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The Evolution of a Concept System:
Reflections on Case Studies of Scientific Research,
Italian Literature and Humanities Computing

Abstract: By using rigorous arrangement criteria it is possible to organize concept systems whose structure can point out the following evolutionary phases: the rising through the characterization of the object and its typology; the features and the capacity to organize the knowledge domain within which it develops; the vitality produced by the impulses and motives of research which tend to increase the knowledge domain; the capacity to relate with other concept systems, identifying their osmotic relationships between knowledge fields; the generation of new knowledge fields; the solution through its integration in more complex systems in which new knowledge, correctly organized, converges.

1. Introduction
To perform the research described in this paper, we applied Dahlberg's "Systematifier" category model for the analysis and concept structuring of the following domains: Scientific Research, Italian Literature, Cereals Cultivation and Humanities Computing. The application of the model to such diverse domains might highlight—according to the subjective viewpoint of the users of these principles—interesting aspects of the domains structured: that is, aspects in part common to all the domains examined and in part specific to each of them. It has been possible to note, for example, how a concept system representing the structure of a domain evolves at a rhythm which stresses the various phases of its life and characterizes a domain physiognomy, sometimes unidentified even by scholars of the subject.

The paper sets out to illustrate these aspects by focusing on three of the domains cited. Another paper considers the problems involved in the study of Cereals to stress how, applied to a specific disciplinary sector, analysis and inductive procedure may help to improve knowledge not only of the discipline inherent to the sector itself, but also of other disciplines.

2. The Concept System
A field of knowledge is identified and defined through a material or immaterial object taken from the reality and concepts which, on the basis of their statements, refer to the object itself. The organization of the structure of this field of knowledge may be determined by analysis of the characteristics of each concept and application of an inductive procedure. Analyzing the characteristics of the object and the concepts correlated to it, it is possible to highlight, through an inductive procedure, concepts of a higher order which ultimately identify with the application of categories to the field of knowledge in question.

The Systematifier category model allows us to identify these concepts of a higher order in each knowledge field, and to note relationships between them and all other concepts. We thus generate the general structure of the knowledge field, the framework of the system in which each category encompasses the concept cluster correlated to it. By establishing hierarchical relations between the single conceptual units which combine to form a cluster, the knowledge field is

ordered in a *concept system* represented by relationships between the single conceptual units.

The identification and definition of a field of knowledge are made according to forms and patterns which stem from two typologies. The first is a field of knowledge marked by an autonomous, independent object of reality described by its characteristics and the conceptual units which refer to it. Examples of this typology may be found in the fields of «Scientific Research» and «Italian Literature». The second typology considers a field of knowledge which emerges from the integration of different objects, each equipped with characteristics and conceptual units of its own. The new field which is thus determined is the product of a combination of different domains of knowledge and ultimately takes on a life of its own, represented by a structure of its own. An example is «Humanities Computing» which is determined through the integration of the domains of Humanities and Computer Science.

3. Identification and Definition of a Knowledge Field

The identification of a new field of knowledge takes place through scientific research activity which helps to increase knowledge of an object of reality. The new knowledge field is defined through the object and the concept cluster correlated to it. Even if the object is by its very nature integrated within a discipline—"cereal", say, in Agricultural Science, or a literary phenomenon in Literature—new concepts, which scientific research gradually adds to the field, progressively increase its development. The field of knowledge which has achieved a certain degree of development is thus *autonomous*—with often unapparent *methodological characteristics of its own*—*disorderly and shapeless*. If these concepts are ordered logically following a structure model, it is possible to use them and make them usable. It is thus necessary to organize the conceptual structure by attributing the proper classification in the system to each conceptual unit which belongs to the relevant knowledge field.

Through analysis and experimentation, we have seen how Systematifier embodies the simultaneous duality of formula and guide. As a formula, it provides rules and principles to which the right values have to be attributed in order to establish the structure of the system. As a guide, it directs the user towards rational choices in his own disciplinary field, offering him every opportunity to experiment and verify the principles themselves.

The Systematifier category model goes on to delineate and characterize the new field of knowledge, evidencing the *object*, its *action*, its *theory* and other characteristics.

3.1 Object

This category encompasses all concepts which identify the *object* and its properties, that is, ‘what the object is’ and how it appears.

The identification of the *object* is easy to imagine in some cases—in the study of “cereal”, for example—but demands closer attention in others—the «Research» and «Italian Literature» domains, for example.

In the «Research» domain it was necessary to distinguish the “research” concept from that of “science”. “Research” taken as *the action carried out for the improvement of the process of knowledge and the process of application*, is often considered a synonym of “science”, *a process for knowledge*. Defined in this way, we tend to regard “science” as any scientific activity carried out irrespective of the results it obtains, as opposed to “science” as *rigorous, methodical and systematic knowledge*: that is, *unified, true knowledge* open to critical, conceptual and experimental verification. It was thus necessary to attribute a proper role to these terms within the system, eliminating any possible ambiguities. Likewise, it was necessary to attribute a proper
role to their derivatives: science policy, national and international science, forecasting and assessment of science and technology, big science and little science, science parks, science in the market and so on (Negrini, 1992, 296).

In the case of «Italian Literature», as an organizational criterion for the concept structure it was necessary to identify the 'literary fact' contained and illustrated in the literary work. The literary fact is the event which occurs at a certain place at a certain time in history, the product of the creative imagination of the author expressed using the means, forms and rules he decides to adopt (Negrini and Zoci, 1995, 127). The object of the «Italian Literature» system was identified as the "literary work" since, in so far as it contains the literary fact—that is, the instrument with which the author communicates his message—it is characterized by the criteria used by the author to express himself. These may encompass, for example, "form"—dialogue, drama, melodrama, novella, poetry, epic poetry, song, novel, satire etc—or "content"—diary, biography, historical work, obituary, collection of poems etc. In defining this particular system, it was possible to note how the categories which combine to form the structure of the system are also valid for a broader system covering «Literature» in general.

The "Humanities Computing" domain is a case apart, since it consists of the integration of two separate and autonomous knowledge fields, each of which enjoys an existence and independent development of its own. Since they benefit from powerful and accurate logical and technological instruments, the humanities receive a stimulus and an impulse to verify their methods of investigation and analysis, and thus make them more consistent. Hence the decision to identify the various sectors into which the humanities break down as the object of the new field of knowledge.

These reflections were indispensable to establish the contents of the domains and the demarcation of their boundaries—a task preliminary to the study of the formal structure of a field of knowledge—and to find inside it the proper classification of the concepts which form the domain.

3.2 Action and Process

Knowledge of the action made or undergone by the object, including the ways and forms with which the action takes place, represent the content of another Systematifier category. The concepts which express this action cast light on the purposes and methodologies of knowledge in the domain considered.

In the «Research» system, the action was viewed in terms of two distinct aspects: first, at "macrolevel" to record the activities generally carried out by public and private bodies and industry; secondly, at "microlevel" to analyze single research project and to define the methods and procedures needed to achieve innovative results at the theoretical, applied, experimental and productive levels.

For «Italian Literature», Literary Criticism was considered as the action performed on the literary work. It sets out in fact to study the work to investigate the literary fact and, from it, understand the creative image of the author. Criticism’s interpretative analysis of the literary fact is a process that cannot be arrested, reflecting the critic’s spirit and soul, but also the historical-cultural moment in which it manifests itself.

In «Humanities Computing» the action is considered as a method of scientific investigation of the object, its role being that of a "logical engine" capable of producing a consistent formalization of the research procedure and activity.
3.3 Theory
A fundamental category is that of theory about the object. By describing the object in question, the aim is to obtain a logically consistent formulation of the general principles of the knowledge field. Basically, theory consists of identifying and defining the principles which regulate and determine the existence of a knowledge field. It is possible to observe that the correct formulation of the theory of a domain emerges only at an advanced state of development of the knowledge field, and that, besides, theory also establishes the terminology to describe the objects or actions surveyed.

3.4 Other Characteristics
A criterion for identifying other characteristics which may help to structure the knowledge field may be provided by the result or product of the action performed or undergone by the object.

In the case of the «Research» system, in the context of the “microlevel” of the single research project, the result is presented in the drafting of a final report, a scientific paper describing the progress achieved and the procedures adopted to attain the set objectives. The measure of the scientific value of the product obtained is directly dependent on the product’s intrinsic capacity to furnish new knowledge. At the applied level, the product of research consists of an invention which, by virtue of its creation of new knowledge or utilization of phenomena already known, is susceptible to immediate practical employment in a different operating process. This is the process of innovation, a crucial factor in economic progress. The importance of an invention is thus proportional to the potential applied utility of the results achieved.

In the «Italian Literature» system, the result of the critical process consists of the conceptual units identified in the literary work, which we refer to as “elements” (esoteric, aesthetic, formal, literary, psychological etc). These concepts prove particularly significant in so far as they introduce the “added value” of the work as furnished by literary criticism—valuable new information for the researcher.

Another criterion which has proved common to these systems is the role of the physical person responsible for the creative process: a “scientist” or “engineer” for the «Research» system, an author, mediator (critic, actor, interpreter), reader and public for the «Italian Literature» system.

In the case of «Humanities Computing», it was possible to note that the result of the relationship established between the two fields of knowledge consists of an original research methodology and of the production of new tools for research which, in turn, are capable of determining new knowledge and new products. Hence the newly identified domain ultimately activates a process with autonomous fallouts, while simultaneously contributing also to the two original domains (Fig. 3). The tools consist principally of the application-oriented software developed: for example, the algorithmic formalization of rules for the analysis of the content and style of a text, for automatic translation or for the automatic composition of texts and music, as well as for the speech and music synthesis. As the product, we identified: data bases and expert systems in the various sectors of the humanities, landscape surveying and analysis systems (GIS), systems of computer-aided translation and automatic synthesis of sound and speech and, finally, systems for the automatic generation of language.

4. Dynamism of a Conceptual System
The application of Systematifier to define a concept system helps us to perceive in it a flow of knowledge which characterizes the system’s natural “motion”. It is produced by different impulses and aimed at improving new cognitive processes that are schematically representable.
The «Research» system is characterized by two different motions which originate in other sciences: in the *Science of Science*, which poses the «Research» system theoretical queries and produces culture; and in *Social and technological science*, which poses the «Research» system economic, technological, social and environmental queries. The results acquired in the «Research» system fall out over these sciences. The resulting flow of knowledge integrates the respective sciences which thus become a driving force for new cognitive processes (Fig. 1).

In the case of the «Italian Literature» system, criticism’s action of investigation of the work which contains the literary fact weights a centripetal action of interpretation of the literary fact. Criticism gives rise to different aspects of the literary fact which become the object of new studies and new critical surveys, thus producing the system’s continuous motion of (Fig. 2a).

Analysis of an experimental sector such as Cereals Cultivation has likewise revealed a constant action in pursuit of new methods to improve products, and in analyzing their results for agriculture, food and industry. Yet this new knowledge is the point of departure for new studies and triggers a continuous process, which can be represented as a circular motion wherever the point of arrival is higher than the point of departure, and so on (Fig. 2b; process 1, 2 ... n).

In the «Humanities Computing» system, the novelties are the formalization of the research method and the potential of the multimedia approach. The humanities have to re-elaborate their study method constantly and, by revisiting its logical and philosophical roots, computer science reprocesses the theory of formal languages to allow constant investigation of the interaction between man and machine (Fig. 3).

5. The Relationship with Other Conceptual Systems

Not all the concepts that belong to a field of knowledge are of an endogenous nature. Many of them may be imported from other fields of learning with which they enter into would have been written differently. They are no less important for the researcher since osmosis. It was possible to note how concepts borrowed from other disciplines may become part of a system and, once inside it, acquire special meaning, hence a place of their own in the structure.

In the «Research» system, for example, criteria of evaluation and appraisal of scientific and technological research refer to statistical, economic, technological and bibliometric knowledge. Albeit acquired, concepts such as *Technology balance of payments (BTP)*, *Patents, BTP Indicators, Measures of research quality, Innovation statistics, Process Innovation, Knowhow* etc are to be regarded as new to the «Research» system in so far as they represent methodologies for evaluating research. They need to find their proper place in the system according to their own
special conceptual characteristics. In such cases a sort of “transdisciplinary” system emerges consisting chiefly of applications of the methodologies of one field of knowledge to others.

It may happen that concepts acquired from other disciplines maintain their original meaning and it is thus necessary to allocate them in such a way that reflects the correlations which they had in the ambit of their original discipline. The Systematifier model allows us to evidence such knowledge in a special category—exogenous flows vital for the concept system. An example of this second case is knowledge, which introduces to the new system phenomena or problems studied by the original system.

For «Research», this may consist of knowledge of a philosophical nature taken from the «Science of Science» domain (for instance, concepts such as logic, scientific method, theory, hypothesis etc) or of economic, social, health, technology or environment policy transferred from the respective systems.

The phenomenon is especially marked in «Literature» since not strictly literary terms serve to express the literary fact: concepts to do with Philosophy such as knowledge, aesthetics, idealism, modernism, nihilism, truth, nothingness; to do with Religion such as Christianity, cross, devil, hell, Franciscanism, Jesus Christ, to do with Psychology such as eroticism, imagination, madness, genius, melancholy, reason, sentiment, passion, dream, love; to do with Politics such as anarchy, antifascism, democracy, peace, war and so on for many other disciplines. These units are instrumental for the writer since they are essential for description of the event of the literary fact: that is, setting, character, mood, historical moment or anything else that may be molded by the author’s creative imagination. Without these elements the work would never have been written at all, or they are an essential element of the literary fact, fundamental for penetrating into the world of its author and understanding his message.

In the case of «Humanities Computing», the most important contributions come from Theoretical Computing, Cybernetics and Artificial Intelligence, but also from removed disciplines such as Statistics—although in this case the relationship would appear to be more strictly instrumental and application-oriented.
6. The Proliferation of a Concept System

We have seen how an object of reality, even if it is traditionally part of one discipline, may through a set of items of knowledge referring to it acquire a connotation of its own and identify a particular domain. The same phenomenon may occur for a concept inside the structure of a concept system. The analysis and research carried out on its nature and evolutionary process make it a new object of knowledge and investigation which introduces a cluster of new concepts to the system, either acquired from other domains or totally new. Correlated to a new concept-object, this cluster of concepts invariably tends to expand and break away from the original system to achieve a structural autonomy of its own. This may happen, for example, with the study of a literary movement (Romanticism, Futurism etc) framed in the historical, artistic, intellectual and philosophical movement of a country or a culture and comparable with similar movements in other countries or cultures. It happens with studies on innovation and the characteristics and technological, social and occupational impact thereof.

The same trend may be noted in a more accentuated form and with a much more consolidated statute in Computational Linguistics, the crossroads where the original competencies of the two constituent domains of «Humanities Computing» meet. Similar phenomena may also be observed in sectors such as Teaching and Archaeology, which are most directly prepared to absorb the potential of multimedia and already show the first signs of original evolution.

Like embryonic cells, these clusters are elements of a new life with properties that force them to break away from the original system. They are flows of knowledge which nourish new domains, generating through their process and methodology the perpetual evolution of science.

7. Progressive Integration of a Concept System

Our knowledge is made up of disorderly sets of correlated, integrated and overlaid concepts. Systematized knowledge fields are limited parts of knowledge which have been analyzed and
organized, but which, in isolation, cannot represent all our knowledge. If these systems are founded on the same structural principles, then comparison between two of them might generate the presence of the same concept in both systems. This conceptual unit is common to the two structures and allows us to create a relationship between the two systems and study their rational combination and integration. "Concepts-objects" may appear that are hierarchically dependent (Science/Research: Literature/Italian Literature), or a concept may be the object of one system and present with a different allocation in a second system. Analysis of the relationships between these structures, and of the role of each concept within the categories, allows us to combine ordered clusters of concepts from the two systems and to integrate them rationally (Negrini, 1995). The crumbling of the original structures generates a system with a more articulated, complex form—a broader organized part of our knowledge. Without the analysis and ordering of original systems, "elements" of a universal system of knowledge, this broader "part" of the whole knowledge learning would not be achieved.

8. Conclusions
The application of Systematifier to identify and define knowledge fields makes it possible to understand particular aspects thereof and to note (depending the personal point of view of the user of the model) concept systems which evolve and change according to the evolution of knowledge processes.

The model represents constant criteria, valid for each domain, and allows us to create a stable structure in which each concept is allocated according to its characteristics. A distinctive feature of the model is that the progressive increase in the number of concepts does not modify the general structure but confirms basic principles, since it is easier to identify the role of each concept in the system, even if the allocation of the concept modifies the original hierarchical order inside the category. One fundamental result of the application of Systematifier needs to be stressed. The paradigmatic model allows us to record in a logical form complex concepts which, by virtue of the structure of the system may be "disassembled" and "reconstructed": for example, type of literary work, content, work criticism, product of criticism. The indexer can use this structure to analyze a subject and, by disassembling it, to identify in the categories concepts useful for the formulation of the object. The seeker can use the structure to find the single elements of a subject, with the aid of the defined categories. By these structure, he will be able to identify the concepts regarding those categories and to build up complex concepts.

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References
mentation (K. G. Saur Verlag).