Implications of the philosophy of Ch. S. Peirce for interdisciplinary design: developments in domain theory

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ABSTRACT

Subject of this paper is the establishment of a connection between categorical pragmatism, developed by Charles Sanders Peirce (1839-1914) through phenomenological analysis, and Domain Theory, developed by Thijs Bax and Henk Trum since 1977. The first is a phenomenological branch of philosophy, the second a theory of interdisciplinary design. A connection seems possible because of similarity in form (three-partitions with an anarcho-hierarchical character), the not-absolute conception of functionality and the interdisciplinary and procedural (participation based action) character of both theories.

1 INTRODUCTION

In contradiction to the smooth varieties that have become prominent since Peirce, Peircean pragmatism is a scientific-philosophical methodology for the unified, testable and agreement-apt treatment of the fields of expression/imagination, technical design/praxis and cognition/reason. Peirce's pragmatism may be conceived in flashback as the integration of the results of his philosophical and practical work in the fields of phenomenology (especially his theory of categories), logic and semiotics. In each of these fields the state of affairs at that time is brought in a new stadium of development. These stadia are not rejected, but in line with the tradition of sciences, brought to a higher level of generality that includes the previous stadia. This higher level is achieved especially because Peirce connected the previously separated fields in one unifying pragmatistic framework. This frame of thinking is constituted by three universal and mutually related categories, used for distinction, execution and reflection of purposeful and meaningful actions.

In the seventies the design discourse paid attention to his triad: abduction - deduction - induction (from his logic), and to his triad: syntax - semantic - pragmatic (derived from his semiotics), however, without much influence on theory building. It is assumed that especially the application of his categories will have a lasting impact.

Domain Theory originated from architectural design of the built environment, but claiming validity for the whole field of technology (Trum & Bax, 1990). Within that wider field, architecture is defined as the quality of objects that controls complexity by means of form. Knowledge of design as a reciprocal process of giving form, meaning and control is considered to be the very core of the science of technology. It is a theory dealing with multidisciplinary design; the theory itself is establishing an inter-disciplinary field, based on common factors determining the various fields or domains of design in order to define their interfaces and interactions. As a consequence, it is also a theory of architectural research and education.

The theory is based on General Systems Theory, the theory of Structuralism and on principles of Evolution Theory, in a way these theories are connected by Bill Hillier and Adrean Leaman in their paper 'Systems, structures and transformations' (Hillier and Leaman, 1972/3).

The architectural debate on these notions is silenced since the years '70. Both in architectural theory and practice, notions like Structuralism, Post-modernism and Deconstructivism are superficially used terms without any intrinsic reference to their corresponding philosophy. Only in the thinking of John Habraken (Habraken, 1998) the SAR (Foundation Architects Research 1965-1990) and its successor 'Open Building' (1987-1999), an approach to the design process as implemented in projects, research and education is found, doing justice to philosophy and actually contributing to its development. This contribution is based on a de- and reconstruction of design and action fields.

Domain Theory, at close observation, appears to be an application of Peirce's pragmatism. Domain Theory is the result of an utmost generalisation of a specific design practice, dimensioning architectural objects by a classification of its constituent domains and agents, leading to three dimensions: form, function and process. The pragmatism of Peirce is the result of the utmost generalisation within philosophy with regard to what is classifiable and relatable, leading to three categories: potentiality, actuality and intentionality. Domain Theory is developed independently from Peirce's theory, so there can be a reciprocal affirmation.

In order to establish a connection between Domain Theory and Peircean categories, the correspondence of the basic notions of both theories is verified. Main question is the relation between the three Peircean categories and the three dimensions of Domain Theory. A comparison is carried out by representing both theories, each in the form of one encompassing model. For Domain Theory this model is a three dimensional, cubic representation in the form of the GOM-model (GOM: Design Methods Group at TUE); this model is a synthesis of three cubic sub-models: a form, a function and a process model, also represented as a 3x3, form-function-process matrix. For Peirce the pragmatistic triangle is the representative model; this model is the synthesis of a phenomenological, logical and semiotic triangular sub-model, representing three aspects of his mode of thought. The triangle may be modelled as a 3x3, potential-intentional-actual-matrix. Both matrices have the same structure and appear to be governed by the same principles. The cubic, three-dimensional relations of Domain Theory are identical with the triadic relations in Peirce's theory.

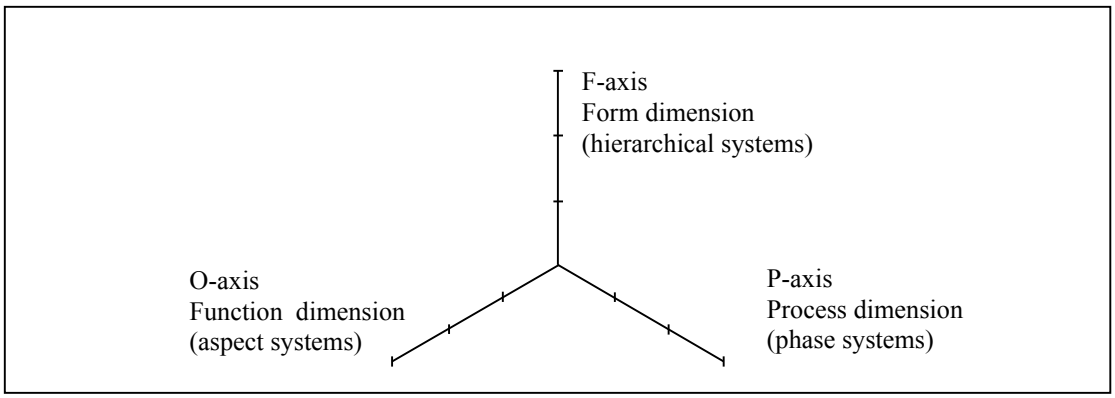


Figure 1: **GOM-model, dimensions**

Dimensions in Domain Theory, denoted as categories, appear to be Peircean classes, defined in a field determined by his categories. Categories in Domain Theory are of a lower level of generalisation than Peircean categories; the two matrices differ only with respect to their level in a hierarchy. This hierarchical relation of the two matrices determines a framework for the definition of notions in triads (categorese) and offers a perspective for a design approach of incremental classification: 'design by classification'.

2 DOMAIN THEORY BY BAX AND TRUM

2.1 **GOM-model: anatomy**

The GOM-model is the central model in Domain Theory (figure 1). It is the framework for the representation of an architectural object: an object-in-development. It is a cubic representation within a space ordered by an F-, O- and P-axis. On these axes the form, function and process dimension of an object is represented ('O' stands for Objective by which a function is related to the properties of an object). They guarantee the necessary and sufficient description, explanation and prediction of the behaviour of an object. Dimensions and their articulations determine - separately and jointly - in a cohesion of dependency and complexity the space of the object. Each dimension corresponds with a sub-system. The model is inspired by General Systems Theory (In 't Veld, 1973), (De Leeuw, 1976), in which these systems respectively as hierarchical, aspect and phase systems determine the nature of the articulations of the dimensions of the architectural system.

The form-dimension is hierarchically articulated in levels, the function dimension in aspects and the process dimension in phases (Figure 2). Aspects are denoted as performances, indicating the objectives the object can realise, based on its properties and the application of certain rules. The number of articulations within a dimension is principally unlimited, however a choice is made for a triad. This number equals the number of dimensions and determines a central position in the cube for an active subject. For each dimension in the cube three 'tranches' are discerned: form,

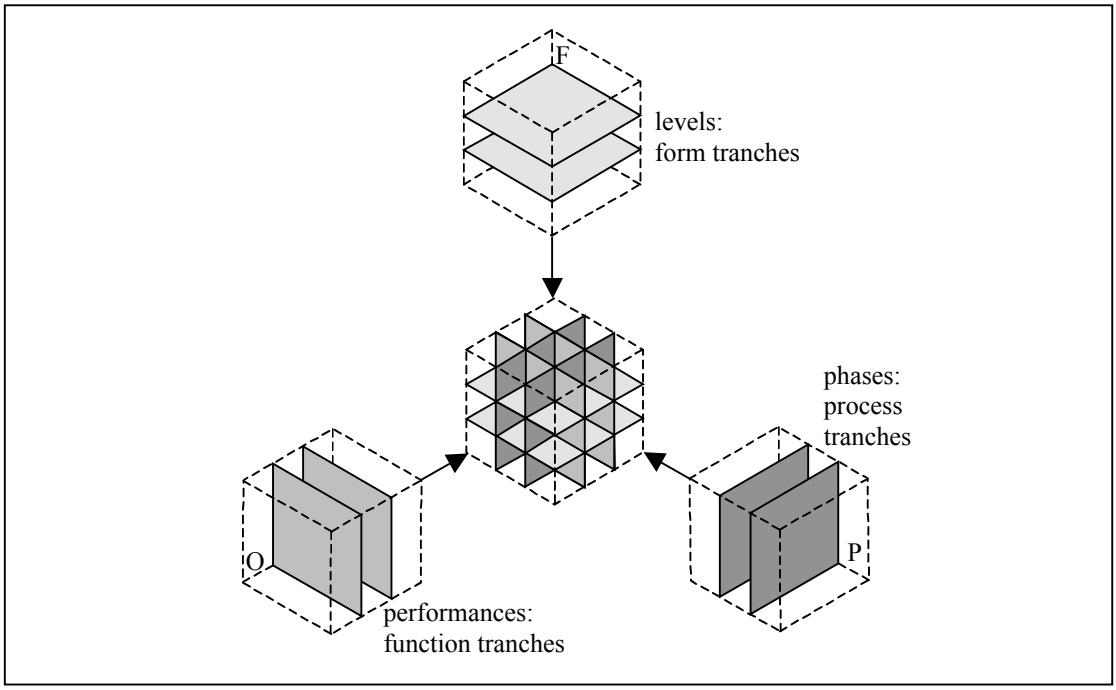


Figure 2: **GOM-model, articulations**

function and process tranches. The result of the intersection of the tranches is a 3x3x3-cube, a floating cube, the position of which in the ordination system of F-, O- and P-axes is determined by the attention and position of the subject.

Each dimension corresponds with a sub-system and with a partial object of a lower order in a hierarchy of objects. According to rules of recursion, each partial object is dimensioned and articulated as an object again. The architectural object is considered to be the result of the integration of partial objects: a form, function and process object. This process is visually represented by the weaving of three cubes along the axes of the model into a central cube; this is the integral GOM-model (figure 3).

2.2 **Three hierarchies**

The three-dimensional representation of the object is interpreted in three different ways. The linear representation shows the articulation of the axes (figure 4a), this means the articulation of respectively the form, function and process dimension in a one-fold way; the planar representation shows the relation between the dimensions in a twofold way (figure 4b). In the cubic representation the form, function and process dimension are integrally related in a threefold way (figure 4c). Domain Theory supports a cubic view on reality; the cubic description of an object provides the complete description of the architectural object.

The form, function and process partial objects are independent objects and objectives as we know them as a pattern of elements, a program, or a situation (SAR70, 1974). The form of the object in Domain Theory is the description of an object as a configuration of (spatial) elements; they are the elements of a situation which are intriguing the designer. The form represents a potentiality; its properties are

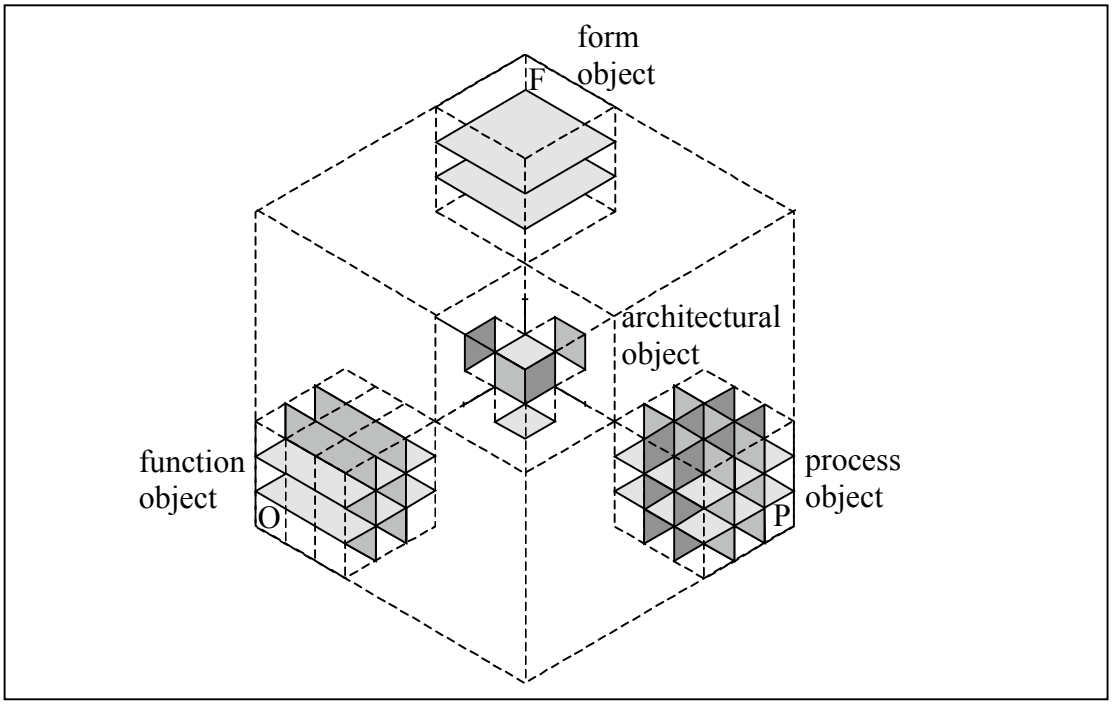


Figure 3: **The integral GOM-model**

predicates. The function of the object concerns the intentional application of a destination to the elements of the configuration, based on a program. Function contains form; its properties are denoted as attributes.

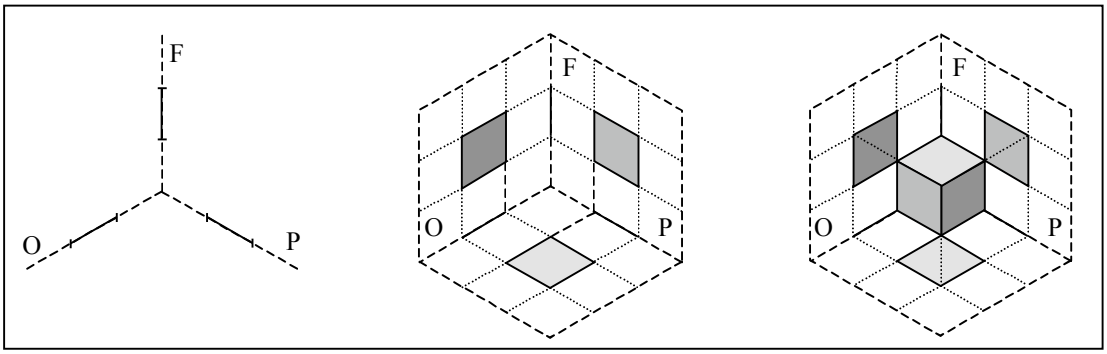


Figure 4a: **Linear, one-dimensional representation of object**

Figure 4b: **Planar, two-dimensional representation of object**

Figure 4c: **Cubic, three-dimensional representation of object**

The definition of a form object is a condition for the definition of a function object and this is again the condition for the definition of a process object. The objects take a

position in a hierarchical ordered context; they have a valence 1, 2 or 3.

This hierarchical relation determines the dependency of the dimensions. The same regards the articulation of the dimensions. The articulation of the form dimension is independent, it shows an articulation in levels and is one-fold determined; the function dimension is twofold composed and contains both the articulation in levels and performances. The process dimension is threefold composed and contains the articulation in levels, performances and phases.

The order of form, function and process dimension refer to a possible sequence and they determine the content of a stadium 1, 2 and 3 of an iterative cycle, leading to the tuning and incremental integration within an object.

2.3 **Model and reality, adaptation by tuning**

A model is a representation, a part-whole compression that makes the relevant reality more manageable (any relevant reality itself is already something made perceptible/conceivable/manageable). Only those dimensions and articulations are relevant that accommodate adaptation of the model to reality. This means mutual tuning of articulations and dimensions of the object evoked by its environment. The process of tuning of articulations of dimensions and the tuning of dimensions is represented in three schematic steps.

(1) Tuning of the three dimensions of a partial object has to be completed before they can contribute to the dimensioning of the architectural object. According a principle of consolidation, known from Evolution Theory, development takes place via stable states or stadia (Koestler, 1967), (Simon, 1981). Transfer of information to a higher level has to be proceeded by synthesis on the original level. The result of this step is a proposition for the articulation of the three dimensions of the architectural object in the form of a linear representation. The form dimension of the form model is denoted as the primary dimension of that model; the articulation of that dimension results in the proposition for the articulation of the form dimension of the architectural object model, etc. The way tuning takes place in the partial objects doesn't differ from the tuning within the architectural object. This is the content of the following step.

(2) Tuning of the three dimensions of the architectural object takes place in the sequence of incremental integration, according to the stadia 1, 2 and 3. Tuning is both, a formal and intensional process. This means that all formal articulations of the dimensions, being the result of the intersection of all the tranches, must have intensional relevance. Because, to start with, the form model has to be integrated with the function model, the articulation of the form-dimension in levels has to be tuned to the articulation in levels of the form-dimension of the function model. Only those articulations of the form dimension of the form model in levels are relevant that have relevance too for the articulation of the form dimension of the function model, and vice versa. So, the task is to discern articulations of the function dimension of the function model in performances which levels correspond with the levels of the form dimension of the form model. In this way the levels of form (of the form model), via the levels of form (of the function model), are tuned to the articulation of performances (of the function model). The articulation of the dimensions of an

architectural object is the result of an incremental process of tuning and integration in three iterative stadia of a cycle (figure 5): (a) tuning of form level via function level to

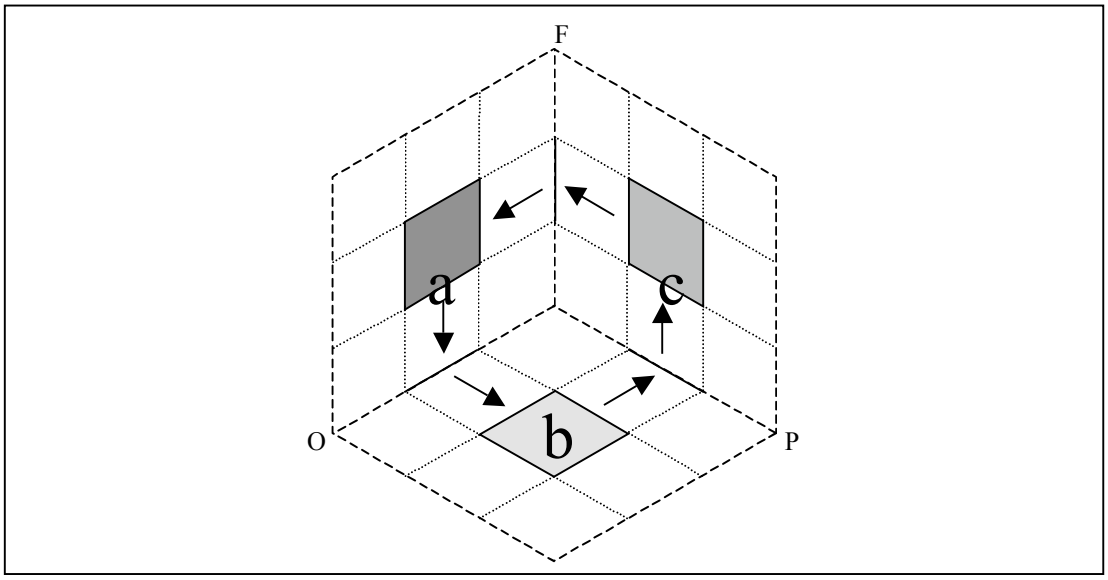


Figure 5: **Tuning process of dimensions of an architectural object**

function performance, (b) tuning of function performance via process performance to process phase, and (c) tuning of process phase via process level to form level. These tuning processes are illustrated with planar representations resulting in a cubic representation.

(3) The result of the tuning processes must be checked on the lower level of the partial models. It is also necessary to check the acceptability of the articulations on the higher level of a project (to which the object is partial project).

In spite of the enormous complexity of the problem at hand, it is possible to work efficiently, because many of these tuning processes have got their form already within a cultural context; in fact they define a culture. In design practice elements are complex, in which the dimensions of form, function and process have reached a temporary synthesis. The difficulty in practice is rather that of analysis if changes in social and technological relations enforce a new synthesis. Domain Theory offers an instrument for such a synthesis directed analysis.

2.4 **Three sub-models**

2.4.1 *Form model*

The form-model is represented as a cube with a formal, functional and temporal dimension. Each dimension is articulated in three parts. In the building field form is considered a configuration of spatial elements, composed of space and material elements. Form is expressed in terms of orientation, number, proportions, size and place of its constituent spatial elements.

- The form dimension (of the form object) is articulated in three spatial levels. For

this articulation three principles are valid: (1) a constant complexity in number of kinds of elements for each level, (2) double role of spatial entity, functioning as element or situation at level transition, (3) empty situation is structural element on higher level and vice versa (Bax, 1976). This type of articulation fits in an old tradition in architecture, going back to Vitruvius (Van der Laan, 1967). Articulation and sizing of a building in parts, divisions and segmentations determine its proportions according the notions of ordinatio (taxis), eurythmia and symmetria. These hierarchical subdivisions lead to an articulation of form in scales.

- The function dimension (of the form object) determines the function of form as a shape. It concerns the meaning of form as a whole, expressed on three levels: an empirical level, an instrumental and a symbolic level (Bax, 1996).
- The process dimension (of the form object) determines the time aspects of form. It concerns the life span or stability of form in terms of time, the rhythm of its transformation, its frequency. Forms have tempo and endurance. Form in this dimension is articulated in periods in a scale of time: long, middle and short time terms (SAR65, 1971).

2.4.2 *Function model*

The function model is represented as a cube with a formal, functional and temporal dimension. Each dimension is articulated in three parts. Articulation regards the function aspects to be appointed to form elements. It concerns both, their effectiveness and efficiency (Archer, 1969), using criteria based on norms, values and rules (Trum, 1979) as used by subjects in design practice.

- The form dimension (of the function object) is articulated in three levels. This type of articulation finds its base in a goal tree as used in political sciences (Kuypers, 1976) and as described by Jones in ‘specification writing’. This hierarchical articulation leads to an articulation of functions in levels of specification, corresponding with the levels of form in the form model.
- The function dimension (of the function object) determines the function of the function and describes its effect. Three types of effect are discerned: the formulation of a wanted state, the coming about of a state, the up-keep of a state. They represent three modalities of change, respectively neutral, positive and negative. Change (also ex- and interchange) is according to Jones the very essence of design.
- The process dimension (of the function object) determines the process aspects of function. It concerns the type of process in which the functionality of an object is expressed. Three types are discerned in a hierarchical order: policy, planning and design processes, corresponding with the process articulations of the form model. The functional model is expressed in the form of a taxonomy of concepts (Bax & Trum, 1993).

2.4.3 *Process model*

The process model is represented as a cube with a formal, functional and temporal dimension. Each dimension is articulated in three parts. Articulation regards the

procedural aspects to be appointed to function elements. These elements are related to activities as building stones of a process, and determined by parties (subjects), with their expertise and mandates, budgets and terms.

- The form dimension (of the process object) determines the form aspects of the process, articulated in three levels. This is a hierarchical articulation in terms of complexity of the activities of which the object is the subject; it corresponds with the form articulation of both the form and the function model. This articulation exemplifies the hierarchical designing organisation.
- The function dimension (of the process object) determines the function of the process and is articulated in accordance with the performances (in disciplines). This articulation corresponds with the function articulation of the form and function model.
- The process dimension (of the process object) determines the process aspects of the object. It concerns the type of processes in which the object becomes reality. This happens in tasks that are carried out parallel or serial in time.

The process object determines the position of an architectural object within a project. The architectural object is a material object next to two other types of objects, viz. the object of the designing organisation and process design as an object. A project is considered an object of a higher level in the same way as the partial objects, mentioned above, belong to a lower level in a hierarchy.

2.5 **Integral GOM-model**

2.5.1 *Matrix*

The three models are brought together in the form of a matrix. The rows of the matrix contain the form, function and process model respectively. These models form the dimensions of an architectural object. The titles of the rows are: Form (F), Function (O) and Process (P)-dimension. The titles of the columns are: form, function and process articulation. The titles of the rows, though using the same name, indicate a higher level than the titles of the columns; for distinction the titles of the rows start with a capital. Rows and columns define fields; the content of the fields is determined by the three sub-models. In each field appears one term as indication of a triad.

Architectural Object	form articulation of F, O, P dimension of Object in levels	function articulation of F, O, P dimension of Object in performances	process articulation of F, O, P dimension of Object in phases
1. Form dimension	*3 levels of form*	3 performances of form	3 phases of form
2. Function dimension	*3 levels of function*	*3 performances of function*	3 phases of function
3. Process dimension	*3 levels of process*	*3 performances of process*	*3 phases of process*

The matrix shows the following items:

- The architectural object as a layered, hierarchical composition of three partial

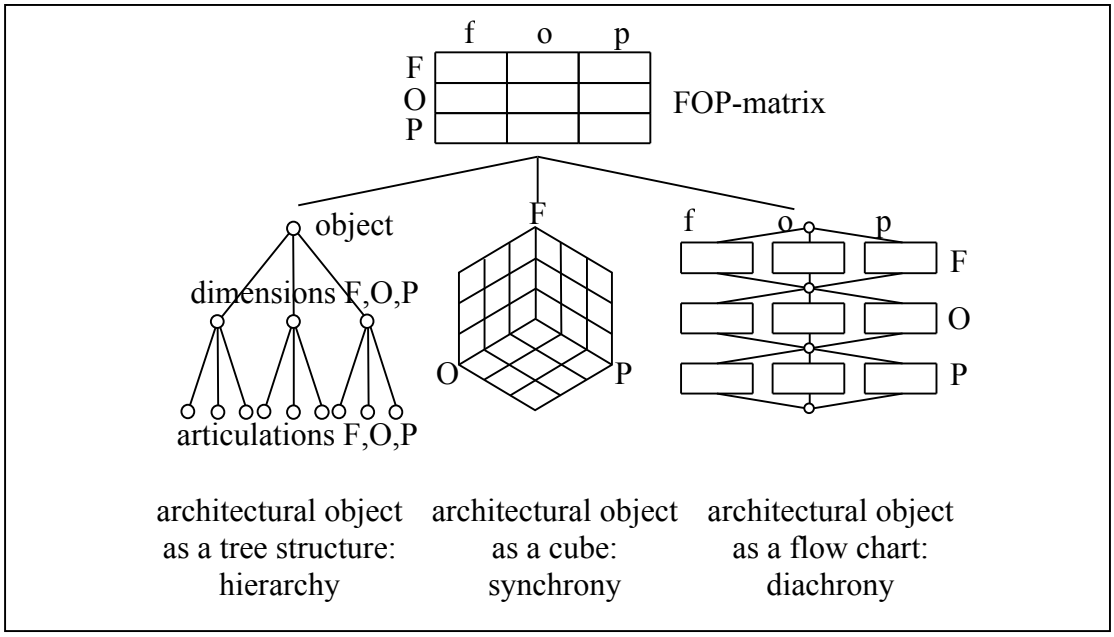


Figure 6: **Three interpretations of the dynamic matrix as representation of an architectural object-in-development**

objects (dimensions); the rows show the hierarchy of a form, function and process object; the columns show the hierarchy of a form, function and process articulation; the articulations of the primary dimensions of the partial objects are underlined.
- The architectural object as a synchronic composition: the stable states emphasising the tuning of articulations within each dimension of the object in columns.
- The architectural object as a diachronic composition: the sequence of stadia 1, 2 and 3 in a cycle, emphasising the tuning of dimensions of the object in rows; the elements of incremental integration are in italics.

The matrix is denoted as a dynamic matrix.

2.5.2 *F-, O- and P-representation of the matrix*

In figure 6 the architectural object is shown with its hierarchical, synchronic and diachronic properties. Dependent on the emphasis on these properties the architectural object can be represented schematically as a tree structure (with emphasis on hierarchy), as a cube (with emphasis on synchrony), and as a flow chart (with emphasis on diachrony). These representations are three interpretations of the dynamic matrix as the representation of an architectural object-in-development.

More specifically, in the cube representation the following types of activity areas are discerned (figure 7):
- The cube as a whole defines an activity space.

- The 3x3 tranches determine activity fields: level-, performance- and phase-bound activity fields.

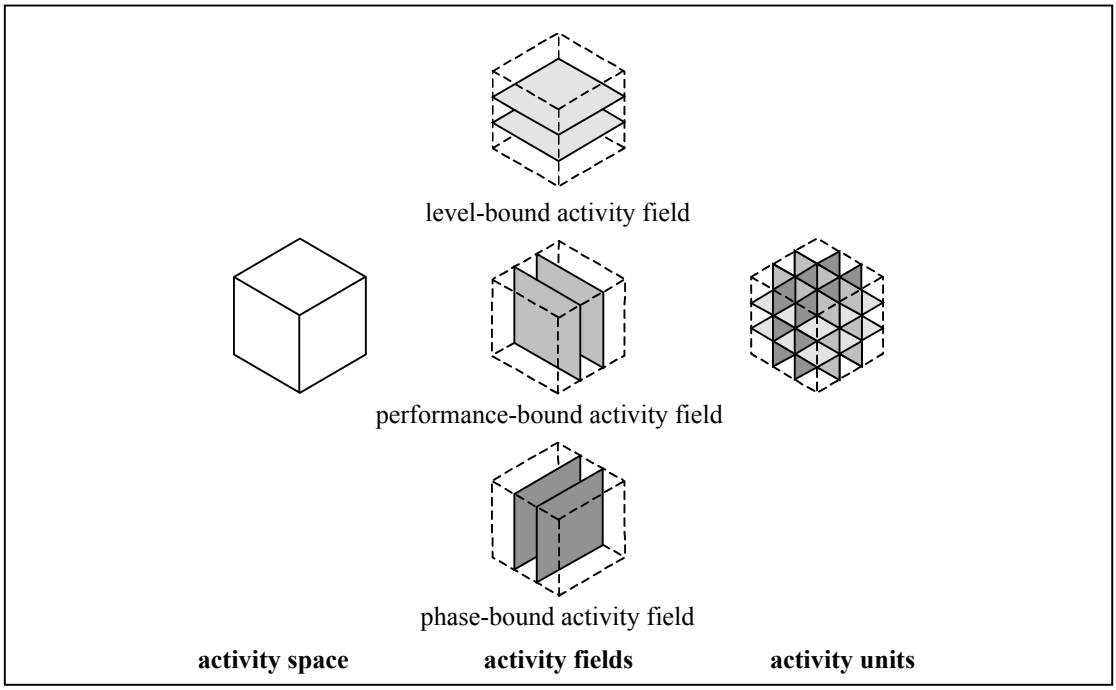


Figure 7: **Types of domains**

- The 3x3x3 smaller cubes, resulting from the intersection of tranches, determine activity-units.

Domains are activity areas that determine the territory of a subject or a group of subjects, organised in disciplines, professions or task groups, parties or agents. A subject can operate in various domains, and one domain can be the activity area of various subjects. Participation is the denotation of a design organisation in combination with a design process, based on domains. A design activity is multidisciplinary by its very nature; the science discerning domains in their coherence is interdisciplinary. Domain Theory is an example of such a design theory.

The three dimensions of activity space correspond with three directions of design process; these processes are processes of adaptation and tuning. According to their direction the following processes are discerned (figure 8):

- F-processes of specialisation and generalisation, also denoted as processes of ordonnance, tuning of levels.
- O-processes of differentiation and integration, tuning of performances, and
- P-processes of delegation and co-ordination, tuning of phases.

Each direction shows, dependent of their orientation on the centre or the periphery of the model, two types of processes.

2.6 **Pragmatism of the GOM-model**

The integral GOM-model, the dimensions and articulations of which are tuneable, offers the structured space for the definition of domains as activity areas. This means that they can be identified, defined and specified as relatively autonomous research, design and teaching areas. Domains are areas of knowledge production, application and transfer; in short, areas of scientific development controlled by researchers, designers and teachers with their students. Domains are defined by objects in relation with active subjects; they are pragmatistic by nature.

Properties of objects are based on the form, function and process dimension of the architectural object. Form, function and process are the basic categories of an object-in-development: a dynamic object. Because of its hierarchical structure and recursive mechanisms, the FOP-matrix is the representation of a periodic system of categories. On this level of abstraction, it is possible to compare the Domain Theory with Peirce's process philosophy.

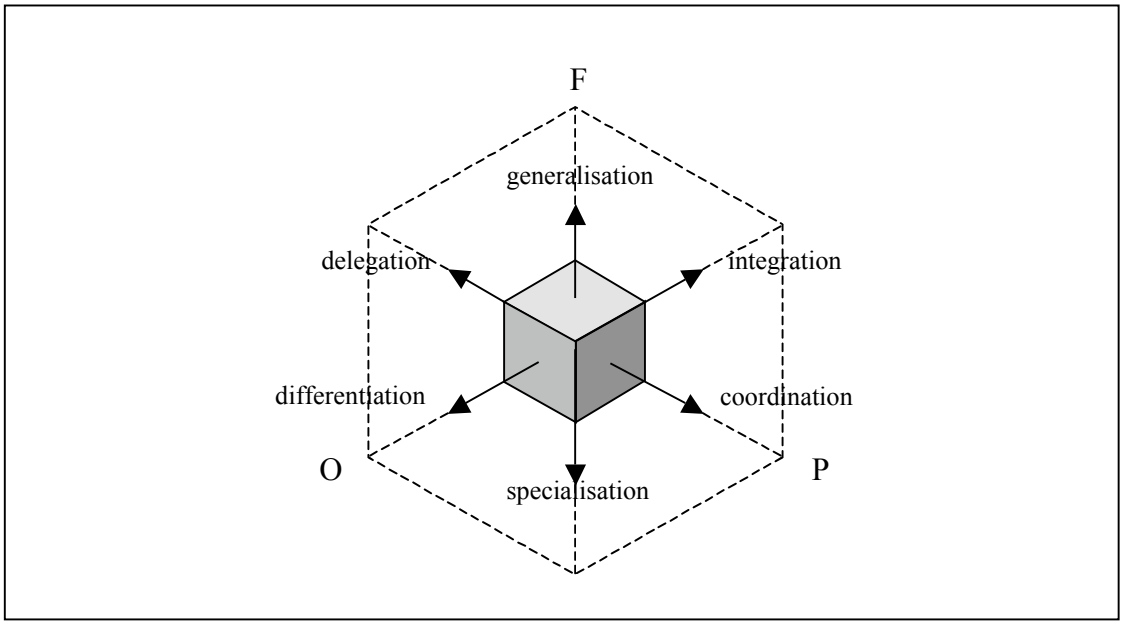


Figure 8: **Processes**

3 CATEGORIES, LOGIC AND SEMIOTICS IN PEIRCE'S PRAGMATISM

The pragmatism of Peirce is reconstructed here as the result of an imagined development, viz. a pragmatistic analytical reconstruction of the order of developments that have lead to Peirce's pragmatism. In this order three stadia may be recognised indeed: phenomenology, logic and semiotics. Each of these stadia may in turn be reconstructed as a whole that develops according to three interrelated (sub)stadia. Each (sub)stadium includes the preceding (sub)stadia as a part or as a presupposition of it.

3.1 **The universal categories according to Peirce's phenomenology**

With Peirce, phenomenology is the intuitive analytical approach that opens with a mind that is still open to whatever may present itself (the mind just before it gets preoccupied with questions of logic and language analysis); more specifically, it is this approach as applied to the enterprise to arrive at the ultimate categories of thought-and-reality. The categoriology arrived at, derives its character of universality from being independent from any specific language or logic, and from any specific culture-bound way of conceiving.

Peirce: "*Phenomenology*, or the Doctrine of Categories, whose business it is to unravel the tangled skein of all that in any sense appears and wind it into distinct forms…" (Peirce, C.P.1.280) and "The business of phenomenology is to draw up a catalogue of categories and prove its sufficiency and freedom from redundancies, to make out the characteristics of each category, and to show the relations of each to the others." (Peirce, C.P.5.43). According to Peirce, the three categories are those general kinds of components that may be distinguished within any phenomenon (see for instance Peirce, C.P.8.265). In his search for what constitutes a sufficient and necessary base for representing, handling and conceiving whatever might present itself as part of the phenomenal world, Peirce ultimately arrived at an ordered set of three omnipresent categories. He named these most elementary categories at the basis of any phenomenon after their formal hierarchical order: Firstness, Secondness and Thirdness. Accordingly, we have:

1. Firstness: anything, not presupposing anything else,
2. Secondness: that which appears, depending upon something else,
3. Thirdness: any Third, i.e. anything mediating between two appearances, thus presupposing a 'pair of things' and showing itself as highest in hierarchy.

However, next to the formal order of logical dependency, simultaneously a material order of dependency is operative, viz. the 'process-order' as to how the constitution of phenomena proceeds:

3'. Thirdness: anything mediating between a Beginning, or First, and an End, or Second; the latter being a result that presupposes the mediation of a Third in the constitutional process-order.

Because of this duality, the interrelational connection between the three omnipresent categories is anarcho-hierarchical in character: the three play a simultaneous game, in which each one has its proper and irreplaceable role to play, a role that can only be fulfilled through a hierarchically ordered interplay with the other roles that keeps the anarchical character of each one's irreplaceable position in tact. This anarcho-hierarchical interrelatedness of the three categories may be indicated, for short, as a 'triarchy'. Because of this biasedness in the formal order of the three categories, and for reasons of having a key with respect to content concerning them, it is in many contexts of discussion advantageous to use the more characterising names Peirce has given them, viz. 'Potentiality', 'Actuality' and 'Intentionality' (as explained below) next to the universalistic names 'Firstness', 'Secondness' and 'Thirdness'.

The anarcho-hierarchical character of the interrelation between the three categories is best illustrated by a triangular graph, such as the phenomenological

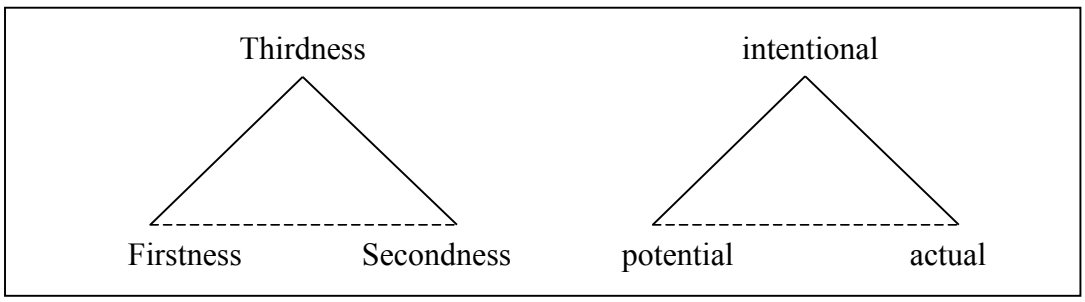


Figure 9: **Phenomenological Triangle: categorical version and epistemic - ontological version (dotted line indicates mediated connection)**

triangle of figure 9, in which the Third mediates the connection between the beginning (First) and the end (Second).

The omnipresence of the categories makes for the in-finite variety of the forms, ways and features of their appearances. Two examples of anarcho-hierarchically connected appearances of the three categories are: 'the potential - the actual - the systematic / intentional' and 'form - function - control'.
Elucidation:

- First example. This is still a generalistic example, occurring on a universal epistemic-ontological level. It tells, that whatever is actual must be possible (i.e. presupposes the potential), and that it appears through systemic connection, viz. as indicated by an indexical sign or as the result of a cause, and/or through intentional connection, viz. as the application of an overall concept. The latter, which precedes in a sense the Second (in this case: the actual) and which holds the position of a Third, is the 'systematic/ intentional'-component.
- Second example. This occurs on a more concrete level. We have to do here with mechanism-like appearances. Think of organic, psychological, social and artificial mechanisms. A specific form (a constellation of elements, e.g. a feromone, a message, a system or an organic constellation) may exercise a teleologic function or may realise an intended effect (say 'warning for fire'), in which case a Third is operative, a controlling factor, seeing to it that - in different contexts with varying conditions - the form still performs its function adequately. Here again, the Third logically presupposes the Second, the function that is to be realised; whereas it still, in a cybernetic sense, precedes the Second as it regulates the adequate performance of the function.

The cyclic character of the roles of the three categories is reinforced by the circumstance that a Second, e.g. a concrete 'fire-warning' function, may become a First or a Third in another context: in certain contexts it may become - as a 'sign for safety' - a quality or potentiality (i.e. a First), and in other contexts it may be identified with a norm, an institution or a regulative idea, e.g. it may become a standard for all 'fire-warning functions', and as such become a Third.

3.2 **Three stadia in the development of logic**

During its long Western history since Aristotle, the main struggle for progress in logic was along the lines of the technical medium of expression that determines the level of the scope and precision to be covered by logic. In this respect, and in retrospect from the pragmatist viewpoint of Peirce, three stadia of development within logic can be distinguished (Nauta, 1981):

1. Aristotelian logic, using formats of common language, in which subjects, monadic predicates and verbs play the same overall role. The lacking expression technics causes here non-relational properties (qualities) to be the only things that are adequately represented and studied. This is to say that such simple mathematical relations as 'greater than' and 'x is a function of y and z' cannot be grounded logically.
2. Fregean logic, using artificial language systems with truth-functionally defined, i.e. context-independent, logical connectives along with variables, parameters as well as relations next to simple properties. Seemingly all kinds of relations may be represented and studied at this stadium of logic. But the intrinsic design that all notations and operations are context-independent causes that complex relations, whenever they are rendered in a Fregean type of logic, come down to a linear concatenation of dyadic relations. For instance, the triadic relation 'the dollar has a value in between the guilder and the pound' may be rendered as: fl.< $ < £. This is a linear concatenation of fl.< $ and $ < £. In this case there is no problem, because economics is still solving questions and problems as if they could be understood in linear, context-independent terms
3. Peircean logic, using a dialogical notation system of existential graphs that enables to express non-linear relations as well as to account for the intensional (non-truthfunctional) effects of non-linearity and context-dependence. As to their capacity of expression and analysis, these three stadia of logic may be synoptically represented by Peircean graphs as follows:

* The first stadium has just isolated points. For example, the following constellation of two Peircean graphs (which is again a Peircean graph):

A. .B

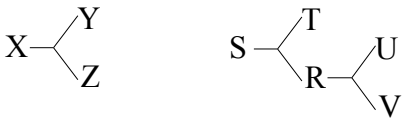
(say: 'A has the property of being 10 meter long' AND 'B has the property of being 20 meter long'). The number of isolated points that could be used is unlimited. They are logically connected through graph-constellations that add logical connectives, such as AND (as is the case with the simple kind of graph-constellation used here), OR and IF/THEN, to the symbolised propositions.

* The second stadium has next to isolated points one-dimensional graphs:

Q. A _____B X___Y___Z

(say: 'Q is a questionnaire' AND 'A is shorter than B' AND 'X puts Y in the hands of Z'). The number of points that could be linearly connected through a one-dimensional graph is unlimited. And so is the number of one-dimensional graphs. They are logically connected to other representations of (concatenated) dyadic relations (and to representations of properties) through graph-constellations that add logical connectives to the symbolised propositions.

The third stadium has next to isolated points & linear graphs non-linear graphs:



(say: ‘X [in the act of putting Z in the hands of Y] is presenting Z as a gift to Y’ AND ‘S registers with notary T the contract R as agreed and signed by U and V’). The number of interrelated points, and thus the complexity of a non-linear graph, is in principle unlimited. Note that the number of linearly connected points adds up to the capacity, but not to the complexity, of a graph.

It is characteristic for the higher level of Peircean logic as compared with Fregean logic, that it enables to do what Fregean logic is unable to, viz. to give adequate representations of such intentional acts as presenting someone a gift. By Fregean notation systems such acts are reduced to behavioural notions, thus ignoring the very intentional and contextual aspects that make behaviour meaningful.

Apparently, the development from monadic predicate logic via linear predicate calculus to a 'non-degenerate triadistic' logic (as Peirce puts it) exhibits three steps of increasing subtlety and complexity. This hierarchical order is paralleled here by a presupposition-hierarchy: monadicity is presupposed by dyadic or linear relatedness, and this in turn is presupposed by non-linear relatedness or real triadicity. As it is impossible to reduce non-linear relations to linear ones without losing the distinctive character of intentionality and context-dependence, and as it is impossible to render relations, however simple they may be, as the upshot of a constellation of monades, we meet here with three different levels of expressing, designing and conceiving. The hierarchical interdependence of the three stadia is well represented by the logical triangle as rendered in figure 10.

The triadic interrelation of the stadia corresponds to the interrelatedness of the three universal categories as pictured in the phenomenological triangle:

* the position of monadicity in this interrelation corresponds to the position of the still unrelated potentiality of Firstness in the phenomenological triangle,
* dyadicity correponds with the polarity inherent in the actuality of Secondness,
* triadicity corresponds with the character of being emergent (i.e. beyond behaviouristic description) that is characteristic of the intentionality of Thirdness.

3.3 **Semiosis as a triarchic process**

Peirce defined semiotics as the general study of semiosis; and he defined semiosis as the universal process through which something, any thing, becomes meaningful, i.e. comes to be functioning as a sign. In his view, semiotics is a philosophical

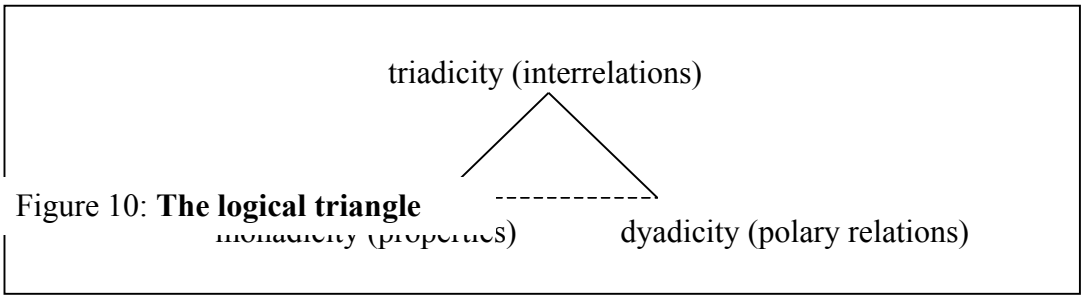
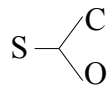


Figure 10: **The logical triangle**

generalisation of logic. As such it presupposes and includes logic as a scientific discipline. In a sense, this is in a nutshell what his specific brand of pragmatism comes down to. The Peircean conception of semiosis corresponds with the anarcho-hierarchical triadicity of the three categories: semiosis is a process, in which a sign (a First) through the mediation of an interpreting vehicle or "interpretant" (a thought, a concept, a sign that interpretes the first sign, etc.: a Third) comes to indicate an object (a Second). Subsequently, the object or the interpretant in question may in turn be functioning as a sign. Therefore, any idea, thing or process that presents itself may be understood in terms of signs and semiosis. The triarchic character of semiosis is rendered in the semiotic triangle (figure 11).

Note that the semiotic triangle is isomorphic to the kind of non-linear graph that reflects any specimen of semiosis in Peircean logic: 

(say: S, e.g. the north star, indicates O, the direction of the North, through C, i.e. through traditional knowledge). Note, however, that in the logical notation, because of its symmetry as opposed to the asymmetry-aspect of the semiotic triangle, the position of the First in question (etc.) is intended but cannot be expressed.

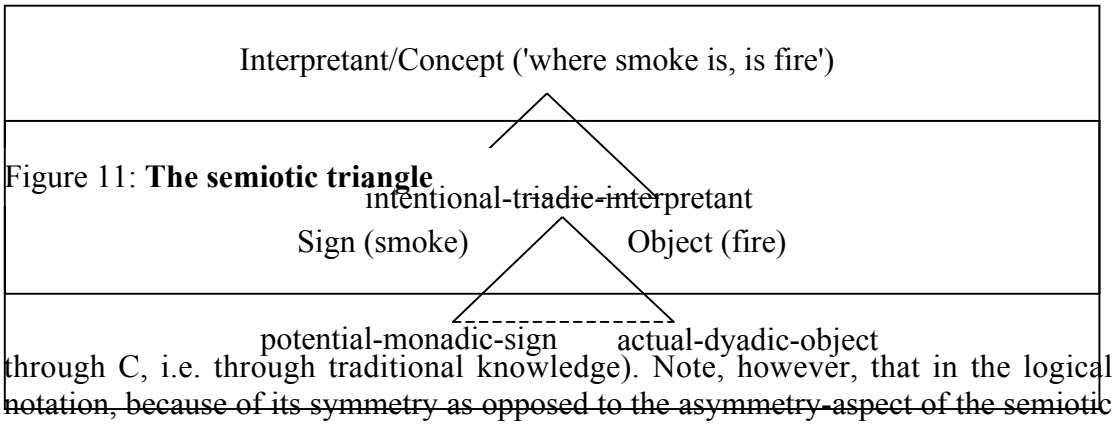


Figure 11: **The semiotic triangle**

The mediating vehicle in the process of semiosis is usually called 'interpretant' by Peirce. Next to that term he uses also the terms 'immediate object' and 'mental effect'. And next to the term 'sign' he uses the term 'representamen' .

Peirce: "A representation is that character of a thing by virtue of which, for the production of a certain mental effect, it may stand in the place of another thing. The thing having this character I term representamen, the mental effect, or thought, its interpretant, the thing for which it stands, its object.' (Peirce, C.P. 2.564)

Just as the three categories are interdependent, so are the three components of semiosis. Consequently, the expression or image that goes with an imaginational situation can never be defined independently of the other two semiotical components. The same holds for the object that goes with a practical situation, and for the cognition or content of thought that goes with a cognitive situation.

3.4 **The pragmatistic matrix**

The unified way of conceiving, characteristic of Peirce's pragmatism, may be reflected here in an easy way by combining the three triangles that model synoptically what has been treated above as the three categorical steps that constitute Peirce's

pragmatism: his phenomenology (as a First) with the epistemic-ontological version of the phenomenological triangle, his logic (as a Second) with the triangle of the three stadia of logic, and his semiotics (as a Third) with the semiotic triangle. The three triangles are isomorphic in that their structure is anarcho-hierarchic (as expressed by the dotted base) and that the categorical positions and interrelations are the same (as expressed by the abstract categorical version of the phenomenological triangle). As a result we have the pragmatistic triangle as rendered in figure 12. At each corner of the triangle we find a triadic expression, which should be understood triarchically. Such expressions could be multiplied; and this would result in endless lists of terms which characterise (in the relational context in question) the peculiarities of Firstness, Secondness and Thirdness respectively. The categorical version of the phenomenological triangle (figure 9) is the abstract result of the imagined association of all such peculiarities, i.e. of the unlimited extension of the pragmatistic triangle.

It is instructive to re-order the pragmatistic triangle in the typographical form of a matrix. The resulting pragmatistic matrix, as rendered below, reflects in its columns the stadia of logical development, i.e. the presupposition-order, in each of the subsequent fields: phenomenology, logic and semiotics, that are constitutive of pragmatism. In order to reflect in the matrix the asymmetry and duality of the anarcho-hierarchical order of the pragmatistic triangle, the diachronic development of hierarchy (‘I-II-III’) inherent in the columns is balanced by a synchronic anarchy in the rows: the rows reflect the cybernetic mediation order ('1-3-2') of the peculiarities belonging to one of the three categories in one of its three constitutive stadia.

Pragmatistic matrix: Phenomenon	1	3	2
I	potential	sign	monadic
II	actual	object	dyadic
III	intentional	interpretant	triadic

The use of the Arabic numerals as an index for the columns, as opposed to the roman ones for the rows, is an indication for the circumstance that the categorical developmental order, for instance that of logic (2), is of a lower level of abstraction than the order of the constitutive attribute-stadia belonging to a category. For instance, the constitutive order: actual-object (as medium)-dyadic (II), is so abstract, that it can scarcely be checked not to be purely context-dependent, whereas the categorical order: monadic-dyadic-triadic (2) is evidently valid.

The matrix as a whole represents the formal synchronic/diachronic (anarcho/hierarchical) constitution of a phenomenon, conceived as the process of a result/ result of a process, and this through the exposition of a well-ordered cluster of structuralising ingredients.

4 CONCLUSION

The matrix of Domain Theory and the pragmatistic matrix are isomorphic. In both cases there are 3x3-matrices in which the titles of rows and columns in each matrix are of the same type, and the titles of the columns are of a lower level of abstraction than the titles of the rows. In both cases the matrices describe an entity: an architectural object or any other phenomenon as a result of a process and at the same time as the process leading to a result.

The difference between the two matrices is a difference in level of abstraction: the pragmatistic matrix is of a higher level than the matrix of Domain Theory. The content of the fields of the pragmatistic matrix defines the format of the matrix as determined by its titles. The matrix, made empty of its content, defines a framework of thought which accommodates, depending on its context, other ways to fill it in again. It is argued that Domain Theory provides a possible content. The triad of indices or titles of the form-function-process-matrix, constitute an element, i.c. a column in the (empty) pragmatistic matrix, more specifically the 2-column, which has an actual character. The sequence of these dimensions has to be changed to form-process-function in order to comply with the potential (I)-actual (II)-intentional (III)-sequence of the pragmatistic matrix. This adaptation is not in contradiction with the previous argumentation: from a point of view of logic, function encompasses both, begin and end of a process, i.c. form as a beginning and process (result) as an end, and is as such highest in hierarchy. In Peircean terminology Form is Firstness (I), characterised as potential, monad and sign; Process is Secondness (II), characterised as actual, dyad and object, and Function is Thirdness (III), characterised as intentional, triad and interpretant. In the same way the other two columns can be given a content; e.g. column 1: space-time-intention, and column 3: system-transformation/game-structure (Hillier and Leaman, 1972/3), (Bax, 1976). The three columns as a whole correspond with the cybernetic order of stadia, denoted as Type, Model and Plan. The pragmatistic matrix with its adapted content gets the following shape (the titles of the rows and columns of the matrix are indexes, indicating Peircean categories, the fields define classes).

In order to make the matrix easier for use, the abstract indices I or 1, II or 2, and III or 3 can be substituted by the more concrete terms potential (P or p), actual (A or a) and intentional (I or i). Each title and field can be coded accordingly; the title of the rows gets the first position in the code.

Matrix of architectural object

Classes	p		i		a	
Aspect/stadium	(PAI/p)	Type	(PAI/i)	Model	(PAI/a)	Plan
P	(P/p)	space	(P/i)	system	(P/a)	form
A	(A/p)	time	(A/i)	transformation	(A/a)	process
I	(I/p)	intention	(I/i)	structure	(I/a)	function

This matrix demonstrates the accordance between the categories of Domain Theory and those of Peirce, the goal of this study. The categories of Domain Theory are conditioned specifications of Peircean categories; they form a triad of classes within a matrix determined by Peircean categories.

A cubic approach appears to be the same as a triarchically approach to reality.

This notion is expressed clearly in figure 13 showing the Peircean triangle as an oblique section of the Domain Theory cube: the three cubic axes inside the triangle form a so called Peircean fork, the way Peirce himself represented the triarchical function.

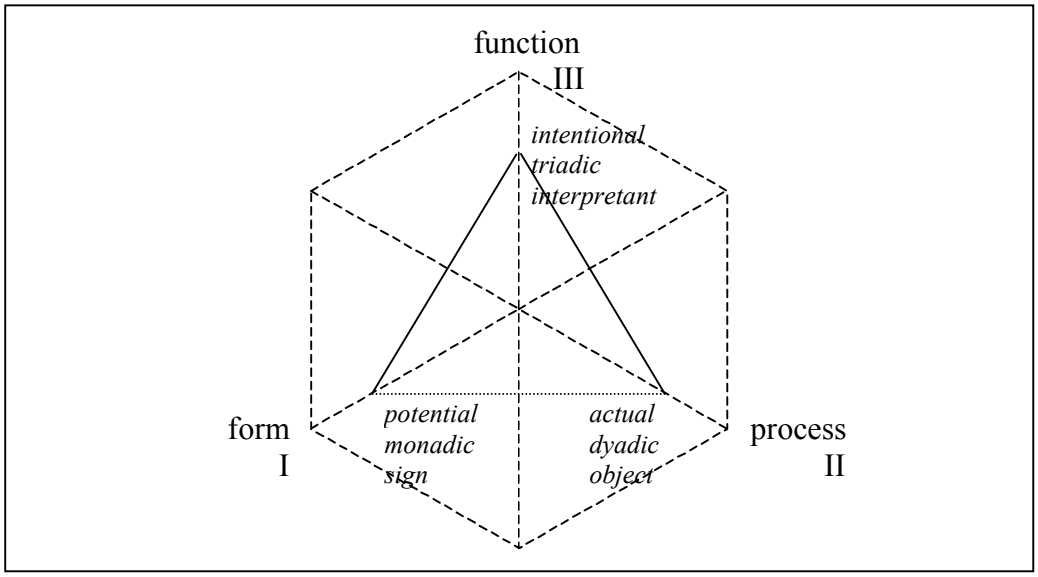


Figure 13: **Cubic and triarchic representation of**

Just like the cube can be fragmented into series of smaller cubes, leading to a fractal-like representation, the triangle is part of a pragmatistic, semiotic network of triangles. The direction of extension of these networks is meaningful in itself. The aforementioned triads abduction, deduction, induction and syntactic, semantic, pragmatic can be extended with a triad construction, instruction, adstruction, corresponding grosso modo with the fields of design, teaching and research in technology and science.

The filled-in matrix evokes the following annotations:

1. In each field of the matrix, and so for each class, a code appears (P/p, P/i, etc.) The code denotes the logical position of the term and indicates the way the term has to interpreted. In this way there is a certain freedom of speech, guaranteeing at the same time adequate communication between disciplines in multidisciplinary projects in which each discipline uses its own terminology.
2. Each column in the matrix is the indication of stable state or stadium in a development cycle. These states or stages names are given, according with design practice: Type, Model and Plan; here too the code provides the foundation for interpretation.
3. In the pragmatistic matrix the terms form, function and process are defined as a triad. This implies that the elements of the triad are interdependent; this way of defining deviates from the ideal of analytical philosophy, but is inherent to a ‘designerly way of thinking’. E.g. the term ‘P/a, form’ means a class, (1) defined as belonging to (aspect-) category P and (stadium-) category a, (2) defined as

belonging to a triad together with process and function, (3) defined as belonging to a Plan, which is an element of a triad together with Model and Type. The definitions of terms, functioning as a class, is based on their logical position in the matrix. On the highest level of abstraction form is defined as Firstness: characterised in terms of potential, sign and monad. Actually, the making of a list of definitions was the reason for starting the study of Peirce's work.

4. The relation between object matrix of Domain Theory and pragmatistic matrix has a hierarchical character. Three classes from a column in the pragmatistic matrix define a new, more specific object matrix. The object matrix, using the same principle, can be specified again in order to refine the description of the object. In a reversed process, more general objects, like projects and life cycle trajects can be defined. The mechanism generating categories for an adequate level of description of architectural objects within a pragmatistic framework is denoted as 'categorese'. 'This method of incremental classification opens a perspective for a design method, denoted as 'design by classification'.
5. A specific application of Domain Theory and Peircean theory is the further development of the function model into a taxonomy of concepts in the form of a matrix (Bax, 1996).

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