal taste, or dependent on the judgement of their purpose." [7]

This phenomenon is often noticed during discussions with nonprofessionals on building projects. If the person cannot develop a positive relationship to the project, be it only to understand the design concept, he will often only find it "ugly" (e.g. brutalist buildings). Lack of user "calibration" or absence of "excitation" can lead to aggression toward the built environment.

RESONANCE BASED DESIGN METHODE - MOTIVATION AND STRUCTURE

These considerations lead to the conviction that cooperation and resonance should be a decisive planning maxim when planning future-oriented and sustainable buildings. Sustainability is strongly linked to user acceptance and in turn, with the adaptability of the building. Therefore, buildings designed to be sustainable are able to react to changing requirements, achieve high acceptance and lasting value retention.

«Adaptability is an indicator for long retention of value. The building is able to react to new requirements with reasonable cost, time, and effort. » [8]

The Resonance based Design Method tool based on evolutionary basic principles of cooperation and resonance, aims to ensure that during the entire planning process the necessary information is made available, and that scenarios can be created from it. This process from design to realization of the building and its transmittal is an iterative process in which solutions are produced and selected. At the end of this sequence of creating and evaluating, the alternative appearing to be the most appropriate solution is selected - the planning result codification. This procedure is not unlike the process in evolution comprising variation, selection, and reproduction, and is divided into five phases (programme formulation, building design, planning result codification, realization, and reproduction) [1].

The tool for the Resonance based Design Method uses a matrix to correlate the *five phases of the planning process* with the three cooperation levels: process, construction, and neighbourhood. From this, specific cooperation and resonance based strategies and building measures are generated, and at the same time, formulating opportunities as well as risks. The tool is designed as an "open system", a "smart system", in which the available criteria can be extended or even modified. The model can be used in planning and for the evaluation of existing designs and buildings that successfully withstand the pressure of selection because of their high adaptability potential and user orientation. The resulting classification system makes it possible to analyse and record existing buildings according to the stored cooperation and resonance criteria. These buildings are compared with each other and are available as possible solutions for other designs. The recorded designs and buildings are catalysts in encouraging and leading discussions. The system allows different interpretations and offers no hard truths.

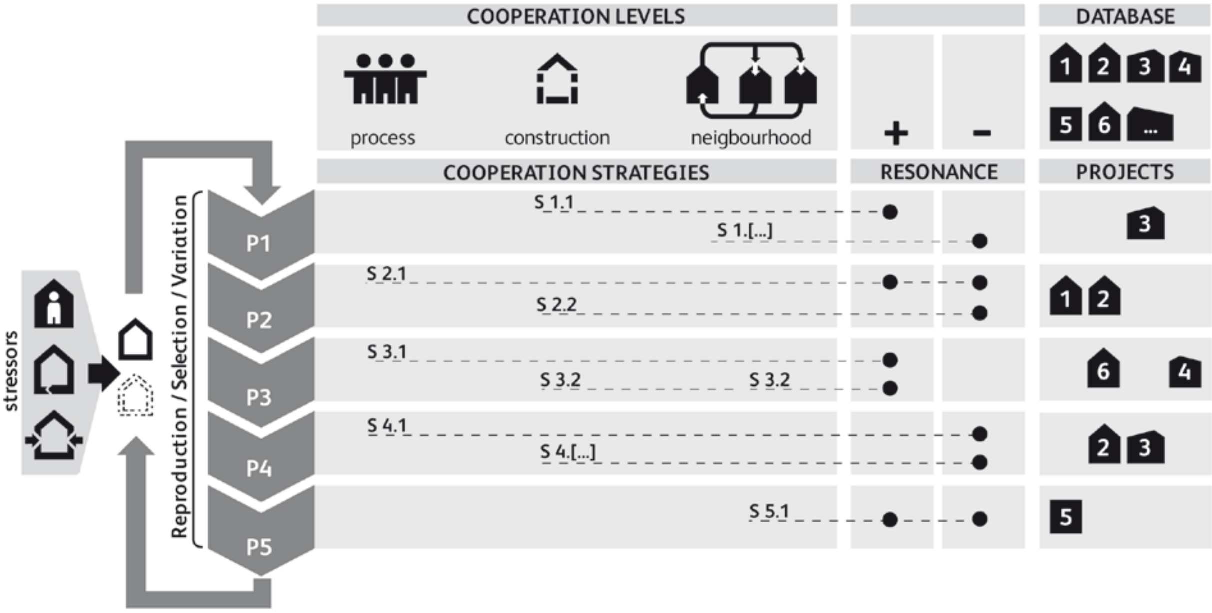

Figure 3: *Basic structure RESONANCED BASED DESIGN METHOD*

RESONANCE BASED DESIGN METHOD - PRINCIPLES AND STRATEGIES BASED ON HEALTH CARE FACILITIES EXAMPLES

The following strategies are part of a current research project at the Competence Centre Typology and Planning in Architecture. The table is based on the evaluation and analysis of different health care facilities and interviews with planners. It is in a trial phase and is being constantly revised and expanded.

Phase 1 - Programme formulation The vision and programme of the building to be planned are formulated. At the end of this phase, the requirement profile and target agreements for the building have been defined.		
Strategy	+	-
S1.1 Joint vision The involved parties formulate a vision under the supervision of persons responsible for feasibility and finance. [I 1] Keywords: Create a vision in a participatory process / Freedom and limitation / Feasible targeting / Determination of fixed parameters / Information transfer / Information exchange / Coordination vs. Cooperation [9] / Regulatory feedback / Artificial controlled selection / Data fitting / Prioritization / Sufficiency / Sharing a Vision	Joint vision	Group size can be excessive Time consuming Concealing information
S1.2 Contrasted target specifications Target specifications are made transparent through repeated distribution to all concerned parties and are compatible after repeated reviews. [I 2] Keywords: Structures created through collaborative construction [9] / Joint decisions / Optimal and stable group size [9] / Efficient networking efficiency / Advantages of collective / Avoidance of conflict / Repeated interaction / Consensus	Consensus	Time consuming Inappropriate specifications

Phase 2: Building design Variations are produced, selected, and developed in the design phase. In the process, ideas are created, reviewed, and compared with the formulated target agreement. At the end of this phase, the favoured design has been determined.		
Strategy	+	-
S2.1 Flexible repositioning The floor plans are set over a square grid that allows repositioning of the programme units throughout planning. This strategy facilitates the easy, quick, and effortless production of multiple scenarios. [I 1] Keywords: Overall system / Rapid modifications / Flexibility / Speed and accuracy [9]	Flexibility	
S2.2 Development of appropriate scenarios Participative procedure in development and selection within multiple scenarios. Keywords: Evolutionarily stable decisions [9] / Targeting future resonance / Integrating use and external forces / Variation as an opportunity / Appropriateness / Feasibility / Prediction	Wide choice	
S2.3 Prototyping and simulating Maximising the number of digital spatial simulations and the number of prototypes (room, corridor, waiting areas, etc.) reduces failure risk. [I 2] Keywords: Grasping partial reality / Testing / Evaluating resonance / Rectification opportunity / Adaptation to feedback	Avoiding future failures	Cost increase Time increase

Phase 3: Planning result codification The design is documented in an objective, comprehensible and clear manner, which enables discussion and comparison. At the end of this phase, neutral, definite building plans exist.		
Strategy	+	-
S3.1 User friendly means of communication Facilitating understanding during the planning process. [I 1] Keywords: Evolutionarily stable choices [9] / Communication / Understanding / Interaction / Formalizing the process	Increase of acceptance Facilitating understanding	
S3.2 Value retention Retention of value and quality during the building's life cycle. [Fig.CS2], [Fig.CS3], [I 2] Keywords: Fitness of building parts / Preservation of resources / Not only long life cycle but also high quality	Extension of life cycle and quality	
S3.3 Facilitating renovation Decisions that facilitate future renovation work. [Fig.CS2], [I 1] Keywords: Smart renovation reducing effort, time and cost	Reduction of disturbance	
S3.4 Reduction of risk of disturbance Strategies to minimise the need of repair and/or disturbance. [Fig.CS1], [Fig.CS2]. [I 1] Keywords: Sufficient mechanisms with low maintenance / More with less [11]	Increase of resonance	

Phase 4: Realization The planning result codification is realized according to the building plans. Stressors such as costs and time pressure lead to reviewing feasibility. At the end of this phase, the building has been constructed.		
Strategy	+	-
S4.1 Enhancement through synergies Benefitting from the combination of several parts and their interaction which reaches better results than the performance of each individual part. [Fig.CS1], [Fig.CS2]. Keywords: Synergistic interaction / Dynamic spatial patterns [9]	Higher performance	

Phase 5: Reproduction The wide range of information stored in each realized or documented building offers potential for future solutions. At the end of this phase, these patterns are adopted for other buildings or designs and consequently distributed throughout the building stock.		
Strategy	+	-
S5.1 Systematic evaluation Systematic evaluation for new adaption and maintenance of resonance. [I 3] Keywords: Identification of failure and success factors / Open survey / Rectification measures	Constant increase of resonance	
S5.2 Satisfaction questionnaire Questionnaires allow detection of shortcomings and defects that need to be eradicated in future developments as well as success factors to be reproduced. [I 3] Keywords: Collaborative construction and reproductive success [9] / Constructed building as reference for future constructions	Multiplication of resonance patterns	

Fig.CS 1: *Institute for pathology and forensic medicine, county hospital, St. Gallen. Fixed louvers were calculated and designed to reduce mechanism complexity This solution reduces maintenance and disturbance.[10]*

Fig.CS 2: *Institute of Pathology and Forensic Medicine, County Hospital, St. Gallen. A PU floor was chosen because it allowed an easy and quick refurbishment, reducing disturbance and increasing acceptance [10]*

Fig.CS 3: *Institute of Pathology and Forensic Medicine, County Hospital, St. Gallen. Metal partition walls can be repositioned and recycled. The reflexion of light contributes to optimal distribution of illumination [10]*

Fig.CS 4: *Cantonal Hospital Zug and Care Centre. By constructing the facilities next to each other, high synergies are achieved through sharing services, staff, and underground mechanical engineering [I 3]*

CONCLUSION

The evolutionary principles of cooperation and resonance hold great potential for the planning and evaluation of future-oriented, sustainable buildings. Demands to boost resonance forces us, as planners, to take a holistic view, consider the user's perspective, and to work with scenarios for use, operation, and maintenance: The architectural object becomes a complex living space to be planned. In this process, we rely on information that can be gained only through cooperative understanding of planning and building. To achieve this, the grid of the RbD-Method provides a basic structure to record, evaluate, and store information in terms of cooperation and resonance. Buildings are compared with each other in the grid. The information stored in the grid provides possible solutions for future designs.

OUTLOOK

The grid of the RbD_Methode is undergoing an intensive test phase. Apart from collecting case studies, the greatest challenge will be to develop the tool designed as an "open und smart system" so that criteria can be changed, whilst the tool retains a coherent basic structure. Our interest in being able to collect, retrieve and store information on buildings in a simple and interesting manner and make it available to designers and planners means that the contents can be prepared for various didactic events (workshops, seminars, lectures and tutorials). The tool is therefore being developed and implemented using different media during the test phase.

This paper is a project of the research cycle "Evolutionary principles in architecture". More extensive research on selection and variation is already being done. Further publications on this theme are in progress.

REFERENCES

[1] Schwehr, Peter, *Evolutionary Algorithms in Architecture.* - open house international. Vol. 36 no.1, 2011
[2] Schurz, Gerhard, *Evolution in Nature und Kultur: Eine Einführung in die verallgemeinerte Evolutionstheorie* - Spektrum Akademischer Verlag Heidelberg, 2011
[3] Bauer, Joachim, *Das kooperative Gen: Evolution als kreativer Prozess* - Wilhelm Heyne Verlag München, 2010
[4] Bosma, K; Van Hoogstraten, D; Vos, M; *Housing for the Millions: John Habraken and the SAR (1960-2000)* - NAi Publishers, Rotterdam, 2000
[5] Bauer, Joachim, *Prinzip Menschlichkeit: Warum wir Natur aus kooperieren* - Wilhelm Heyne Verlag München, 2008
[6] Duden - *Das Große Fremdwörterbuch. Herkunft und Bedeutung der Fremdwörter.* 4. aktualisierte Auflage. - Dudenverlag Mannheim, Leipzig, Wien, Zürich, 2003
[7] Mühle, Stefan H., *Relativität in der Psychologie und der Physiologie und die emotionale oder unbewusste Wechselwirkung mit der Gesellschaf. - available at:* http://www.schwimmteich.npage.de/get_file.php?id=16126563&vnr=540796 *(accessed 15.06.2011)*
[8] Plagaro Cowee, N. Schwehr, P., *Die Typologie der Flexibilität im Hochbau. –* Interact: Hochschule Luzern, 2008
[9] Sumpter, J.T.David, *Collective animal behaviour.* – Princeton University Press; New Jersey, 2010
[10] Marktwärts, *Institute for Pathology and Forensic Medicine, County Hospital, St. Gallen. New build 2011. – Baudepartement des Kantons St.Gallen Hochbauamt; St.Gallen, 2011*
[11] Campo Baeza, A., Professor of Design Studio, Technical University of Madrid, 1993-1994

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FURTHER RELEVANT LITERATURE:

Evolutionary principles:

Buskes, Chris, *Evolutionär denken. Darwins Einfluss auf unser Weltbild.* – Primus Verlag; Darmstadt, 2008

Dennett, Daniel C., *Darwins gefährliches Erbe: Die Evolution des Lebens*. – Hoffmann und Campe; Hamburg, 2001

Dawkins, Richard, *Das egoistische Gen*. – Rowohlt; Hamburg, 2002

Gould, Stephen Jay, Illusion Fortschritt. Die vielfältigen Wege der Evolution. – S.Fischer;: Frankfurt/M., 2005

Zrzavý, J.; Dorch, D.; Mihulka, S., *Evolution: Ein Lese-Lehrbuch*. – Spektrum Akademischer Verlag Heidelberg, 2009

Planning process

- Bertram, Ekkehart, *Raum in Vorstellung und Wirklichkeit: Reader zum Seminar Tragwerk und Architektur WS 2000/2001* – Universität Stuttgart, Fak2011ultät Architektur; Institut für Innenraumgestaltung und Architektur, 2000
- Favre-Bulle, Bernard, *Information und Zusammenhang. Informationsfluss in Prozessen der Wahrnehmung, des Denkens und der Kommunikation.* – Springer; Wien, 2001
- Fischer, Robert; Schwehr, Peter. *Typenbasierte Evaluation. Chancen für die ganzheitliche Wohnbauerneuerung. – Schweizerisches Status-Seminar „Energie- und Umweltforschung im Bauwesen“, 2008.*
- Rittel, Horst W. J., Planen, Entwerfen, Design: Ausgewählte Schriften zur Theorie und Methodik – W. Kohlhammer; Stuttgart, Berlin, Köln, 1992
- Salingaros, Nikos et.al. *Darwin Processes and Memes in Architecture: A Memetic Theory of Modernism. - http: cfpm.org/jom-emit/2002/vol6/salingaros_na&mikiten_tm.html*
- Sarkis, Haschim, Le Corbusier's Venice Hospital. – Prestel Verlag; Munich London New York, 2001
- Schwehr, Peter; Fischer Robert, Building Typology. IEA ECBCS annex 50, Prefabricated Systems for Low Energy Renovation of Residential Buildings – Luzern; Lucerne University of Applied Sciences and architecture, Competence Centre for Typology and foresight Planning in Architecture (CCTP), Technikumstrasse 21, 6048 Horw, Switzerland, 2009
- Schwehr, Peter, *Ein entwurfsbezogenes Orientierungssystem.* Universität Stuttgart, Fakultät für Architektur und Stadtplanung; Dissertation, 2002.
- Verderber, Stephen, *Innovations in Hospital Architecture.* – Routledge; New York, 2010