Mapping affinities:
visualizing academic practice through collaboration

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To my family

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Abstract

Academic affinities are one of the most fundamental hidden dynamics that drive scientific development. Some affinities are actual, and consequently can be measured through classical academic metrics such as co-authoring. Other affinities are potential, and therefore do not have visible traces in information systems; for instance, some peers may share scientific interests without actually knowing it.

This thesis illustrates the development of a map of affinities for scientific collectives, which is intended to be relevant to three audiences: the management, the scholars themselves, and the external public. Our case study involves the School of Architecture, Civil and Environmental Engineering of EPFL, which consists of three institutes, seventy laboratories, and around one thousand employees. The actual affinities are modeled using the data available from the academic systems reporting publications, teaching, and advising, whereas the potential affinities are addressed through text mining of the documents registered in the information system.

The major challenge for designing such a map is to represent the multi-dimension and multi-scale nature of the information. The affinities are not limited to the computation of heterogeneous sources of information, they also apply at different scales as individuals, laboratories, etc. Therefore, the map shows local affinities inside a given laboratory, as well as global affinities among laboratories.

The thesis presents a graphical grammar for affinities. This graphical system is actualized in several embodiments, among which a large-scale carpet of 250 square meters and an interactive online system in which the map can be parameterized. In both cases, we discuss how the actualization influences the representation of data, in particular the way key questions could be appropriately addressed considering the three target audiences: the insights gained by the management and the relative decisions, the understanding of the researchers' own positioning in the academic collective that might reveal opportunities for new synergies, and eventually the interpretation of the structure from an external standpoint that suggests the relevance of the map for communication.

KEYWORDS

Academic metrics, academic practices, actualization, affinity, cartography, design, digital traces, interaction, mapping, network visualization, potentiality, scientometrics, visualization.

Résumé

Les affinités académiques sont l'une des dynamiques cachées parmi les plus fondamentales qui animent le développement scientifique. Certaines affinités sont actuelles et, par conséquent, peuvent être mesurées à l'aide de métriques universitaires classiques telles que la coproduction. D'autres affinités sont potentielles et n'ont donc pas de traces visibles dans les systèmes d'information ; par exemple, certains pairs peuvent partager des intérêts scientifiques sans le savoir a priori.

Cette thèse illustre le développement d'une carte des affinités pour les collectifs scientifiques, destinée à trois publics : le management, les chercheurs eux-mêmes et le public externe. Notre étude de cas porte sur la Faculté de l'Environnement Naturel, Architectural et Construit de l'EPFL, composée de trois instituts, soixante-dix laboratoires et un millier d'employés. Les affinités actuelles sont modélisées à l'aide des données issues des systèmes académiques qui rendent compte des publications, enseignements et supervisions, tandis que les affinités potentielles sont traitées par la fouille de textes appliquée aux documents enregistrés dans le système d'information.

Le défi majeur pour concevoir une telle carte est de représenter la nature multidimensionnelle et multi échelle de l'information. Les affinités ne se limitent pas au calcul de sources d'informations hétérogènes, elles s'appliquent également à différentes échelles. Par conséquent, la carte montre les affinités locales au niveau d'un laboratoire donné, ainsi que les affinités globales entre les laboratoires.

La thèse présente une grammaire graphique permettant de représenter les affinités. Ce système graphique est actualisé selon plusieurs modes de réalisation, parmi lesquels un tapis à grande échelle de 250 mètres carrés et un système interactif en ligne dans lequel la carte peut être paramétrée. Dans les deux cas, nous discutons de la façon dont l'actualisation influe sur la représentation des données, notamment la manière dont les questions clés pourraient être abordées de manière appropriée en fonction des trois publics cibles : les informations acquises par le management et leurs décisions, la compréhension de la position des chercheurs dans le collectif académique qui pourrait révéler des opportunités de création de nouvelles synergies et éventuellement l'interprétation de la structure d'un point de vue externe suggérant la pertinence de l'outil de communication.

MOTS-CLES

Actualisation, affinités, cartographie, design, interaction, métrique académique, potentialité, pratiques académiques, scientométrie, topologie, traces numériques, visualisation, visualisation de réseaux.

Contents

Introduction

Today organizations are more than ever complex systems. They are large, ramified, distributed, and intertwined so that their organic structure seems like a tangle of activities. Day by day individuals contribute to keeping these structures alive with their work, thoughts, and personalities, and as a result organizations rely on these daily practices.

Contemporary sociology aims to untangle the network of practices through the analysis of *digital traces* that are distributed in desktop computers, smart phones, Wi-Fi and GPS signals, payment systems, badges, information systems, etc. Digital traces are all the information that individuals leave behind them during daily activities. The challenge is therefore to recompose a faithful image of an organization using the data that its members left behind in various forms.

Understanding how an organization results from the activities of its members deeply interests the management. The dynamics of employees is a fundamental information in order to take decisions and plan the future. In particular, managers are interested to have a global view in order to optimize as much as possible the *performance* of both the organization and its employees.

The concept of performance deals with the challenge of obtaining the very best from the employees. Today the management often uses *indicators* to measure their performance. However, in a perspective of governance where a network of individuals is responsible for the whole organization, the same indicators are at the disposal of all the employees as a form of self-discipline.

Nowadays performance does not only interest corporations, but also large universities. In the academic environment, scholar performance is measured by different indicators such as the citations, the h-index, or the impact factor. Directors and boards use such metrics to evaluate or recruit employees and, at the same time, the same scholars use them in order to be positively evaluated or recruited. That bidirectional use of the indicators clearly shows that the academic environment adheres to the logic of performance-based governance.

Current academic governance policies do not usually take into account a dimension that plays a critical role in research and teaching dynamics, *affinities* between scholars. This thesis focuses on this dimension and the way to represent it. Affinities are *diversified* as they can take many forms, from a common interest to a committee membership, from a shared teaching activity to an article co-authoring. Affinities are *multiple* as scholars might share different kinds of affinities at the same time, which reinforce their overall ties.

Affinities can be classified as *actual* and *potential*. A certain number of potential affinities indicates a predictable tie between scholars. Such affinities might be representative for subjects of research, common interests, continuity between topics, sharing the same mother language, graduating at the same university, publishing on the same journals, attending same conferences and committees, etc. These potential affinities become an actual tie when a collaboration takes place as it may be the case in co-authoring a paper, or supervising the same doctoral candidate. As a consequence, affinities offer two different dimensions, one is solid and composed of different ongoing collaborations, and one is projected towards the possible opportunities to explore.

Designing an affinity indicator can be fundamental within academic organizations. Situating affinities in a *visual representation* creates a new space where actual and potential performances are blended together. Contrary to the other metrics that reinforce the distances between individuals, the logic of affinities helps plan the future through collaborative dynamics. The central idea is to represent what is happening with a special consideration in fostering new synergies. With respect to the logic of governance, planning these synergies is the interest of both the management and the scholars. For that reason, the metric of affinities has to be at the disposal of the whole collective. Furthermore, to use it, the metric has to take the shape of an instrument or a *map*, in order to orientate all the actors among all the possible choices offered by the collective of research.

The main questions in terms of design and research discussed in this thesis are the following. How can affinities be identified and measured? Are actual and potential affinities relevant for academic metrics? Can a visualization represent the academic affinities? How may a visualization represent an academic organization through its affinities? What kind of design solution enables to represent them in a multi-scale and multi-dimension space? Can such representation be the result of a collective agreement? What is the influence of the actualization of the map in the social dynamics? Can the same representation be relevant for scholars, managers, and general public?

The thesis is organized in three chapters. The first chapter at page 3, the *State of the Art*, describes (A) the concept of affinity within the academic practice (B) the evolution of relational visualizations (C) the geographical principles that influence visualizations and (D) the case study on which the thesis is focused. The second chapter at page 43, the *Design*, introduces (A) the design process (B) the limitations we encountered during this process (C) the principles that characterize the map and (D) a simple example of navigation from an individual to the whole map. The third chapter at page 95, the *Reading*, discusses (A) the role of the reader (B) the validation of the map through the interviews and (C) the various forms of actualizations we offered to interact with the map. Even if it is based on the design practice, the discussion touches many disciplines, namely research metrics, geography, sociology, philosophy, psychology, graphic design, and interaction design.

State of the Art

This chapter is about the various disciplines that this thesis brings together. The first section discusses the metrics that are currently employed to measure the academic practice. Indeed, these metrics are inappropriate for describing the heterogeneity of the practice that scholars daily take part in. With regard to this issue, we introduce the concept of *affinity* that we use to propose our own metric based on collaboration, which we classify as *actual* and *potential*. The second section shows the results of an investigation about the way in which these affinities and the collective of research have been represented in the last century and half. The third section leads to the use of visualization that might embody the characteristics of a map as an instrument for orienting the reader in the academic environment. Finally, the thesis is situated in a specific context that represents the case study, the fourth section introduces the *Affinity Map* as an instrument to understand the ENAC and help the decision-making process with a view to the governance. It is intended as a way to integrate the top-down and the bottom-up contribution to the organization of the academic environment. This chapter defines the state of the art of the thesis and contributes to give the context of the map design, which will be discussed in the second chapter.

Measuring Affinities

A practice is defined as the application of a group of theories. A specific practice describes the way in which a group of professionals train their habits as well as the iteration of activities that takes place day by day, characterizing their working life. This repetitive training is a natural behavior for personal improvement and, without a doubt, scholars are not exempt from that practice.

Pierre Bourdieu imagined academia as a flat surface populated by scholars. A magnetic force applied to this *field* tries to place individuals apart or out of the plain. This magnetic force corresponds to the scientific recognition of a specific domain of research, and the only way to reach a certain position or maintain it consists of the *habitus*. Bourdieu defines the habitus as an ensemble of behaviors that allow the scholar to stay central in the field and be durable (Bourdieu 1976, 22). On his side, a scholar puts up a fight against that magnetic force by means of his habitus; that is his practice.

An apprentice thus enters the field through a process of *mimesis*. Through the observation of prominent scholars and the imitation of their practice, apprentices may converge towards a central position in a field. Obviously, that is not an easy task, so it is not by chance that Bourdieu uses the word *resistance* to define it. But adopting the same practice as their peers helps the apprentice be recognized and then become accepted into a scientific collective.

This section introduces the practices of scholars by analyzing their composition and the metrics used for quantifying them. Successively, the entire thesis focuses on a specific characteristic of the practice, the collaboration (Sonnenwald 2008). Through the concept of *affinity*, we want to focus on the practice of collaboration between individuals by investigating both actual and potential collaborations, and the way in which a metric of collaboration could be created.

Academic Practice

One of the most discussed activities for the scholars is writing, which is developed through a large diversity of tasks (Hartley 2008). Publications are the official way to communicate discoveries to the scientific public, and their immutable form in time gives them an almost sacred importance. That importance is even greater when we remember that literature and citations are widely considered for recruitment and promotion. Indeed, there is even the common wisdom of a Latin proverb that reminds us of that: *Verba volant, scripta manent*, which means the written words remain, while the spoken words disappear. For that reason, scholars put a lot of effort into their writings, which closes the loop and further reinforces its importance. This is demonstrated by the many ways in which it is explored (Bazerman 1991) and, more generally, by the existence of typography, whose main concern consists of improving the aesthetic quality of the printed text (Bringhurst 2004).

However, even if writing is an essential skill to be good at as a scholar, the entirety of practice cannot be reduced only to writing, as there is something more complex and rich at work. The daily work of a scholar is characterized by teaching activities, meetings, discussions with peers, etc. Indeed, several activities compose the academic practice, and belong to each discipline. Although those activities are transversal across domains, each domain is characterized by a specific practice. For example, monographs are considered valuable contributions in architecture (Rossi 1981), exhibitions are part of the work of art historians (Didi-Huberman 2013), and the production of scientific images is crucially important in life sciences (Lynch and Woolgar 1990). Despite these differences, the majority of activities that compose academic practice may be arranged into six major classes: publishing, teaching, advising, funding, committees, and conferences. In turn, each activity contains a list of tasks that describes the very core of the academic practice (see Table 1).

	Publishing	*Teaching*	*Advising*	*Funding*	*Commitees*	*Conferences*
Writing	x	x		x	x	x
Organizing		x			x	x
Applying	x			x		x
Reading	x	x	x	x	x	x
Investigating	x	x	x	x		
Reviewing	x	x	x			x
Public speaking		x			x	x
Attending		x			x	x
Travelling		x			x	x
Collaborating	x	x	x	x	x	x

Table 1. Academic practice is composed of academic activities organized in tasks. Activities and tasks are respectively arranged in columns and rows.

Measuring Practice

Measurement is a part of daily life. Today, we use instruments that measure different phenomena such as time, light, temperature, altitude, distance, steps, etc. Measurements are of interest to philosophy of history whose questions concern what is measurable and the conditions that make something measurable (Tal 2017). Since these conditions are not always available in the physical environment, human action is required to make certain events readable through abstract representations such as numbers, vectors, or classes.

Creating a standard measurement is the result of a complex series of *translations* in which human and non-human actors meet, interact, negotiate and, finally, take part in a potential controversy that results in a specific metric. For Michel Callon, the process of translation happens in four steps: *problematization*, *interessement*, *enrollment* and *mobilization* (1984). These steps are presented in a famous article written by Callon, who adopts the actor-network theory to study the problem that afflicts the scallops and the fishermen of the Saint-Brieuc Bay.

Translations are extremely important. As previously stated, human intervention is required when something is not naturally measurable. For example, if there exists a scientific need to study a forest in a laboratory, then it has to be reduced (Latour 1999, 43). The forest, therefore, is shrunken into a series of elements that represent the wooded environment. These elements are collected and reduced through the process of translation; the output of which corresponds to a set of *samples*. Scientists begin experiments in forests, then they work on samples that derive from a careful process of reduction. In a way, these researchers act as relativists because they do not interact directly with the object of study; instead, they deal with the *references* towards these objects.

Samples have different forms. For example, a fragment of cortex or an insect could be samples of the forest. In the past few decades a new form of sample has been introduced along with the rise of the information age, and it is known as *data*. Data are digital pieces of information that are measured, collected, organized, and analyzed. The etymology of the term means *something given* and originates from the Latin. Even if the term *data* is part of the common language, a debate still exists about its variance of use. *Capta*, *sublata*, *traces*, and *vibrations* are all terms that correspond to slightly different meanings (Beaude 2015, 142; Boullier 2015; Latour 1999, 42). In particular, the significance of the term *capta* tells us that data are not something given, but rather *something taken* in order to visualize them (Drucker 2011). In a period when large visibility is given to openness and transparency of data, not many words are used for the process through which events are translated into data and consequently this impacts the quality of the data (Boyd and Crawford 2012, 669).

Alain Desrosières proposes *qualification* and *quantification* as key concepts for the analysis of data production (Desrosières 1995). The first corresponds to the categorization of data, or the moment in which something is identified and elected to become data. The second is the measurement of the qualified data in terms of numbers.

Also, academic practices are qualified and quantified into data through a process of translation that makes the scholar's work measurable. A specific branch of research called *scientometrics*, a term attributed to Vassily Vasslievich Nalimov (see next section), was founded in the 1960s with the specific interest in studying all the quantified measures related to scientific research. Today, scientometrics is a complex and growing field that needs to be further developed before the concept of *affinity* might be introduced.

Bibliometrics

Scientometrics research is interested in the quantitative measurement of science analysis. When introduced in 1969 by the Russian physicist Vassily Vasslievich Nalimov, scientometrics was specifically interested in the quantitative measurement of science, such as the scientific production, the number of individuals involved in experiments, and the amount of funding invested. In the same year, another neologism was introduced by Alan Pritchard, called *bibliometrics*. Bibliometrics was intended as a subset of the scientometrics focused on the scientific publications only. Although the two terms differentiate because of the subject matter, today they are used in an interchangeable way (Gingras 2016, 1).

Modern bibliometrics has been introduced by Eugene Garfield, who proposed the construction of the Science Citation Index (SCI), the first global repository of scientific papers. After the Second World War, the scientific community observed an exponential growth of articles; as a result, important articles were more and more difficult to find. To resolve this issue, in 1963 Garfield proposed the creation of an index to collect and successively retrieve all papers belonging to the most relevant journals using advisory boards made up of experts (Garfield 1970, 133). Over the years, the database has been updated and it includes other collections. Until 2004 it was the only existing collection of papers. That year Elsevier introduced Scopus, followed by Google Scholar (Gingras 2016, 11). Before the introduction of citation indexes, statistics about papers were possible only for small collectives through the construction of specific databases. The SCI allowed for the study of larger organizations and international disciplines and, last but not least, made it possible to analyze citations through quantitative metrics. As a result, SCI was extremely useful for scholars approaching an unexplored domain and looking for the most cited papers, or for libraries so they could choose the most cited journals to add to their academic collections.

It is important to remember that the primary aim of the Science Citation Index was to analyze the history of disciplines, and only later it was transformed into a tool for helping libraries in selecting relevant journals to enrich their academic collections. However, although Garfield had already warned against the possible abuse of these indexes (Garfield 1970, 137), the SCI have been also used with other intentions in mind.

Literature Assessment

Scholars have always been evaluated for their academic publications. The first appearance of assessment was a peer review, specifically in the *Philosophical Transactions of the Royal Society of London* in 1665. From that moment on, the peer review process became a more and more diffuse practice in the scientific circuit, and scholars still have to deal with that. One Isaac Newton's article, for instance, was actually rejected by the *Philosophical Transactions* journal; after that, he promised not to submit another paper in his life and he did not. More recently, even the Nobel Prize winner Albert Einstein was rejected by an American journal; his work needed some corrections according to the reviewer's judgment. Einstein was just as angry as Newton about the refusal, however, he submitted the same paper to another journal including some modifications suggested by the original reviewers (Gingras 2016, 36). Although criticized for its subjectivity, its slowness, and its inequality, the peer review process is still one of the most popular methods of qualitative assessment.

The use of quantitative assessment increased with the introduction of SCI and, for that reason, it is a more recent practice compared to qualitative assessment. Two dimensions made academic evaluation possible through quantitative data: the number of publications and the number of citations received. Analyzing the publications facilitates the evaluation of an individual, a collective, or a nation during a particular period of time. Additionally, citations allow us to identify the most referenced authors of a specific discipline and, by extension, the most relevant ones. However, SCI and similar indexes were not conceived for assessment and some problems therefore arose with their use.

Evaluating a scholar on publication volume is unfair because the mass is not a measure of quality; the mass, for example, might be an index of interest for a debate in a specific period as in the case of *The clash of civilizations?* (Huntington 1993). However, quantity is an index of scientific activity that might be useful for analyzing a large collective, such as an institution, a discipline, or a nation. When on the large scale quantitative analysis is meaningful, at the scale of individuals it is misleading: having a lot of publications or citations demonstrates the personal recognition in a discipline, but it is not a veritable evidence of quality. For example, if a scholar publishes a very good article among low-quality ones, it is fairer to claim the quality of the article instead of the quality of the scholar. The need for a more precise metric gives birth to the *h-index* (Hirsch 2005). The h-index is an indicator that balances quantitative indexes by blending together the volume as well as the citations. Its value corresponds to the maximum common number between the numbers of publications and citations (see Equation 1). Contrary to the SCI, the h-index was expressly created to evaluate scholars, and today it is also applied to scientific collectives. Although citation analysis is increasingly sophisticated, a major criticism claims that it facilitates a short-term and more consensual scientific writing.

Another index that was not intended to be employed in the scholar assessment is the *Impact Factor* (IF), which Sher and Garfield conceived for scientific journals. The IF corresponds to a numerical value equal to the sum of the citations that a journal has collected during the two previous years, divided by the number of articles published in the same period (see Equation 2). Although that index was created to help librarians in journal selection, today the IF is used by publishers for promoting their journals (Garfield 2006). This usage is dangerous because it impairs good judgment: for example, the average temporality of social sciences and humanities is longer than natural and biomedical sciences and, as a result, the IF differs according to each discipline (Gingras 2016, 45). Furthermore, the misuse damages the academic practice: since scholars are attracted to publishing in high-rated journals even if their subject matter does not fit, this creates a higher rate of rejects and more work for reviewers. Some institutions are even offering financial incentives for publishing in high-rated journals.

The creation of indexes does not impact only individuals and journals, but also institutions. First academic rankings were introduced to evaluate world universities between 2004 and 2005. Their biases were so evident right after their introduction that further alternatives were immediately explored (Hertig 2016, 2). Among them, some that are worth noting are the Academic Ranking of World Universities, also known as Shanghai Ranking, and the Times Higher Education Ranking.

Metrics such as the h-index, the Impact Factor, and world rankings are influencing the scientific practice without any doubt. Their use during recruitment and evaluation of employees is modifying the way in which scholars do research. The evaluation is an issue we cannot avoid and, for this reason, it has to be treated with care.

$$h\text{-}index = \max_i \left[\min(f(i), i) \right]$$

Equation 1. The formula to calculate h-index of a scholar, according to all its publications ordered by decreasing number of citations. In the equation, the i is the publication number in that sequence, and f(i) corresponds to the number of citations of the publication i. The result is the maximum value of the array composed by all the minimum between f(i) and i.

$$IF_y = \frac{Citations_{y-1} + Citations_{y-2}}{Publications_{y-1} + Publications_{y-2}}$$

Equation 2. The formula to calculate Impact Factor. In any given year, the IF of a journal corresponds to the number of citations received in the two preceding years, divided by the number of articles published in the same period.

Affinities as a Metric

Citation analysis results are largely presented as tables or plots, however, another part of bibliometrics prefers another way of displaying, the network. Networks use a simple visual grammar composed of dots and lines in order to display relations. Their application fits neatly into interesting patterns of scientific publications. For instance, a network visualization might show how countries collaborate together through article authorship (Gingras 2016, 26). Among various metrics that can be applied to a *corpus* of documents, citations are particularly relevant to bibliometrics. Indeed, networks might be relevant to see who cites whom (citation analysis), how authors share bibliography (bibliographic coupling), and who is cited by the same papers (co-citation).

As stated previously, today bibliometrics and scientometrics are two terms that are interchangeable sharing the etymology of *metron*, a Greek term that means measuring or versing arrangements. On the other hand, what they do not share is the prefix as *biblio* and *science* have different meanings: the first refers to books or more in general to documents, the second refers to science more in general. More precisely, the Oxford Dictionary of English refers to science as 'the intellectual and practical activity encompassing the systematic study of the structure and behavior of the physical and natural world through observation and experiment' (Stevenson 2016). We could therefore argue that scientometrics has a larger field of interest, which includes not only the literature but also the intellectual and scientific practice.

The concept of affinity highlights the richness of academic practice that characterizes universities. Although literature is central in scientometrics and bibliometrics, these disciplines have a larger meaning that is related to the variety of academic practice. Through the concept of affinity, we would like to step back to that original significance of this practice.

Affinities have a potential that relies on their relational dimension. This dimension corresponds to *interdisciplinarity*, which is the chemistry that associates scholars so as to discover new paths of research (Ledford 2015). In this context, we identified two types of affinity, the *actual* and the *potential*. The actual affinity corresponds to real-life collaborations between individuals. For example, a journal article may stand for an actual affinity between two authors; the same goes for teaching, as sharing a course implies a collaboration between two or more scholars. Drawing a network of actual affinities brings a visualization of how scholars organize themselves in the daily practice of academic life.

However, not all affinities come from concrete collaborations. Indeed, there exists a sort of serendipity by which scholars come to work together through different ways. This latent possibility takes the name of *potential affinity*. Potential affinities represent all the possible collaborations that can be created on the base of thematic intersections, similar profiles, or behaviors.

A metric based on affinities relies on the mix between the actual and potential affinities that are available in a given collective of research. Through them, it is possible to create a network visualization about how individuals organize or might organize themselves in the academic practice, offering both a mirror to reflect ongoing groupings and an instrument to plan future collaborations. Furthermore, it would also work as an instrument to evaluate the collaboration degree, the interdisciplinarity, and the innovation of a specific collective of research, which defines who and what situate on the visualization.

The measurement is based on the digital traces that are available in a certain organization, looking for data available on the Internet. For example, publications and teaching courses are often available on institutional web sites. However, some of these data are not publicly available because of an internal decision, and require thus more work on the terrain in order to make them available. For example, accessing certain data might need a negotiation with a person responsible. Finally, we argue that not only the availability, but also the data creation, are political choices within an organization; through the process of decision-making, new data can be generated to better describe other practices that are not translated into data. As a result, studying the activity of individuals corresponds to the work of an ethnographer, who collects data about human culture. Data are not simply something given, they are something to discover and obtain through a social negotiation in a given area.

Visualizing Affinities

The concept of affinity relies on the relational dimension of scientific collectives. The resulting visualization is therefore a hybrid that conciliates two different types of representation, the collective and the individual. Indeed, the affinity visualization brings together two different domains of visualization: one concerning organizational charts that are common in industry, and one regarding the connections of individuals in a social environment. This specific context is introduced by a visual investigation whose outcome is herein presented in a sequence of chronological steps that shows how the representation of collectives changed in the last century and a half.

This section does not want to be exhaustive as a historical research, but instead it wants to illustrate the visual characteristics that introduced a change in a specific period. The following figures therefore float between two representations, the collective and the individual, creating a uniform evolution that will be useful to justify some ethical choices about design which we illustrate in the second chapter.

Organizing Individuals

Looking back at the history of visualizations, Daniel McCallum created the first organizational chart that is shown in Figure 1 (Rosenberg and Grafton 2010). In the first half of the 18th century, he was in charge of almost 500 miles of the New York and Erie Railroads in order to perform a complete reorganization. The task was difficult and risky especially because transports were organized on a single set of rails. For that reason, McCallum decided to guide the reorganization through a visual chart, which was both a model to study and a map for planning. Indeed, although the McCallum visualization is a static image before our very eyes, we have to think of it as a dynamic representation adapting its shape according to daily changes and future plans.

The visualization appears as a tree, which was widely used during the Middle Ages to represent noble families (Lima 2014, 49–77). From trees, the chart inherited a certain orientation with the president at the bottom as if he was a strong root and with all those lower in the hierarchy growing up towards the sky, until the lowliest workers were positioned at the top.

The drawing was used as an instrument of governance as it clearly represents the desired configuration of the organization. The main branches, which start from a node decorated with a star, represent the rail lines with the train stops. Then, the units of workers are associated to the rails through the respective chiefs. What is impressive about that chart is not only its precision, but the fact that all the individuals are represented. Indeed, each single worker is associated to a specific branch on the map.

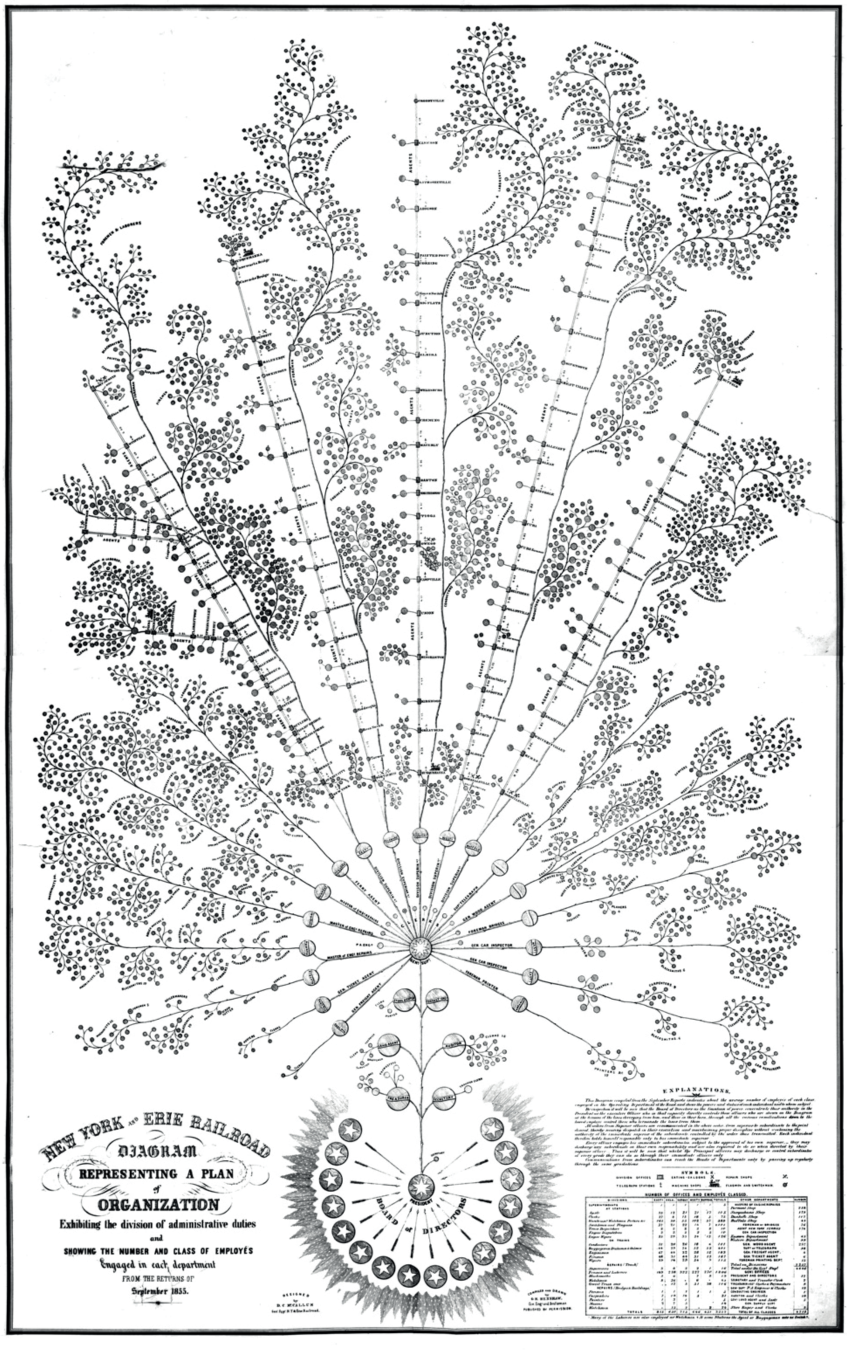


Figure 1. When Daniel McCallum took charge of the operations of the New York and Erie Railroads, he created this visualization that is recognized as the first organizational chart (Rosenthal 2013).

Impoverishment of Visual Language

More recently, with the introduction of what is known as the management of workers, a sort of disillusion of representing people appeared, creating a gap between the management and the employees. At the end of the 1930s, the engineer Willard Brinton published a book including many examples of organizational charts (Brinton 1939, 59–67). From this text, it is noticeable how individuals were anonymized, preferring functional entities that compare them to replaceable components of an engine. In the twentieth century, the large diagrams of organizations were drastically simplified, even though the arborescence is preserved.

At the same time, the tree is inverted to become a pyramid. In the new model the president is placed at the top, as the person elected to govern or the pharaoh, the chief blessed by the god and inspired by him. Metaphorically speaking, the great loss of inversion affects the understanding of the heritage. If in the old arborescence of family trees, the ancestors were recognized as the progenitor of present relatives, giving a sense of transmission and continuity, the inverted diagram gives the illusion that the president commands from the top, therefore losing a feeling of belonging and projection towards the future.

The chart illustrated in Figure 2 appears extremely simplified (Brinton 1919, 14). Any ornament is judged useless and removed, and the care of the visualization itself cannot be compared to maps or family trees. The chart becomes an ephemeral object that will soon be replaced without being a document intended to last over time. Furthermore, the topographical aspect completely disappears, losing the co-presence of humans and non-humans, such as in the case of McCallum's map where humans were graphically associated to the rail tracks (see Figure 1).

Sometimes variations from the standard appear and propose interesting alternatives, such as in the case of the president positioned at the center of the organization, as illustrated in Figure 3 (Smith 1924, 24). In this case, the chief is moved from the top of the pyramid to the center of the image, giving the feeling of being part of a collective and not at the head of it. Moreover, if the standpoint coincides with the top of the hierarchy in the classical structure, this position is restored to a zenithal one in this root-centered tree, such as with geographical maps. As a result, the chief is not looking down at his workers anymore, but instead the workers are seeing him as the core of the organization; in other words, we face an organization with a sense of collectivity.

However, organizational charts did not evolve that quickly. A recent example shows that the Joint Research Center of European Commission in Ispra maintained the same visualization for about thirty-six years (see Figure 4). This kind of visualization does not communicate the sense of complexity and collectivity for large organizations because employees are deleted to make the graph readable.

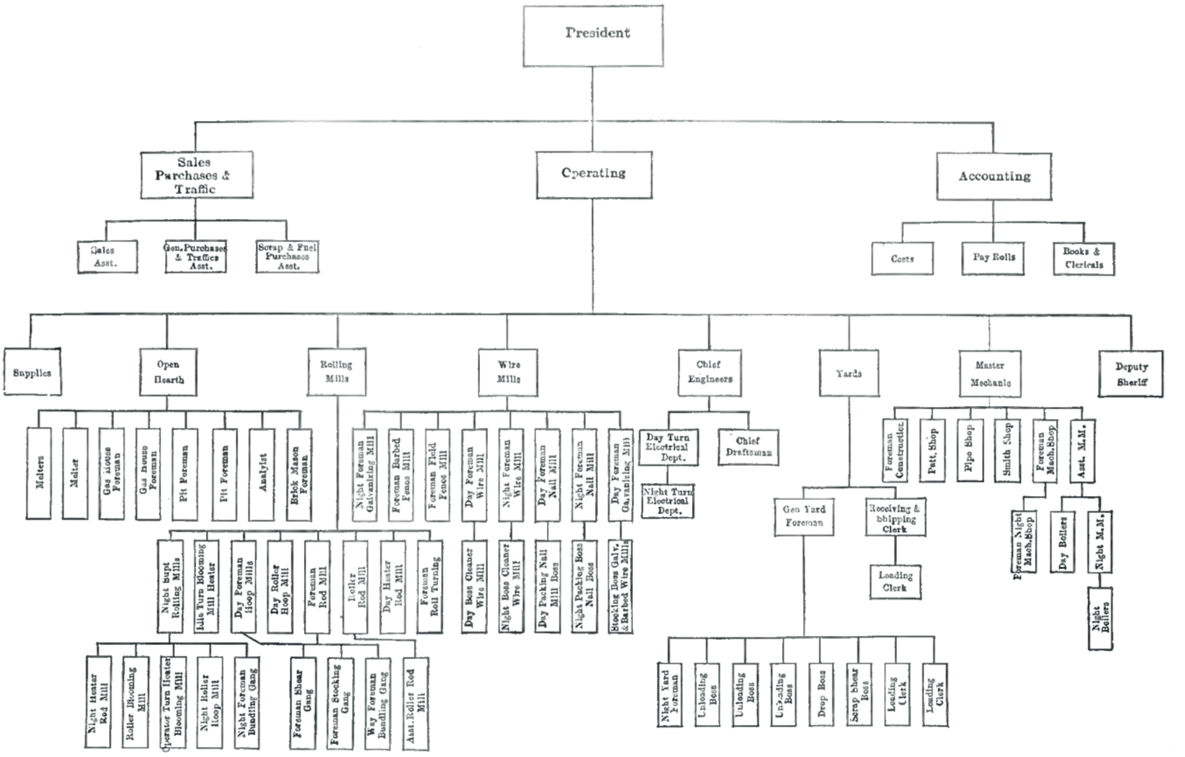


Figure 2. The image shows a classical example of organizational chart, which simplifies the company. This diagram was common at the beginning of the twentieth century (Brinton 1919, 14). © 1919 Willard C. Brinton

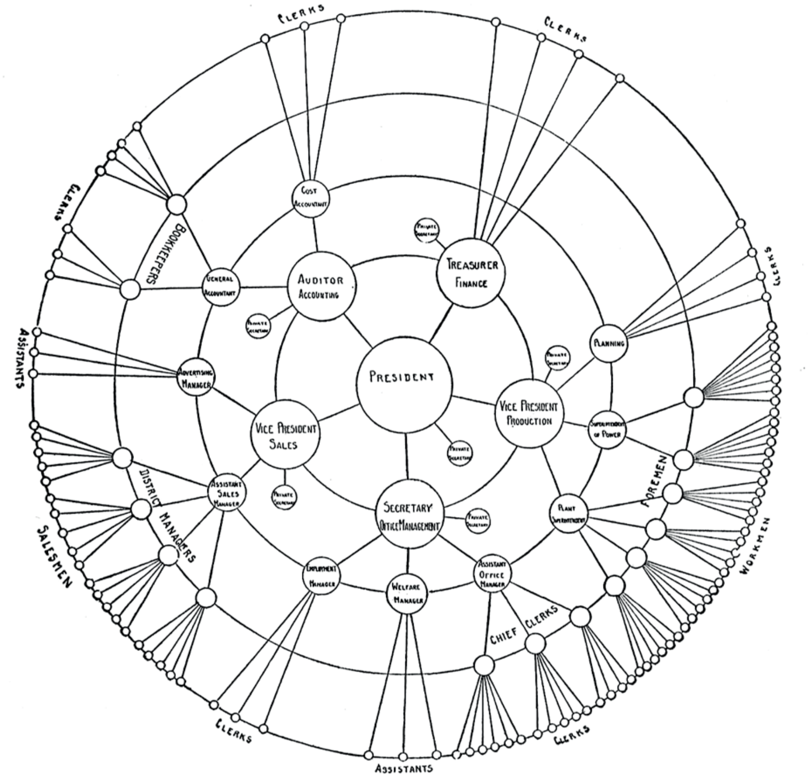


Figure 3. Organizational charts might contain variations compared to the classical tree model. This visualization features a centric view where the president is placed at the center of the diagram (Smith 1924, 24). © 1924 William H. Smith

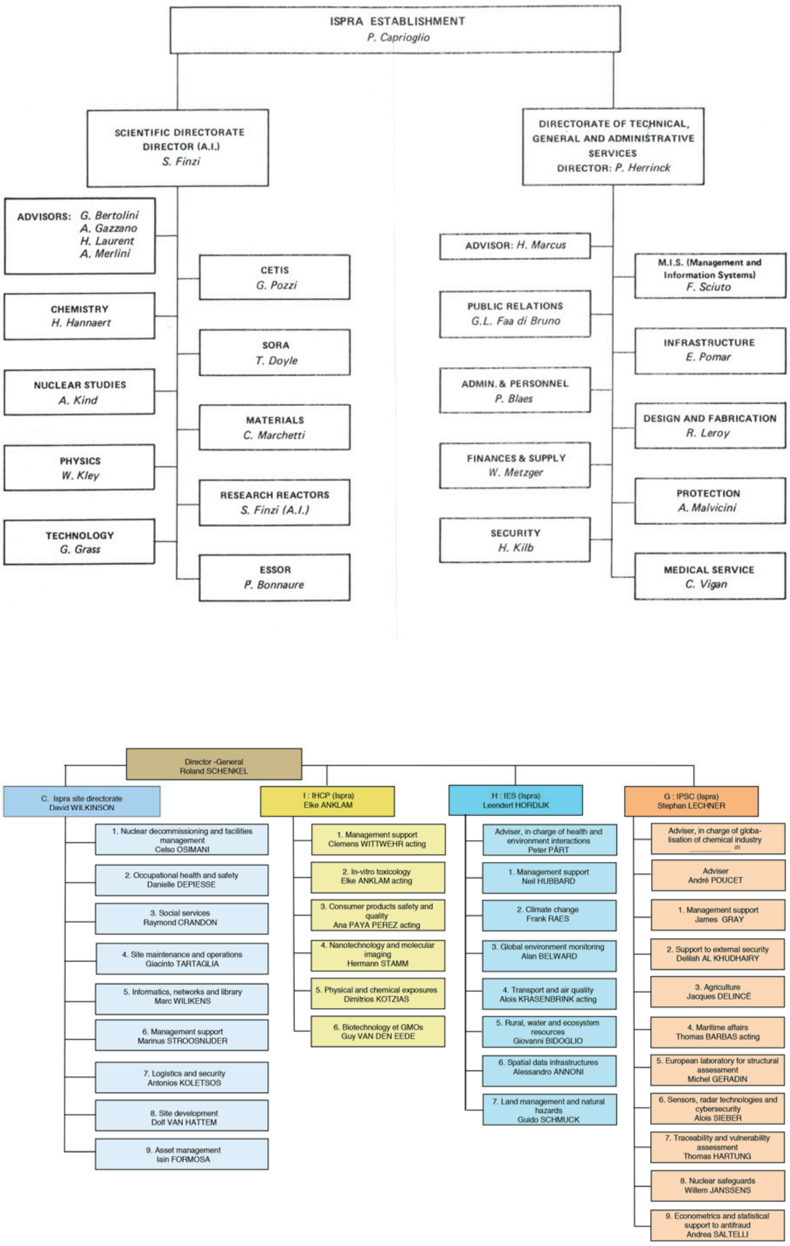


Figure 4. The organization of the Joint Research Centre of the European Commission in Ispra is represented in two different years, in 1972 (personal archive) and in 2008 (Ferigato et al. 2008). Within the space of thirty-six years the visualization layout remained the same, except for the introduction of colors. © 1972–2008 European Commission

Social Ties as Networks

While the private sector favored a representation that gave little attention to individuals embracing functionality over their uniqueness, a specific part of social sciences run in the opposite direction. The psychiatrist Jacob Levy Moreno was the first to systematize social relations that were used to appear as tabular data in diagrammatic shapes, or so-called *sociograms* (Moreno 1934).

During 1930s many Gestalt theorists migrated to the United States of America because of the Nazi Germany. In that period, Kurt Lewin, Fritz Heider and Moreno became the most prominent exponent of that branch of psychology influenced by the Gestalt psychology (Scott 2000, 10). It is noticeable how this influence contributed to the creation of sociograms. These visualizations rely on the famous principle for which the whole and its elements are equally fundamental (King and Wertheimer 2008, 43). Indeed, sociograms offer a general view guaranteeing a certain independence to the single elements. That principle has been the foundation of network visualizations we know today.

The sociogram of Figure 5 shows friendship in terms of attractions and repulsions. Through a phase of observation and interviews, qualitative data were transformed in the table characterized by values corresponding to the attraction and the repulsion between a group of people. These data were successively transformed into network visualizations where individuals were represented as circles labeled using the letters of the alphabet to maintain their privacy. The visual grammar was completed by lines indicating the relations. These lines were characterized using arrows to display directional relations, and segments at the line center to display reciprocal connections.

Moreno introduced a new visual method for displaying data that was unrelated to the topography of a place, but in a certain way containing a spatialization. On the one hand, he gave a visual form to tabular data that were usually arranged in rows and columns, while on the other hand, he modified the social reality into an abstract representation.

Differently from previous visualizations, Moreno valorized the affinities that exist in all the social spaces. These relations differ from a hierarchical chart because they show the way in which the individuals stay together. It is noticeable that we face an organizational overlap where there exist two structures: one representing the top-down model of the management that assures an overall organization, and one representing the social ties that effectively take place between individuals. That happens because individual elements keep independence even though they are organized and classified. Through sociograms, Moreno created an instrument to see the reorganization of individuals and their relations that adapt perfectly to affinities.

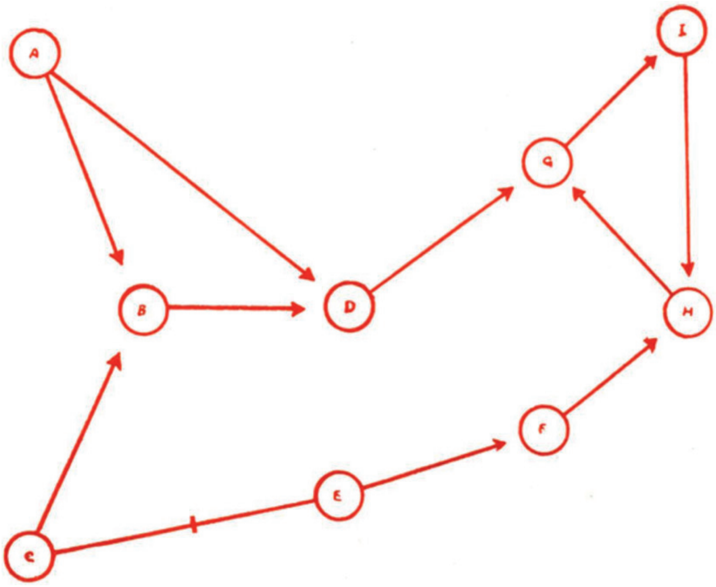


Figure 5. This sociogram represents individuals by nodes connected by directional relations. The arrow illustrates a univocal connection, the segment at the center means a reciprocal link (Moreno 1934, 33). © 1934 Jacob L. Moreno

Affinities in Academic Literature

Social relations are part of the human beings and exist everywhere. The academic environment represents a valuable example. In research, one of the major ways to spread proper professional work is to publish it. Academic practice is intimately related to the act of writing, which contains a universe of social ties. In particular, two aspects of writing are relevant to the relational sphere, the citations and the collaborations. Citations are the most evident example of recognition among scholars, which allows for comparison, advancement, criticisms, or praise of scientific literature. Citing creates a link from the past to the present as an author can cite only works that have been published or are close to being published. In addition, collaborations are relations that scholars have with their closest colleagues. If we think about writing as an intimate practice, it is common for authors to collaborate with someone they respect or admire. Thus, although citations and co-authoring belong to the same writing process, they represent two different relations: the actual and the potential.

Allen Gordon was the author of the first citation visualization (Garfield 1970). The network in Figure 6 shows research articles as numbered nodes, which are connected by their internal references. The graph assumes a vertical direction like a pyramid, positioning the older articles at the top. The numbering follows the same rule; as a result, article one is the oldest and at the bottom the articles are more recent. Citation networks are, in a sense, a temporal visualization because they rely on references to works previously published. Furthermore, taking a more general look on this visualization method, it is interesting to notice that citation analysis often focuses on articles and not on individuals. Although the visualizations do not display individuals, the nodes are an indirect representation of one or more authors.

That differs from authorship visualizations where individuals are represented by their proper names through nodes. The scholar Caty Börner, for example, has an extensive specialization in co-author networks. In a publication, she illustrates a time-lapse animation of the co-authoring network related to a specific department of the University of Indiana (2005, 82). In this visualization, scholars are quantified through the number of published papers, while the relation thickness corresponds to the number of co-authored papers.

Contrary to the citations, co-authorship visualizations make the network of collaborations visible. These relations are the expressions of *actual affinities* proving how individuals work together. Collaborations suggest that authors know each other, spending time in meetings, making drafts, contributing to all of the small activities that converge towards a publication. Contrary to collaborations, citing has a different meaning. Although in some cases citations include close colleagues, article references bear a likeness to *potential affinities* indicating, for example, the closeness of standpoint, the domain proximity, or the common academic education.

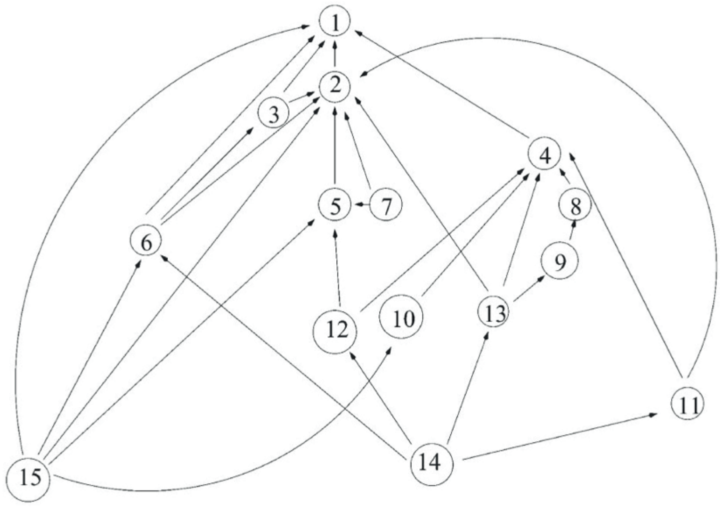


Figure 6. First citation visualization created by Allen Gordon, which shows articles connected by references (Garfield 1970). © 1960 Thomson Reuters

Arranging Individuals by Similarity

A typographical rule says that space around visual elements elevates them. That rule applies to all visual languages from photography to cinema. In the case of data visualization, this space makes way for annotations, sketches, drawings, etc. that the reader may add, thus creating an additional overlay of personal information.

The sociologist Pierre Bourdieu loved to rework its visualizations. Many of his publications went with computed diagrams enriched by his annotations. Indeed, during the 1960s and the 1970s, Bourdieu demonstrated an interest in statistical data analysis using a method called the Multiple Correspondence Analysis (MCA). That method was used for underlying spatial structures of specific data sets (Le Roux and Rouanet 2010, 4–5). An initial qualitative survey is translated into data, which are computed and projected on a Cartesian space. Bourdieu was interested in the annotation that followed the projection: Figure 7 shows how he identified the middle classes, or *la petite bourgeoisie*, through intellectual interests (1979, 14). This process of identification, which is part of the human sphere, is the typical mental effort that a visualization asks from the reader, which is the argument of the third chapter about *reading*.

MCA varies the projection according to the represented entity, which changes meaning according to the research context. In the book *Le Patronat*, Bourdieu uses a visualization that situates individuals (1978). Indeed, the visualization arranges individuals according to different characteristics, namely demographic, familial, educational, professional, etc. Individuals are situated on two axes; one axis opposes *private* to *public* and the other *newcomers* to *establish*. The outcome shows an opposition to the relational logic of networks. If Moreno's approach is an appropriate way to show relations, Bourdieu's method aims to spot the similarities. That opposition emphasizes the contrast between actual and potential affinities, in which a relational logic is balanced by an approach relying on similarity.

Although in *Le Patronat* Bourdieu does not annotate the visualization, in *La Distinction* this process is clarified as exemplified in the Figure 7 (Bourdieu 1979, 296). The visualization displays many groups that appear as geometrical shapes. For example, one of these groups assembles the engineers in a dotted rectangle situated at the center. Bourdieu creates categories by hand thinking over visualizations; this interaction provides a supplementary level of information, which perfectly integrates the original MCA.

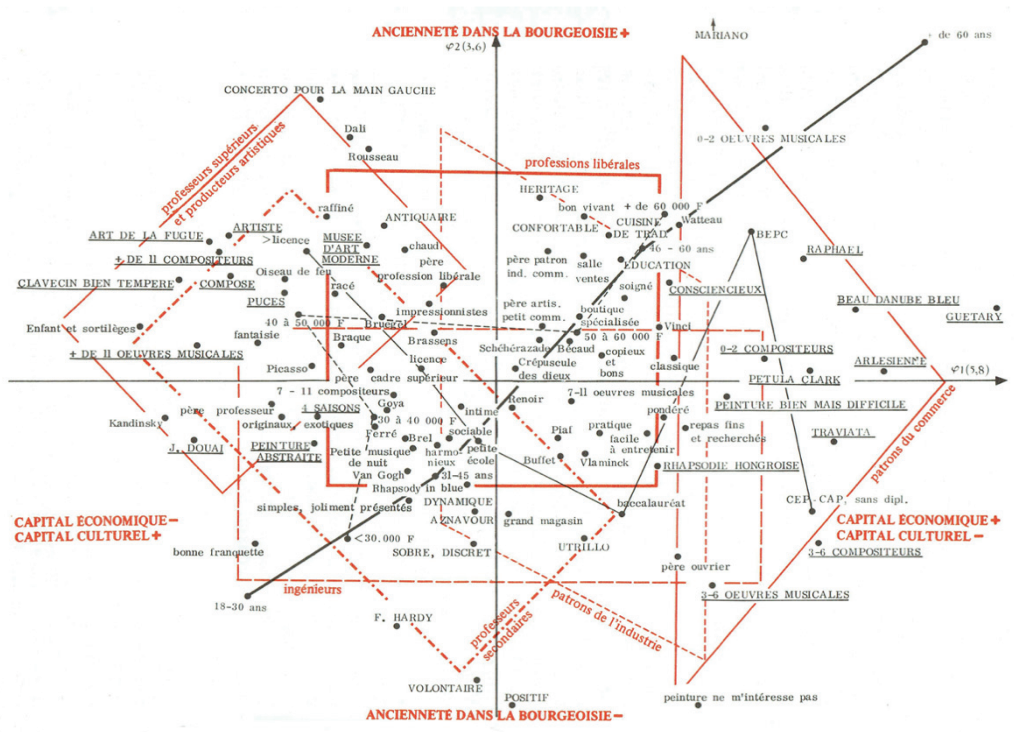


Figure 7. Pierre Bourdieu identifies social groups drawing geometrical shapes on the visualization, which situates intellectual interests (Bourdieu 1979, 296).
© 1979 Pierre Bourdieu

Aesthetic of Organizations

Mark Lombardi was an American artist that found in the network diagrams a way of making art (Lombardi and Hobbs 2004). He was interested in revealing conspiracies of financial and political frauds by opening up the black box of their mechanisms, so he found an excellent tool in networks. In Figure 8 Lombardi drew the relations between the former United States president, Bill Clinton, and the so-called Lippo Group, a real estate development company located in Indonesia. During his lifetime, artwork was just a passion for Lombardi; only six years before his death, his passion for researching scandals become a job. It is interesting to notice that Lombardi was influenced by the father of contemporary data visualization, Edward R. Tufte (Lombardi and Hobbs 2004, 43–46), in particular by his second publication Envisioning Information (1990).

The lesson that Lombardi left is rich with inspiration. First, he demonstrated how networks can be a powerful tool used to organize information and to make it public. He then picked out the aesthetic value of diagrams, which contributes to the pleasure of reading and to the ease of comprehension. His compositions appear minimalist because they contain a lot of empty space, but this helps to highlight and give importance to visual elements. For these reasons, aesthetics covers a great importance in data visualization.

Lombardi also makes the individuals easy to identify. Following an ideal of transparency aimed at showing the abuses of power and their actors, individuals are identified with their proper names. Even if this contradicts the privacy policy applied by Moreno in his research, representing individuals through their real names makes the visualization more interesting and precise. In a sense, the impoverishment of visual language that took place at the beginning of the twentieth century is being replaced by the richness and diversity of individuals, stressing the fact that collectives are composed of real people, resembling, to some extent, a topology of individuals.

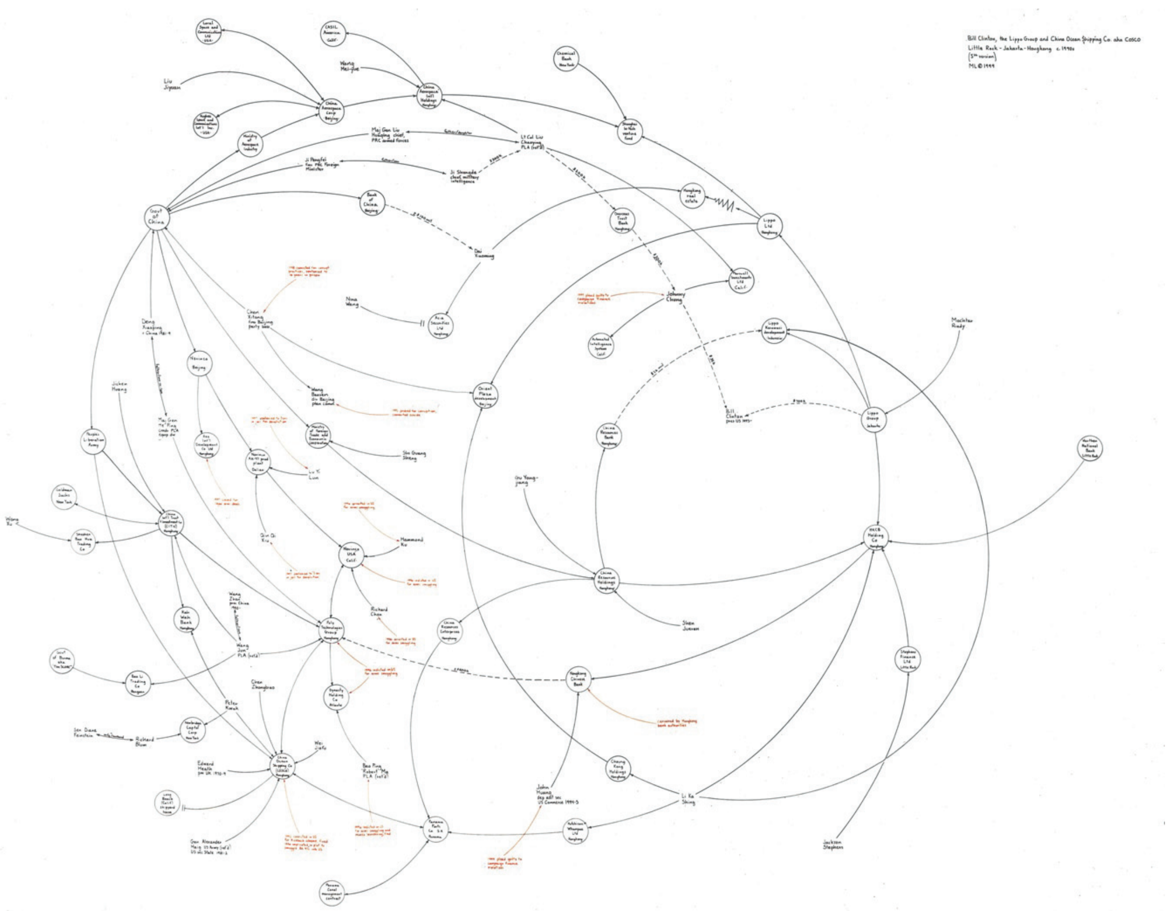


Figure 8. Mark Lombardi reports the involvement of the former President Bill Clinton with the Lippo Group through this art network (Lombardi and Hobbs 2004, 111–113). © 1999 Mark Lombardi

Variety of Academic Practice

Once individuals gain the center of the visualizations and the inquiry goes further, it is evident that the scientific practice hides a complex network of affinities. Although co-authorship and citations cover a relevant part of these affinities, the variety of tasks a scholar daily performs is still incomplete. The software Pure, which is produced by Elsevier, is a good example to comprehend the complexity of academic affinities.

Pure is a comprehensive information management system created for institutions that collect diversified information related to scholars and their work. Among its features, there is a panoramic view of research activities for each scholar. For example, Figure 9 illustrates the network of Professor Elena Pierazzo, which features fields of research, institutes, journals, and peers in order to situate her within the scientific network (Pierazzo 2017). This visualization reveals that affinities in academia cover many aspects of the scholar's practice and that this information has already been translated into digital traces.

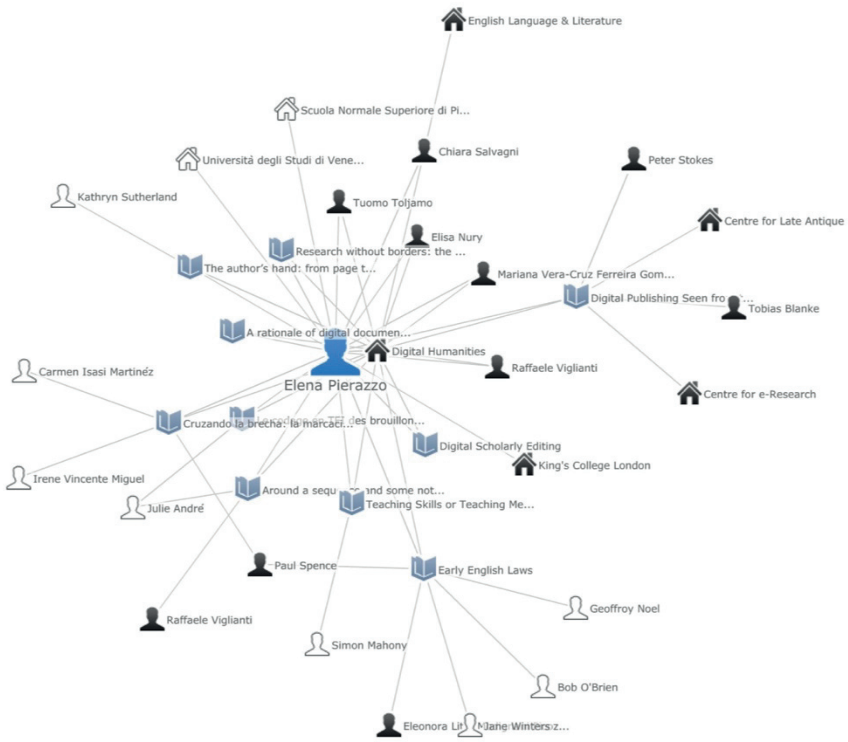


Figure 9. King's College London uses the personal network of each associate. The diagram shows journals, collaborations, and subjects of research in order to describe academic profiles (Pierazzo 2017). © 2017 King's College London

Scientific Practice is Going Public

Today, sharing scientific research is more and more important for two main reasons. One is that a major visibility of research guarantees a greater autonomy in funding research (EPFL 2017, 28–29). Another reason is related to an issue of transparency: making science and scholars public explains the use of funding. Furthermore, the transparency is a *leitmotif* of politics that also pervaded architecture as visible in the City Hall in London and the New German Parliament created by Norman Foster (Foster 2011, 38–39).

The King's College example shows how the variety of the academic practice can be digital and public at the same time. The publication on the Internet of detailed information about academic information is controversial because making personal work public is a delicate operation. Although publications have always been a visible activity, more recently the scholars entered into museums not as visitors but as artworks.

Moritz Stefaner, for example, created two visualizations that represent the scientific practice. These works are permanent installations at the Max Planck Science Gallery in Berlin and at the ArtLab at in Lausanne (Gego, Weibel, and Rottner 2006; Stefaner 2016). The two visualizations have two levels of detail: the one at Max Planck focuses on collaborations between internal institutes and external partners (see Figure 10); the EPFL visualization reaches out to the individuals, making their persona public.

The recent exhibition that has been organized at the ArtLab hosts a specific section dedicated to big data. There, a large data visualization titled 'data monolith' (see Figure 11) takes place among the installations (Stefaner 2016). The specific aim of this public visualization is to give an overview of the institution through its members. Worthy of noting is the fact that only professor names are visible, while other members are not identifiable, as their age and affiliation are not visible.

This installation identified different issues that are treated in this thesis. First, there exists a threshold of privacy that varies according to the role of individuals and the type of information. Second, visualizations of collectives change according to environmental situations: a figure in a paper, an application on the Internet, an installation in a museum; all these situations are addressed to different audiences. Third, there is veritable need to visualize very large organizations for the general public as well as for its members. An *orientation tool* might be the solution?

Figure 10. Max Planck Research Network shows collaboration at the level of the collectives of research (Stefaner 2012). © 2012 Moritz Stefaner

Figure 11. EPFL Data Monolith is part of the Datasquare exhibition at ArtLab. One configuration of the monolith shows professors arranged according to their expertise (Stefaner 2016). © 2016 Moritz Stefaner

Map Principles

Within this project, we employ the map to represent academic practice. Maps are representation based on a language, characterized by the construction of an analog image of a space (J. Lévy 2013a). In particular, we are interested in the relation between visualizations and maps because we argue that the map principles can be translated into visualizations. This section focuses on some characteristics that belong to maps in order to embody them in the *Affinity Map*.

Maps are complex objects, whose uses are not limited to localization. For instance, they are an instrument to navigate through lands or oceans, but maps might also be signs of power as in the case of King Louis XIV of France. When Vincenzo Maria Coronelli built two globes for the king, they were the biggest of the entire world (Cosgrove 2001, 166). The globes were not just instruments, but rather objects to exhibit his magnificence. Today it is possible to visit them at the National Library of France where the majesty of King Louis XIV is still in plain sight.

Technically speaking, maps are analogical representations. Globally speaking, like books, they are transportable documents that bring information all over the world in order to be read, annotated, compared, copied, improved, and being ready to travel again. For that reason, Bruno Latour refers to them as *immutable mobiles* as they are inscriptions charged of meaning with the ability of spreading information (Latour 1990, 26–35).

The Affinity Map does not appear as a classical map. However, we considered useful comprehending the principles that characterize maps because they might be reused for improving visualizations. This section identifies such principles and introduces the visualization into a cartographic domain to finally figure out when a visualization can be considered a map. The answer stays in a process of deconstruction that the famous geographer John B. Harley started during his career (Harley 1989). Although Harley does not refer to visualization as a way to recontextualize the map principles, we think that a shift of the domain is a useful exercise. Hereinafter, the deconstruction takes place accompanying us along this section that illustrates the spatial characteristics of maps.

Correspondence

Maps are representations that are the output of an intellectual analogy based on defined rules. That analogy implies the presence of two different dimensions, or *spaces*, that are intimately connected (Beaude 2010, 2–3). This relation is generally called *correspondence*, which stays for the link between the representation and the space represented. The correspondence ‘between the world and statements about the world’ exists in a form of representation first (Latour 2013, 71). Then, the same correspondence is reinforced by the reader: through the map reading, he experiences the relation in the inverse direction, that is from the representation to the space represented.

Isaac Newton would say that maps are sensible objects as they refer to an immovable dimension such as the time (Mitchell 1980, 275). The time for Newton is an immovable space that humans perceive through sensible objects. Of these, the clock is the interface that ensures the correspondence with the concept of time, which we hardly manage otherwise. The static and perpetual space of Newton is opposed to the definition of Leibniz, for which space and time cannot be absolute entities (Vailati 1997, 12). As Beaude and Nova write, space is always relational, and the map is not an exception (Beaude and Nova 2016, 55). A space is nothing but a specific arrangement of things, space is just the order of the coexistence (J. Lévy 1994, 46). We represent spaces through interfaces, projections, maps, photographs, etc. which are all transformations aimed at making the space tangible and interactive.

The correspondence between the representation and the subject represented is therefore guaranteed by both mapmakers and readers, in a reciprocal action. Mapmakers create maps of places through their experience or the knowledge acquired from immutable mobiles. Travelers connect their environment to a map: when they recognize a sign on the map, for example a village, they create a connection between cartographic and physical spaces. Yet the correspondence might be more complicated since it involves the traveler's memory, for an intellectual displacement.

Roland Barthes writes about that complexity in a book titled *Mythologies* (1991). Barthes refers to a second level of semiotic interpretation through a simple example, saying that a bunch of roses might signify both a bouquet of flowers and the feeling of *passion* (Barthes 1991, 111). There exists therefore a double meaning in the representation that enriches the correspondence. A sign on the map, for example, can be recognized either as a village or as the residence of an own friend, even if it is not visible on the map.

Visualizations benefit from the concept of correspondence, which enriches its meaning through visual analogy. However, the separation of spaces reminds us that the visualization is not a perfect representation of the reality (Harley 1989, 5) because it is always the result of an operation of *reduction* (Beaude 2015, 141) followed by an *amplification* (Leclercq and Girard 2014§26–27). The representation and the represented stay in two spaces that are intimately related through the processes of visualization and reading. The key for a correct reading relies on the notion that visualizations are incomplete, and the mapping of academic practice is not an exception. Looking at the Affinity Map, reader has to remember that it is impossible to represent entirely the academic practice due to various factors, such as the availability of digital traces. In other words, creating the perfect map that corresponds to the scale and the definition of the reality is pure fiction (Borges 1975, 131).

Furthermore, visualizations always imply an impulse for their creation. Maps embody specific needs, namely for navigation, trekking, decision-making, etc. Going back to the reasons of map creation might bring a larger comprehension of its usage, avoiding possible misunderstandings (Monmonier 1991).

Distances of Spaces

The spaces of the representation and the subjects represented are therefore intimately related by a reciprocal correspondence. The elements that inhabit these spaces are organized through distances. For example, two harbors of the Mediterranean Sea may be situated two hundred kilometers apart, which is a distance that the cartographic projection can easily represent. However, the topographical approach may not always be suitable for representing distance, especially in social relations. Indeed, social distances do not rely upon a cartographic space, which hardly represents social ties (Granovetter 1973), as it is the case for affinities. Michel Lussault's concept of *spatiality* illustrates a usage of metrics that can represent social distances. Indeed, the spatiality defines a dimension for the spatial closeness of actors in a social context (Lussault 2013). An example of actual affinity can clarify the concept of spatiality: today's modern technologies allow to communicate through calls, video, and messages between different parts of the word. This ability allows humans to be close and distant at the same time, such as the case of two scholars working on the same paper. Their collaboration through these devices reduces the social distance, in contrast to the topographical distance that might be considerable.

Commonly we think that maps are *topographical* representations that rely on territory; that is almost true in all of the cases. However, maps might also be *topological* when distances do not correspond to territory, as is the case of travel time (J. Lévy, Maitre, and Romany 2016). Topological projection is often applied in visualizations, where the correspondence with the environment is weaker. For example, the genealogical table of the ethnologist Jean Malaurie, which was drawn to annotate his research about the family relations concerning 302 Eskimos, is topological representation (Malaurie 1989). When the distances within the environment lose their meaning, we argue it is more appropriate to talk about a topological representation than a topographical one.

The topological space implies that its distances are inevitably approximated, a consequence that can be explained through the *triangle inequality* problem, which states that, in a Euclidian geometry, the length of the third side of the triangle cannot be longer than the sum of the other two sides. As a result, the theorem proves that a topological space is not veritable by just displaying three vertices; it should also ensure some relation between their relative distances. This is evident when we think about Moreno sociograms (Moreno 1934). The thickness that designers employ in network visualization to draw links reinforces this argument; indeed, that is a stratagem to draw meaningful distances that do not particularly adhere to metrics.

However, it is important to comprehend that network visualizations are powerful methods to represent the space differently. The representation might be strongly misaligned from reality because of a limit of the Cartesian plane intended as a flat representation. The translation of data into a visual form introduces a geometrical limit. However, visualizations draw abstract spaces that hardly would be visible otherwise. Mapmakers, designers, geographers, and engineers are demanded to manage these spaces making the comprehension as clear as possible. At the same time, readers have the responsibility to comprehend the benefits and the limitations that a visual representation implies.

Situation and Localization

The mechanism that regulates the *place* is a matter of great importance. The place is a point in the map where distances are not relevant, but his position is (J. Lévy 2013c). For example, an important harbor is eligible to be situated on the map because it is a *place* of interest. However, at the same time, the same place loses its details and the distances within the harbor are not visible anymore. The place becomes therefore a space where distances do not exist anymore and, consequently, are not represented on the map. This mechanism is crucial because it defines the detail of the visualization: the point after which distances should not have relevance.

The reader takes place in a specific point of view when he looks at the map. That unique position makes the standpoint common for all the readers. From there the reader looks at the elements that are *arranged* by the mapmaker on the surface, merging the two points of view. Each element is *situated* with care according to the rules of the projection. Before being situated, the elements are identified and elected suitable for visualization, and then they are quantified to calculate their position; in that sense, the sociologist Alain Desrosières focused on the production and use of data into visualizations, digging up the mechanism that regulates the production of data and makes possible their use into statistical analysis and visualization (Desrosières 1995).

The reader has thus the opportunity to *locate* places on the map, discovering where they were situated by the mapmaker. In a way, the place has a double feature that reminds of the god Janus, the divinity with two faces looking towards past and future at the same time. Indeed, the place looks at the mapmaker through the construction of the map – the past – and towards the reader through the map reading – the future. In other words, the places are those elements that connect the reader and the mapmaker.

Visualizations are consequently maps when there exists a way to situate and localize places, two actions that belong respectively to mapmakers and readers. However, today these roles are mixed up transforming the readers in active contributors. The philosopher Pierre Lévy was the first to figure out a *collective intelligence* where large collective of individuals are free to contribute and share their knowledge (1997). A good example of collective intelligence is Google Map, which can be modified by adding new places, photographs, comment, and reviews. This change of roles is empowering the readers, whose responsibilities are increased leading to cover some duties that previously were up just to the mapmaker.

Likewise, the Affinity Map requests an active participation from the reader. If the identification of academic practice is a duty of the EPFL, the scholars are responsible for uploading and modeling these data. For instance, the publications are uploaded by scholars with the help of the EPFL library. Yet also the creation of a new course is a form of participation that may come from the scholars. In particular, if the change in the academic practice is reported by the map, we can consider having fulfilled the major aim of the project.

Interspatiality

The map can be extended out of its limits becoming a constituent in turn. Indeed, maps can be correlated with other maps, in relations defined as *interspatiality* (J. Lévy 2013b). The interspatiality associates spaces through three kinds of relations, namely *cospatiality*, *interface* and *nesting*.

Cospatiality puts in relation two maps sharing the same metric. As a result, maps might share the same space. The simplest example is figuring out the levels employed by Adobe Photoshop. These layers overlap one another, sharing the same coordinate system, and they can be activated or deactivated according to need. Indeed, all these layers employ the same metric based on pixels, points, or inches. Otherwise, if we consider a city plan, its electricity and road networks shares the same topographical space. The cospatiality is a powerful instrument to see the relations of elements that belong to different maps.

Interface extends one space into another and *vice versa* through overlapping. If we think that maps are larger objects delimited by a frame, the interface is the property that creates maps moving this frame around, panning it on the plane. The interface therefore simulates a continuity among maps. For example, the atlas is a book that guarantees connectivity over its collection of maps. Likewise, trekkers have more than one map at their disposal for doing long paths.

Nesting is the third relation of interspatiality, and it consists of scaling maps creating smaller or larger frames. The scale is the ratio of spatial distance to the corresponding geographical distance, which means that a small scale displays a large geographical space. The change of ratio makes maps connected through a vertical continuity. Google Maps is a common example of nesting: using the cursor, it is possible to zoom in and out to navigate at different scales. Furthermore, the scalability adjusts the spatial distance: more the scale is larger, more details are visible. A city map for walking is based on large scale, but it is clear that considering interstellar distances as reference influences the range of the scale. The potential of the scale is impressive when it is visually represented by Charles and Ray Eames through their movie titled *The power of ten* (1977).

To summarize, we might claim that visualizations are maps when they are plunged in interconnected visual spaces where interspatiality is performed through interactions of panning, zooming, and layer overlapping.

ENAC Case Study

Maps are also instruments for the governance. The word *governance* was introduced at the beginning of the 20th century as a form of archaism employed in rhetorical and solemn contexts (Garner 2016, 473). Its meaning dates back to the Greeks, for whom the word was related to the skill of steering, for example a ship. In Veneto, a region in the north of Italy, this meaning still exists as a vestigial common saying, which relates the housewife to the sense of governing the house, *governare la casa*. Although its sense became specific to the head of a state over the centuries, the reintroduction of the word governance into the public language made it assume a larger meaning during nineties. Nowadays governance covers not only the state, but also a larger range of institutions. Furthermore, along with the rising interest in networks, it is arguable that the process of decision-making does not belong just to the leader, but rather to a wide variety of actors (Pierre and Peters 2000, 19).

Visualization might be an instrument of governance. With the expansion and the growing complexity of academic organizations, new instruments are needed to steer a university, a faculty, or a school. These instruments might be valuable for decision-making because they help to converge information otherwise difficult to grasp. Indeed, visualizations are tools of exploration, which are useful also in other situations supporting negotiations or decisions (Hoyningen-Huene 1987). Besides, a map for academic governance has to be intended according to the modern definition of the term, conceiving its use for both the deans and the scholars because a scientific organization is steered in two ways: a top-down decision-making that comes from the management, and a bottom-up self-organization that takes place through collaborations.

The Affinity Map is intended to support the governance for a specific case study. This section situates the map within the context of the ENAC school, and introduces the actors and their need that brought us to design such a map.

The EPFL Institution

The study takes place in Switzerland at the campus of the EPFL, the *École polytechnique fédérale de Lausanne*. The EPFL was founded in 1969 by the Swiss Confederation as an engineering college focused on research, education, and technology transfer, in addition to the existing federal polytechnic of Zurich, the ETH. The campus hosts around fifteen thousand people, among which two thirds are students and one third represents the academic and scientific staff. More than one hundred nationalities make the EPFL a cross-cultural institution.

The EPFL is composed of five schools and two colleges, which are organized in sections and institutes; the sections are responsible for education while the institutes for research. In turn, the institutes are divided in laboratories, each of which is headed by only one professor. Although in academia universities generally guarantee the continuity of laboratories over different headships, at the EPFL a laboratory is created for a professor and once he retires the laboratory closes.

At EPFL five schools cover several programs: Basic Sciences, Engineering, Computer and Communication Science, Life Sciences, and Construction, Architecture and the Environment.

The ENAC, the School of Architecture, Civil and Environmental Engineering, is one of the five schools that compose the EPFL. It is organized in three institutes, which in turn are organized into laboratories hosting professors, senior scientists, postdocs, doctoral students, secretaries, teaching assistants, and apprentices. Although the composition of the school seems very rigid, the laboratories share axes of research that cross the institutional hierarchy, offering varied opportunities of collaboration (ENAC 2016).

The ENAC Direction

The ENAC is run by a dean with the support of both a team called the deanship, and a direction board composed of directors of sections and institutes. The strategic proposals related to education and research are approved by the council, formed by the dean along with representatives of the teaching body, the intermediary body, the students body, and the administrative and technical body. The council in particular deals with issues related to education, research, planning, school policy, and nominations. The dean and that political structure are responsible for many thousands of individuals, including ENAC students. In particular, they are responsible for modeling the school in its development, which can be driven in different ways.

The ENAC is modeled through its hierarchical structure. For example, the INTER institute was suppressed few years ago, causing the redistribution of its laboratories in other institutes. The ENAC also develops new synergies as in the case of the Smart Living Lab, which is a research and development center for the built environment of the future that combines the School of Engineering and Architecture of Fribourg, the University of Fribourg and the EPFL itself. Furthermore, the ENAC employs new professors and creates new laboratories. That is what happened with professors Nicola Braghieri and Paolo Tombesi who recently joined the institute of architecture establishing two laboratories, LAPIS and FAR. The ENAC also evaluates professors and laboratories. For instance, since the EPFL incentivizes the employment of young professors through tenure-track positions, a formal evaluation is required to confirm their positions after a period that may span between four and eight years.

The dean, the director board, and the council have therefore the responsibility of taking care of the ENAC through different means. Although today this activity is supported by tabular data, the future may reserve new instruments such as data visualizations or artificial intelligence systems (Hopkins et al. 2011).

Mapping the School

In 2013, Marilyne Andersen became the dean of the ENAC. Before taking charge of the position, Professor Andersen investigated all of the laboratories in order to understand what exactly the school was, and which subjects of research were also objects of study there. However, organizing the gathered information was not easy because of the quantity; she therefore decided to spatially organize it by mapping.

Mapping provided her with a drawing of the ENAC. In this drawing, the laboratories appear as circles characterized by the color codes of institutes; the global configuration was decided according to their interests, placing the laboratories that share *affinities* close each other (see Figure 12). An utmost care was given to the new laboratories – doing a sort of visual planning – and to the external poles to map the synergies out of the school.

The same drawing was reworked producing a second version, which provides a specific focus on the research axes; the management shows great interest in these axes because they summarize the subjects of research in major groups (see Figure 13). For instance, *Sustainable Construction* is a transversal axis that is situated on the border between architecture and civil engineering.

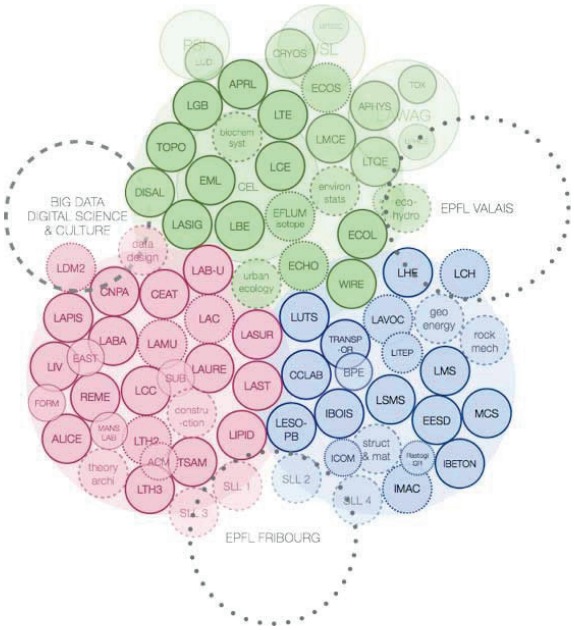


Figure 12. The drawing created by Professor Marilyne Andersen arranges the ENAC laboratories according to their affinities. © 2013 Marilyne Andersen

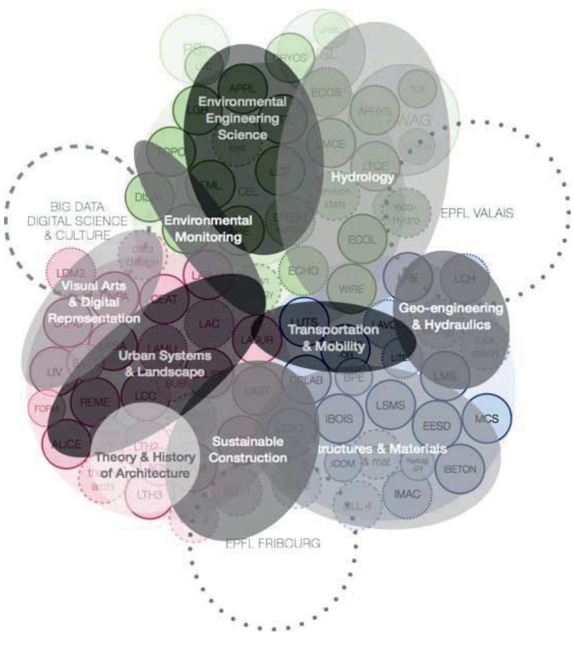


Figure 13. The same drawing overlaps with manual selections indicating the axes of research within the school. © 2013 Marilyne Andersen

The School from the Inside

Professor Andersen, creating these drawings, employed a visual method in order to display a collective of research. These drawings were a clear demonstration of a need for the management practice, which includes issues of comprehension, evaluation, decision, and support. The mapping has therefore been an exercise of management so far. However, during the ENAC General Assembly that took place in October 2015, a latent audience emerged with a keen interest for the school mapping, *the scholars*. In order to comprehend the facts, we step back a little.

After Professor Andersen understood the potential of the visual language as well as the difficulty in creating diagrams by hand, she decided to fund a project of research aimed to design the *digital map of the ENAC*. What you are reading is the result of such research.

The digital map of the ENAC, otherwise known as the Affinity Map, officially began in December 2013. Although the map was intended to be reserved to the management, some positive feedback suggested opening the project up even to the ENAC scholars. In this respect, during the ENAC General Assembly in 2015, the ENAC members were asked for their opinion about opening the map to the whole school. The attendees, who covered a large variety of roles in the campus (see illustration A in Figure 14), were asked to answer two questions through remote controls distributed in the hall. The first question concerning the usefulness of the map received a good confirmation: a large percentage of the audience was convinced about its value (see illustration B in Figure 14). The second question focused on the possible audiences of the map, namely the public, the scholars, and the management. Not only the people in the public were favorable to open the map to all the three audiences, but the preference for the scholars was stronger than for the management (see illustration C in Figure 14).

It was quite a surprise for the deanship to see that more than ninety percent considered the map a useful instrument for the school. That represented the first official approval during a public event. At the same time, the answers demonstrated an interest for a map conceived for the scholars and not only for the management. From that precise moment, the Affinity Map has been conceived as an instrument of governance for both the management and the scholars. If the management is supported in decision-making, the scholars take advantage of considering their position on the map. In bottom-up logic, the scholars look at themselves deciding if their appearance is bad or good and, in the case, how they can modify it.

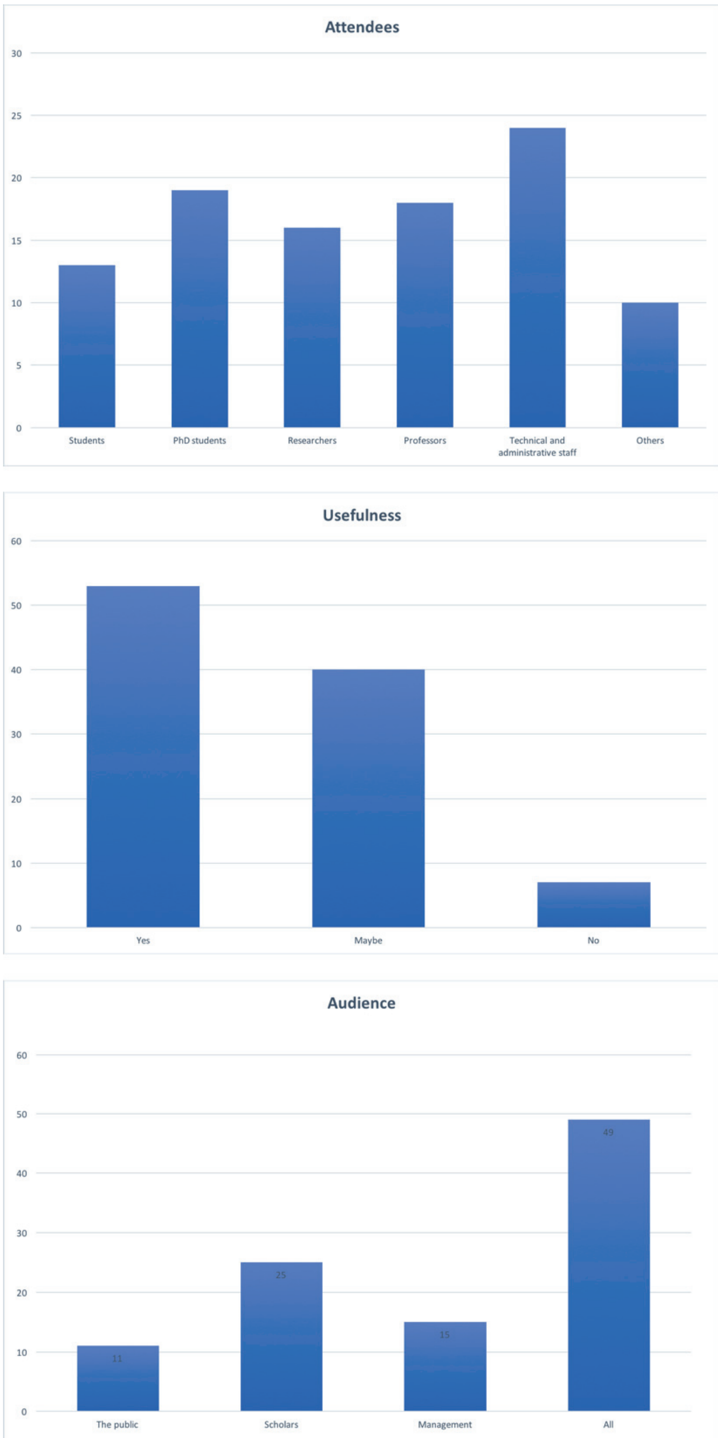


Figure 14. Charts show respectively (A) the audience variety who attended the general assembly, (B) the audience answer about the value of the Affinity Map, and (C) the audience consideration about the final users. © 2015 ENAC

Opening Academia to the Public

At the ENAC general assembly, a third kind of audience appeared, the general public. In the last years, universities have been obliged to integrate public investments with other sources of funding; they discovered that communication and appearance, otherwise called marketing, increases their chances in that direction. That aspect is so crucial that the EPFL employed a private agency. The Affinity Map may also be an instrument to communicate with the public to give an idea of what ENAC does, how many individuals are involved in the daily work, and what the connection between the school and the outside world is.

This communication shift brought universities to reach a general public through museums. As instances, the Max Planck Institute, the EPFL, and the CERN are scientific institutions with their own museums. The digital representation of science and research is increasing with different outcomes in these museums. If we consider the case of the Affinity Map, the visualization brings with it a great deal of information readable for the ENAC employees. In that sense, a public version of the same map would be too complicated thus forcing us to simplify the design.

Furthermore, like in the case of the *EPFL data monolith* (Stefaner 2016), the threshold of privacy has moved beyond the individuals that are now visible. Although the names of individuals are masked except in the case of professors, all of the 15,000 scholars, researchers, employees that attend the campus are represented with a personal graphic element. It is reasonable for some individuals to dislike being exposed to the visitors; it also makes sense that the professors might be the only visible characters. But what about moving again the threshold of the privacy? What could happen by making all the individuals clearly recognizable? When do we have to stop? Although within the research, we really have not had much time to devote to a map addressed to the general public. It is equally true that some experimentation engaged the general public as well as other employees of the institution external to the ENAC from which we can draw conclusions.

Design

Through the previous chapter we introduced the idea of creating a visualization based on affinities. The history of organizational and social charts set a baseline with the previous creations. We argued about the importance of creating an instrument that could serve to analyze academic practice. Finally, we introduced the case study OF ENAC with the project history, the interests, and the audiences to whom the map has to be addressed.

The ENAC school is still central in this chapter that concerns the design. The first section discusses the process of design which we applied for creating the visualization; we justify our choices according to a collective agreement of the team that contributed to the Affinity Map. Then, the theory of affinity is compared with the data availability that requested an initial investigation. The data are subsequently translated into the map, which is introduced paradigm by paradigm. The Affinity Map is not, in fact, a simple network: we enriched the map with a lot of affordances in order to make it more complete and readable. Concepts such as the hexagonal grid, the complexity of nodes, the zoom, the satellites, the keywords, and the constellation will be illustrated one by one. Finally, an example relying on the concept of zoom will show the Affinity Map in a sole journey, from the individual to the whole school, from micro to macro.

The Process of Design

Design is the iterative exercise used to solve or improve a situation through a sequence of thoughtful decisions, which are undertaken by an individual or a team. Although the best solution does not exist, the design process aims to create the best result according to a given set of constraints and compromises. When the process involves figures with different skills, the outcome shows a distinct personality, which represents the whole group that contributed to the design. The Affinity Map is therefore the result of factors that include both human and non-human contributors. The formers are represented by the deanship, the developers and the thesis directors, while examples of the latters include the data, the programming languages, the software libraries and the sources of inspiration. This section discusses the actors that contributed to the development of the map and helped taking a specific direction.

Data assume a key role in the design process. Visualization quality depends indeed on the data, which designers have to translate into visual elements. These, in turn, compose the visual grammar that defines the appearance. Data design (Bihanic 2014) actively intervenes in the process, contributing to the output.

Collaborative Design

The map developed its shape during regular meetings that happened regularly at a monthly or bimonthly rate. These involved the deanship, my directors, and myself. The meetings normally took place in Marilyne Andersen's office, which was appropriately equipped with a conference table and a large library, but did not have enough space to also accommodate a projector.

Meetings were the opportunity for sharing and discussing visualizations. Due to the configuration of the dean's office, the images were usually printed as A0 posters and placed on the conference table, or hung over the library using magnets. Each meeting was organized into three parts: the presentation of visualizations, a discussion where everybody was asked to give input, and a closing round table for planning next steps.

The planning was interspersed with periods of development. These involved software developers, project managers, computer scientists, designers, sociologists, data keepers, etc. All them contributed to the project in many different ways. Therefore, the software creation required the involvement of many individuals with different skills, as was the case with maps in the Middle Ages, whose creation included editors, draftsmen, engravers, printers, colorists, publishers, sellers, etc. (Harley 2001).

This section illustrates the main steps of this teamwork, which represent the most important milestones we encountered during the first stage of the Affinity Map development. In particular, these steps exemplify the approach to the project and the experimentations we did on data in order to check the feasibility of the map.

Preliminary Interviews

The very first meeting ended with an agreement to arrange some preliminary interviews with professors that covered, or had covered, management positions in the school, with the main goal of identifying their interests in the Affinity Map. At that time, the map had already been presented by Marilyne Andersen as one of the main goals of her mandate and all the ENAC collective was thus aware of it, although the audience was still identified in the management team.

As the interviews took place in early 2014, the respondents at that time were identified as the following four professors: Luca Ortelli, director of the *Construction and Conservation Laboratory* (LCC) and of the institute of *Architecture*; Philippe Thalmann, director of the *Laboratory of Environmental and Urban Economics* (LEURE) and of the institute of *Urbanism and Land Development* (INTER); Eugen Brühwiler, director of the *Structural Maintenance and Safety Laboratory* (MCS) and former director of the institute of *Civil Engineering*; and Christof Holliger, director of the *Laboratory for Environmental Biotechnology* (LBE) and former director of the section of Environmental Engineering.

The interviews were structured to last for approximately forty minutes. Professors were asked to describe their laboratories in terms of both subjects of research and position kept within the school. Then, the subject of conversation shifted towards the annual report and the indicators employed for academic evaluation. Interviews concluded with a general reflection about the usefulness of a mapping of the school. The following text summarizes the most interesting subjects of discussion that arose during the interviews.

Professor Ortelli, for example, argued that evaluation metrics scarcely consider teaching activities, although they are crucial for universities. He challenged us to deal carefully with metrics and make the heterogeneity of scientific practice a quality of the map. The same argument convinced even Professor Thalmann, for whom the existing tools do not make the practice visible in its wholeness. He clarified that statement using a practical example about grant proposal, whose preparation is an invisible activity, especially when it is not successful. The map should therefore be capable of making hidden practices visible by disclosing the variety of activities that scholars perform daily.

Current academic metrics make the practice visible through the use quantitative data. With respect to that usage, Ortelli stressed how laboratories cannot be evaluated by size. On the same subject, the sociologist Yves Gingras writes that the quantitative evaluation is dangerous because it marginalizes minor topics, pushing scholars towards arguments of great interest only because of citations (2014, 54). For instance, publications regarding global warming have to be considered as important as publications about local warming. These researches are necessary and institutions have the responsibility to preserve them. As a result, the map should display academic practices in the most equitable way possible, demonstrating an employment of design ethics and a careful consideration for scholars.

Today academic performance is measured through publications rather than other parameters, but it is also true that publication typology differs according to the disciplines. Professor Brühwiler spoke exactly about this argument, saying that book chapters cover an area of major importance in structural engineering. Indeed, the publication practice might change a lot according to the domain: monographs have always been greatly considered in architecture and social science while computer scientists prefer the article format. This variety is not represented by citation analysis and it should be taken into consideration in order to underline the diversity among scientific groups.

If the topics focused on academic practice so far, Ortelli introduced another issue about figuring out how the map might display research subjects. That issue clearly identifies the need for a semantic cartography of the school, which may provide a space regulated by the subjects of research and not by the practices themselves.

Finally, more respondents figured out that the map can be used as a communication tool for different audiences such as the general public, anticipating the decision to open the work out of the management, and that the map has to be aesthetically pleasing to facilitate the involvement of the audience.

These interviews were relevant as they confirmed some aspects that were taken into account during the first meeting. The following points arose clearly during the conversations:

- Consider the heterogeneity of academic practice;
- Make visible the invisible activities;
- Pay attention to evaluation of laboratories and scholars;
- Show the semantic structure of the school;
- Create a communication tool that addresses to different audiences.

Early Sketches

The second meeting was the perfect occasion to discuss the interviews and present some unordered sketches. One important idea was to use the laboratory as the fundamental unit of the map. The laboratory is thus illustrated as a parametric element that is characterized by quantitative data (see Figure 15). The proposal was to create a shape that changes according to the numbers of peers, publications, courses, etc., and to create a parametric object able to translate academic practice into a form. The laboratory image is therefore revealed by a visual identity related to its data. As a result, different shapes characterize each laboratory, keeping the same visual structure. Edward Tufte refers to that visualization as *small multiple* (1990, 67–80). The various elements that compose a small multiple can be observed through a mechanism of association and distinction in order to easily spot similarities and differences.

These instances have been situated in the space (see Figure 16). This is a particularly relevant point because the map is going to be characterized in terms of proximity and distance. Three proposals were advanced to solve the spatial arrangement, namely, the matrix, the network, and the topography. The matrix layout features an arrangement that is based on quantitative data and favors the evaluation. The topographical arrangement is scalable and refers to the geographical coordinates that prevent any kind of evaluation. The network configuration favors a logic based on affinities preventing an evaluation through quantitative data too.

These drawings introduce some embryonal concepts of the map that will be employed in the final version, especially the small multiple, the network, the zoom, and the satellites. Looking at that preparatory draft after more than three years of work is somehow astonishing. Although the final map differs a lot, these sketches represent a relevant base from which the process of design took off.

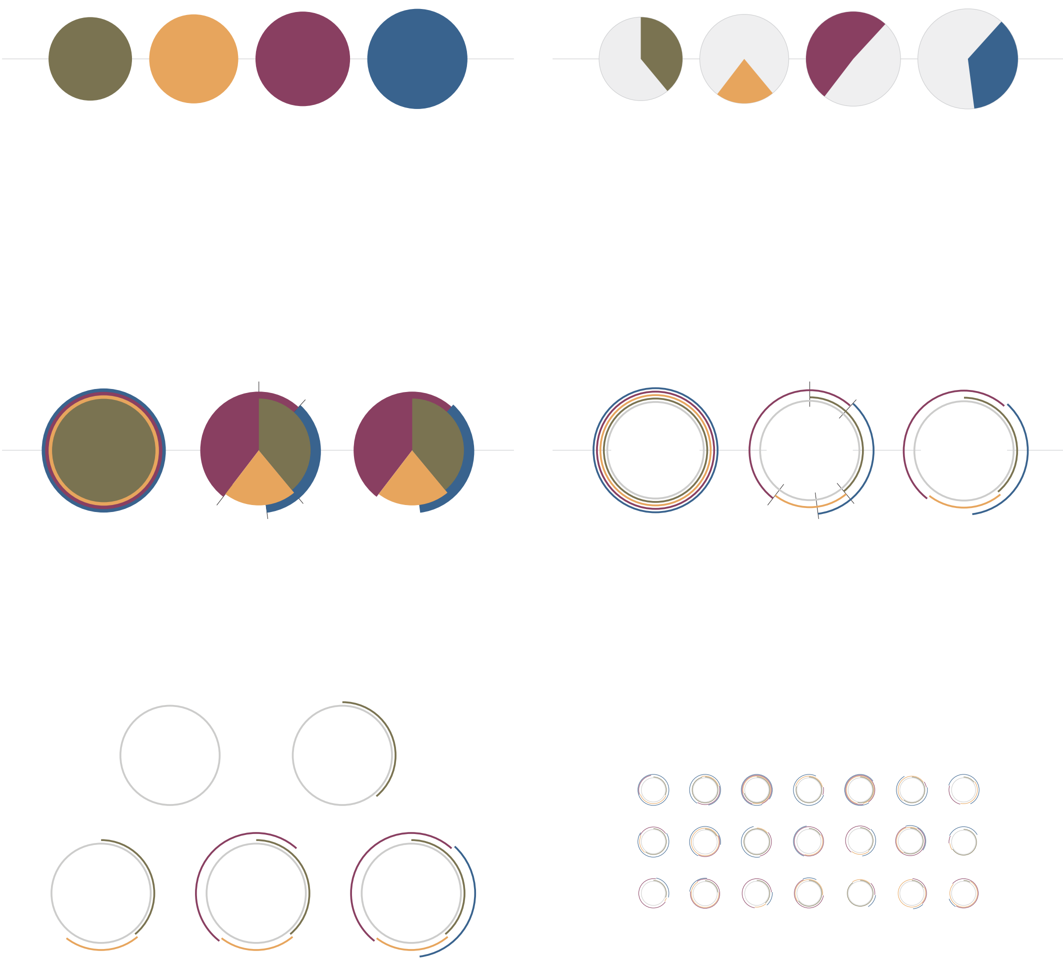


Figure 15. The sketches show the laboratories according to four potential parameters, which are characterized by different colors; unlikely, the last sketch illustrates a matrix-shaped arrangement of the laboratories.

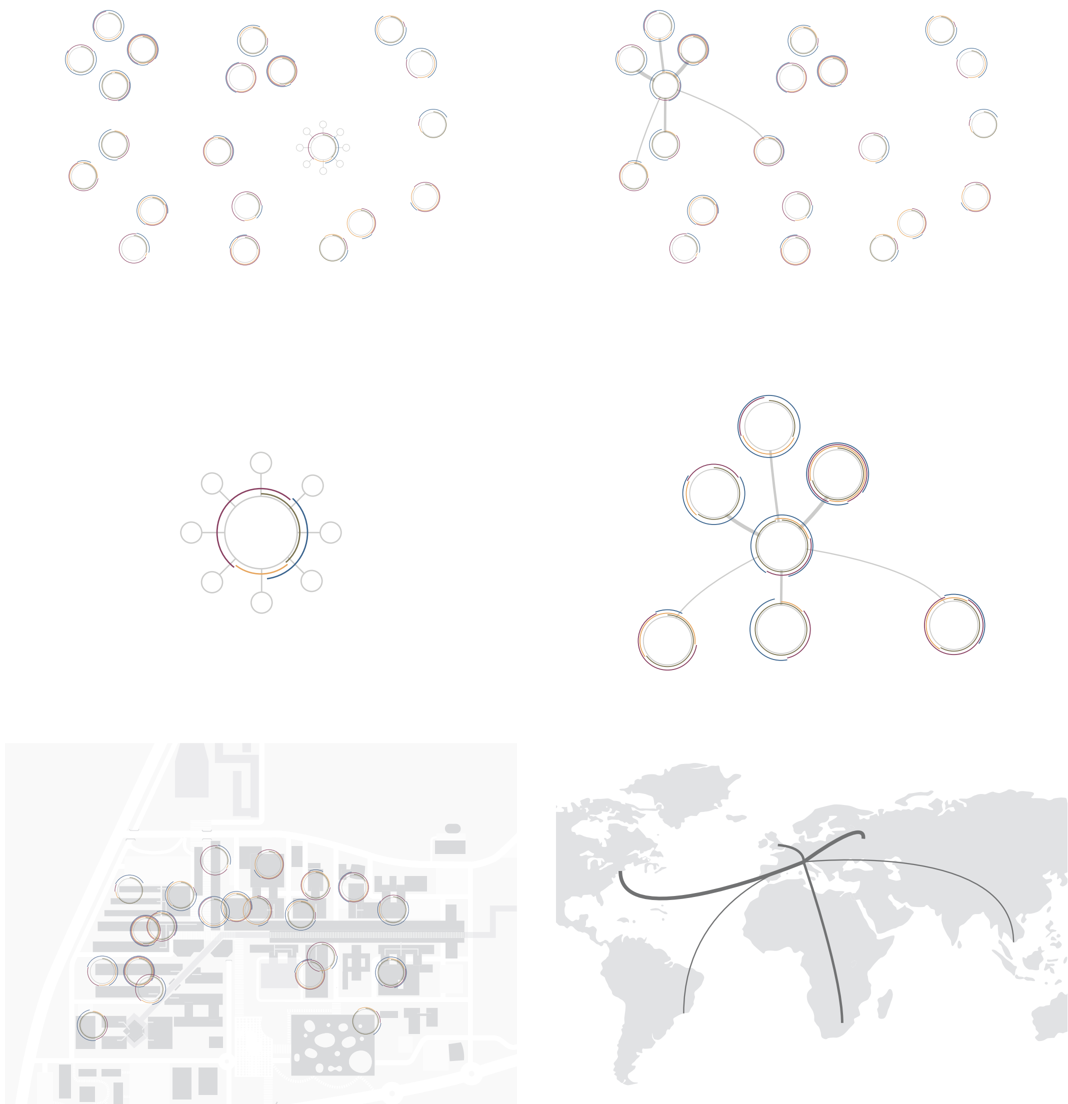


Figure 16. The first two rows show different sketches of networks; the last shows two topographical maps respectively at campus and worldwide scales.

Visualizing Affinities

Among the proposals advanced to give a shape to the Affinity Map, we agreed to use a network populated by laboratories for representing the school's affinities. A series of visualizations had been produced during the year 2014 to evaluate the feasibility of the network approach. These tests have been useful to check quality, quantity, and relevance of data in order to include or leave out certain information sources. The computer application Gephi, which offers an easy framework to analyze networks, helped a lot in this prototyping stage (Bastian, Heymann, and Jacomy 2009).

The first experiment was conducted to establish the quality of the keywords collected during the audit that took place in 2011 (ENAC 2011). Professors were asked to compile their own laboratory report, which comprised a short description enriched by a set of keywords. The visualization illustrates a network of both laboratories and keywords with the intention of checking the data connectivity (see Figure 17). Dark and light grays indicate respectively keywords and laboratories; the unconnected laboratories have been made opaque in order to highlight the graph connectivity. Two clusters are visible: the first is situated in the architecture area and shares the following keywords: architecture, complex design, housing, mobility, urbanism; the second belongs to the environment engineering domain and shares these keywords: climate change, disinfection, pollutants, oxidation. Regrettably, the audit database has a very low connectivity that does not reflect the richness of the school's collaborations. This is a problem that concerns keywords that are manually typed. The visualization proves both a high specialization and a lexical distance between the professors, rather than a difficulty of collaboration. However, that is enough to make the audit database useless for our purposes.

Investigations proceeded through the analysis of the accreditation system, which stores information about the EPFL employees. The visualization shows the network of laboratories that share at least one member (see Figure 18). This is possible since EPFL employees can have more than one affiliation. Looking at the graph, the data set brings up meaningful insights, as exemplified hereinafter.

Scholars work in more laboratories such as the case of the doctoral assistant Jean-Denis Thiry, who is affiliated to LTH 2 and LIPID. That might be interpreted as an affinity between the two laboratories. However, it also happens that secretaries work in different laboratories, as is the case of Luana Huguenin, who works for both CHÔROS and IMAC. The latter example does not represent an academic affinity because the work of a secretary does not match scientific interests, even though we do not have any doubt about its usefulness. Furthermore, scholars may change laboratory during the calendar year, like the doctoral assistant Boris Hamzeian who moved from LAPIS to LTH 3. In this case as well, the link is neither a collaboration nor an affinity.

The same visualization also reveals a delicate issue that needs to be tackled, concerning the laboratory acronyms. For instance, the information system handles the EAST laboratory as three different units: EAST-ONE, EAST-TWO, and EAST-CO. What does this mean? The answer dates back to a political decision. During the presidency of Patrick Aebischer, the Vice Presidency for Information Systems was commissioned to create an information system characterized by a rule that prevents more than one professor from being associated to a single laboratory. However, at a later stage, two professors were associated with the same laboratory as in the case of Anja and Martin Fröhlich who direct the EAST. The problem has been solved by splitting the unit in two entities that are reassembled in a third one, namely EAST-CO.

Finally, this visualization does not provide useful data, but it shows that a certain degree of inaccuracy may spoil the Affinity Map quality. In particulars, identifying the laboratory splits and the multiple affiliations allowed us to tackle these issues in advance.

Another central activity of scholars is teaching. All information correlated to EPFL courses – in bachelor, master, and doctoral school – are stored in the IS-Academia information system. Available data allowed us to create a network with three node types: laboratories, teachers, and courses (see Figure 19). The resulting visualization associates laboratories to individuals and, in turn, individuals to courses.

The visualization shows how every laboratory does teaching activities in terms of collaborations between individuals and units. Two separated parts are clearly visible: the central one illustrates the connectivity through which scholars work together, and the outer ring represents isolated courses that do not share teachers.

It is interesting to notice how some insights we encountered during these tests reappeared in the final map, notably the collaboration between LASUR and CEAT or between LIPID and LAST. The teaching database is therefore very relevant in terms of collaborations, forming one of the axes of the Affinity Map.

Another issue is related to the isolation of individuals. Although the teaching network is readable, it is pervaded by an awful sense of collectiveness given by the detachment of some individuals that work isolated. Even if that information is useful for the managers, being detached from the collective might have a feeling of guilt and suppress any will of collaboration. This issue was taken into account for the final version of the map, especially because we agreed to create a map both for the managers and for the scholars. As a consequence, we will take care of all of the scholars in order to create a map that does not break the spirit of collaboration.

Infoscience is the last data we tested, especially relevant because it collects EPFL publications. This system is maintained by the EPFL library, which classifies publications through a rich set of metadata. Two of them are very interesting for the map, namely authorship and keywords. Authors' data are usually employed in citation and co-authoring metrics (Börner 2010, 54–55), while keywords are standard metadata for articles that authors are required to compile. It is interesting to notice how these metadata account for, respectively, actual and potential affinities. Indeed, co-authoring is an index of collaborations and keywords represent key interests that are traversal to articles.

The Infoscience network shows keywords and laboratories connected through publications associated to the ENAC school (see Figure 20). Uppercase text identifies the laboratory acronyms, and colors stay for the relative institute. Looking at the visualization, in green at the center is visible the institute of environmental engineering, at the top left there is civil engineering, and architecture is split in the top right and at the bottom.

We can look at this representation as the first effort to create a semantic map. In fact, the network features a double layer: one layer shows laboratories in an arrangement that corresponds to the network of potential collaborations; the other layer has a semantic meaning, which shows the subjects of research clarifying the reasons of proximity.

However, as it happened for the audit networks, keywords turn out to be disaggregated because of the authors' subjectivity and the technical lexicon of different disciplines. The nodes are therefore not homogenous and the quantity of common links is reduced, displaying an incomplete configuration. Furthermore, the number of keywords varies according to the quantity of publication, facilitating the visibility of laboratories with more publications. On the other hand, the semantic layer among laboratories proves to be extremely useful to understand the local context of the network. It is an articulate way to enrich the space that exists among the nodes, and compensates the standard network visualization adding a further layer of information. Once we understood the importance of a semantic context for the Affinity Map, the issue was tackled by creating a novel system for keyword extraction. This system will be illustrated later in this chapter.

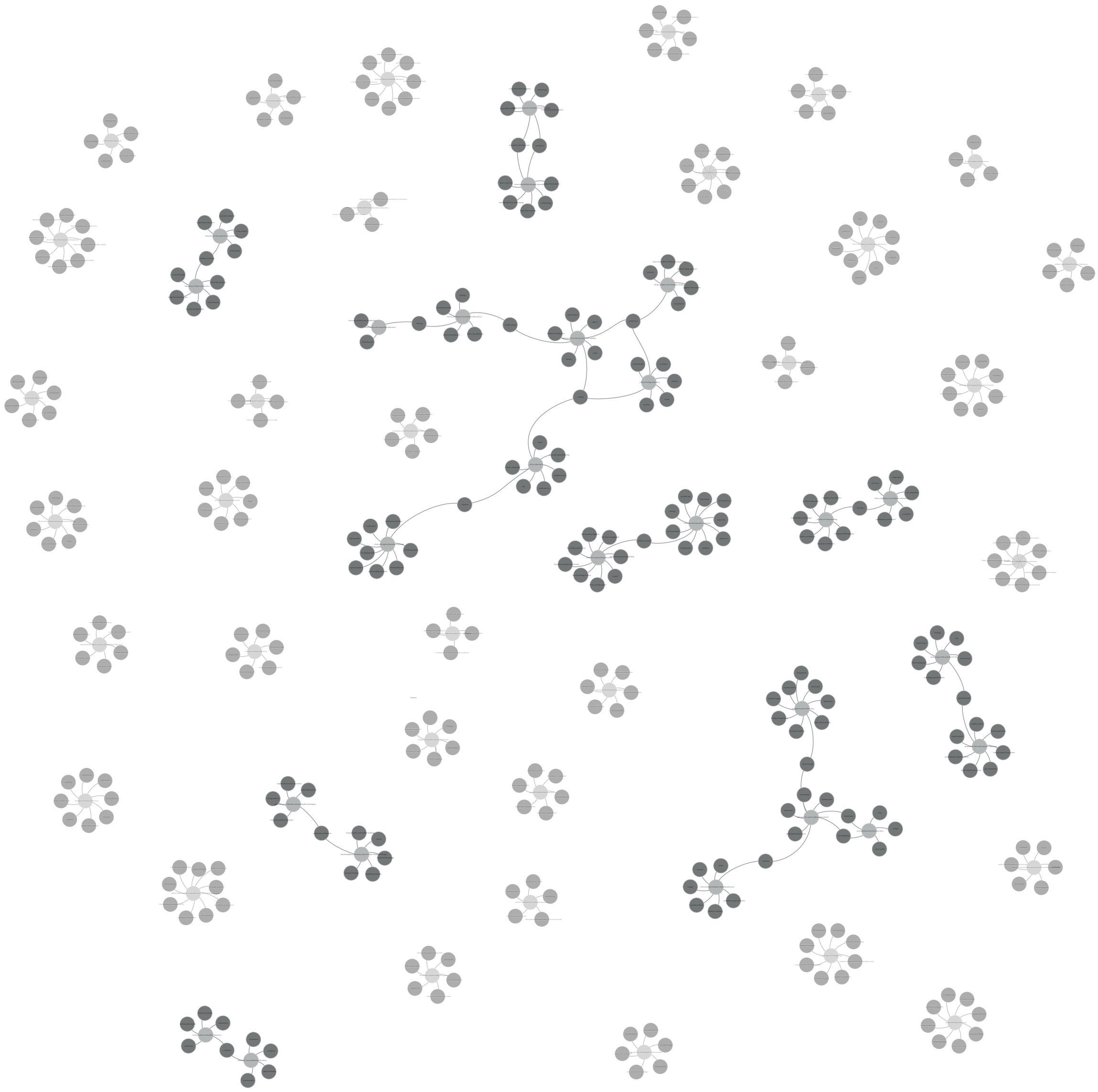


Figure 17. The network shows two types of nodes: the laboratories in light gray, and the keywords in a dark gray. The links are then created according to the audit that took place in 2011 (ENAC 2011).

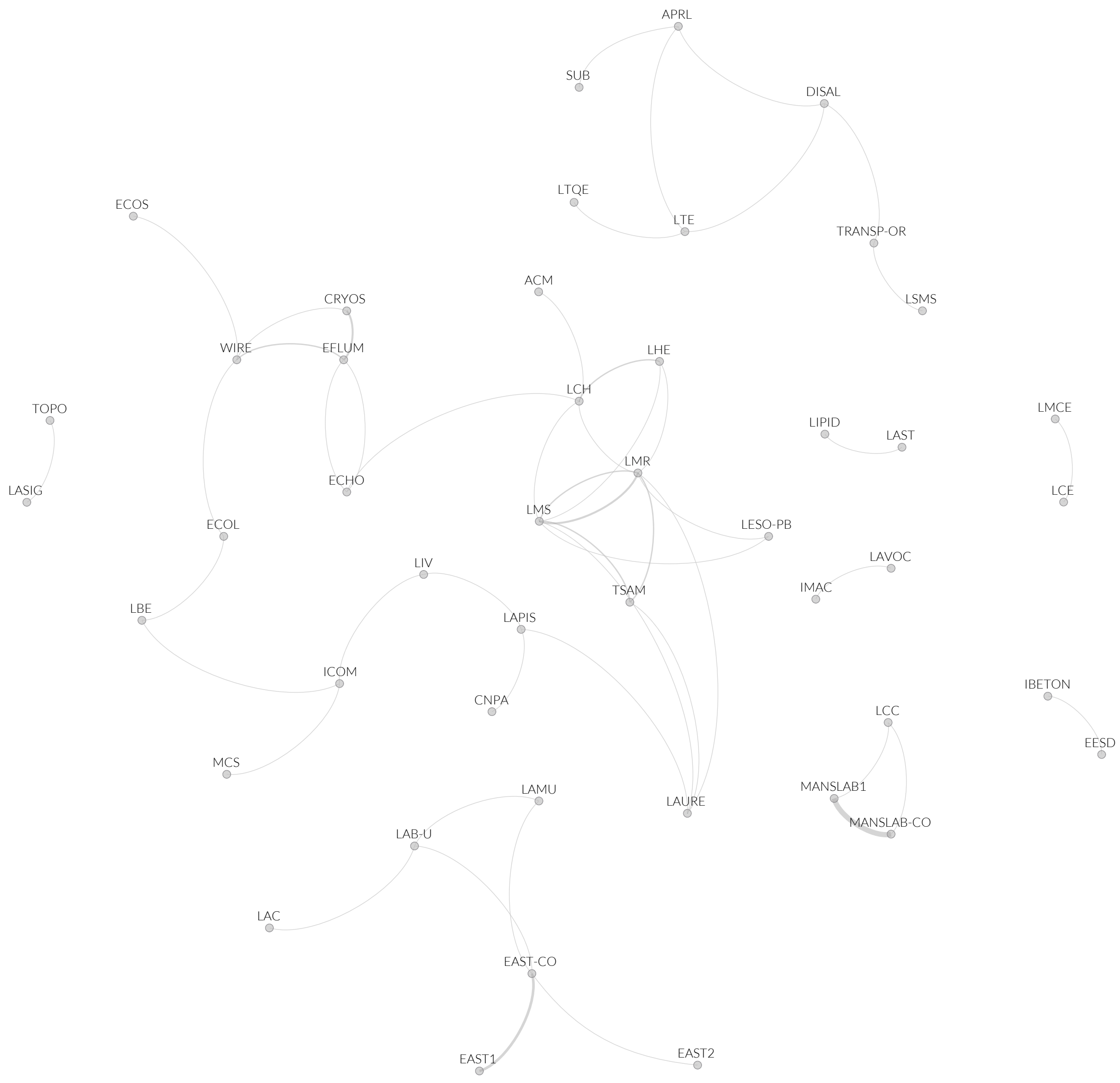


Figure 18. The visualization shows laboratories that share employees. Even if the network is not relevant for displaying affinities, it warns about the fact that individuals may introduce some bias for computing them.

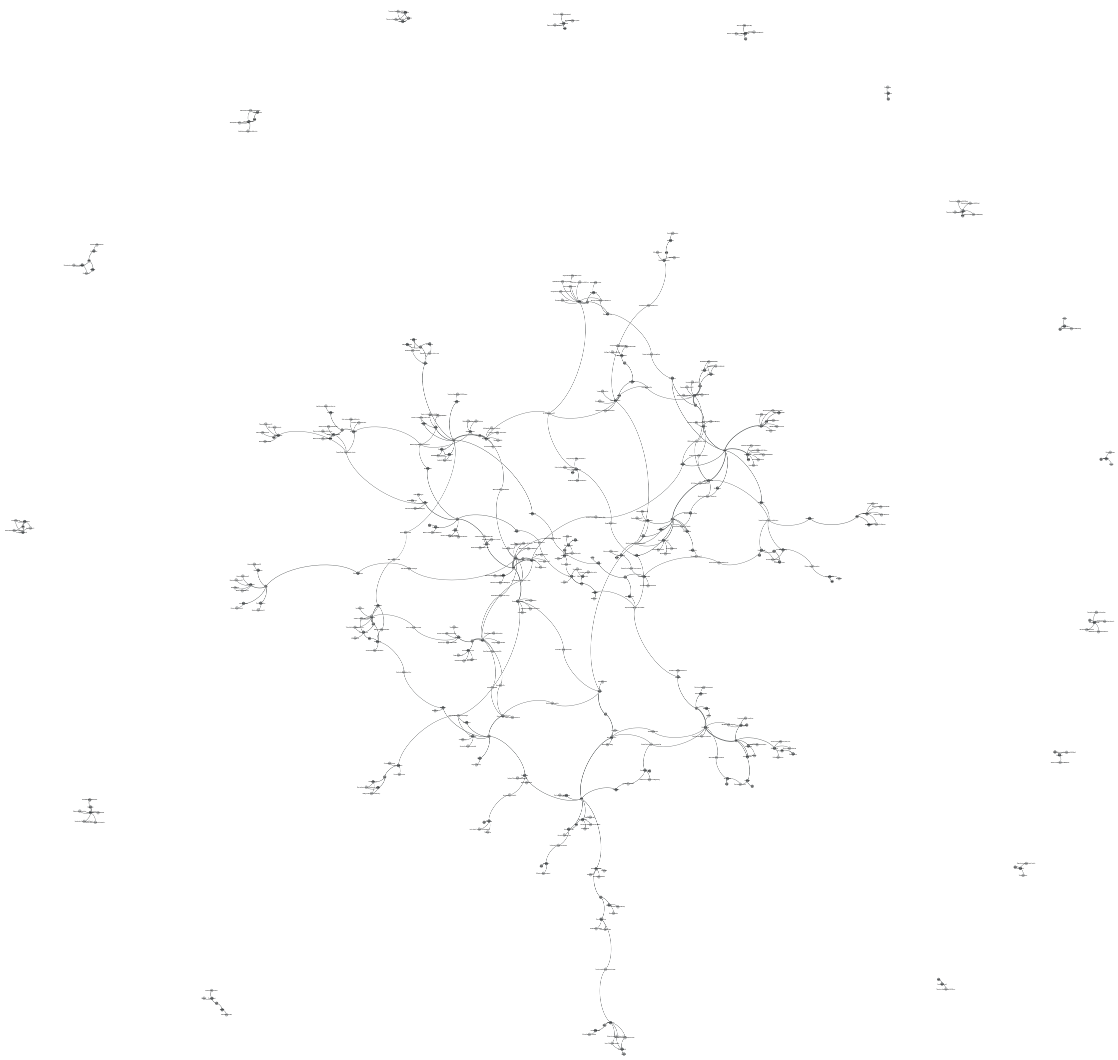


Figure 19. The visualization displays the professors, the laboratories, and the courses of the ENAC school. Teaching network is very relevant to advance the diversity of academic practice.

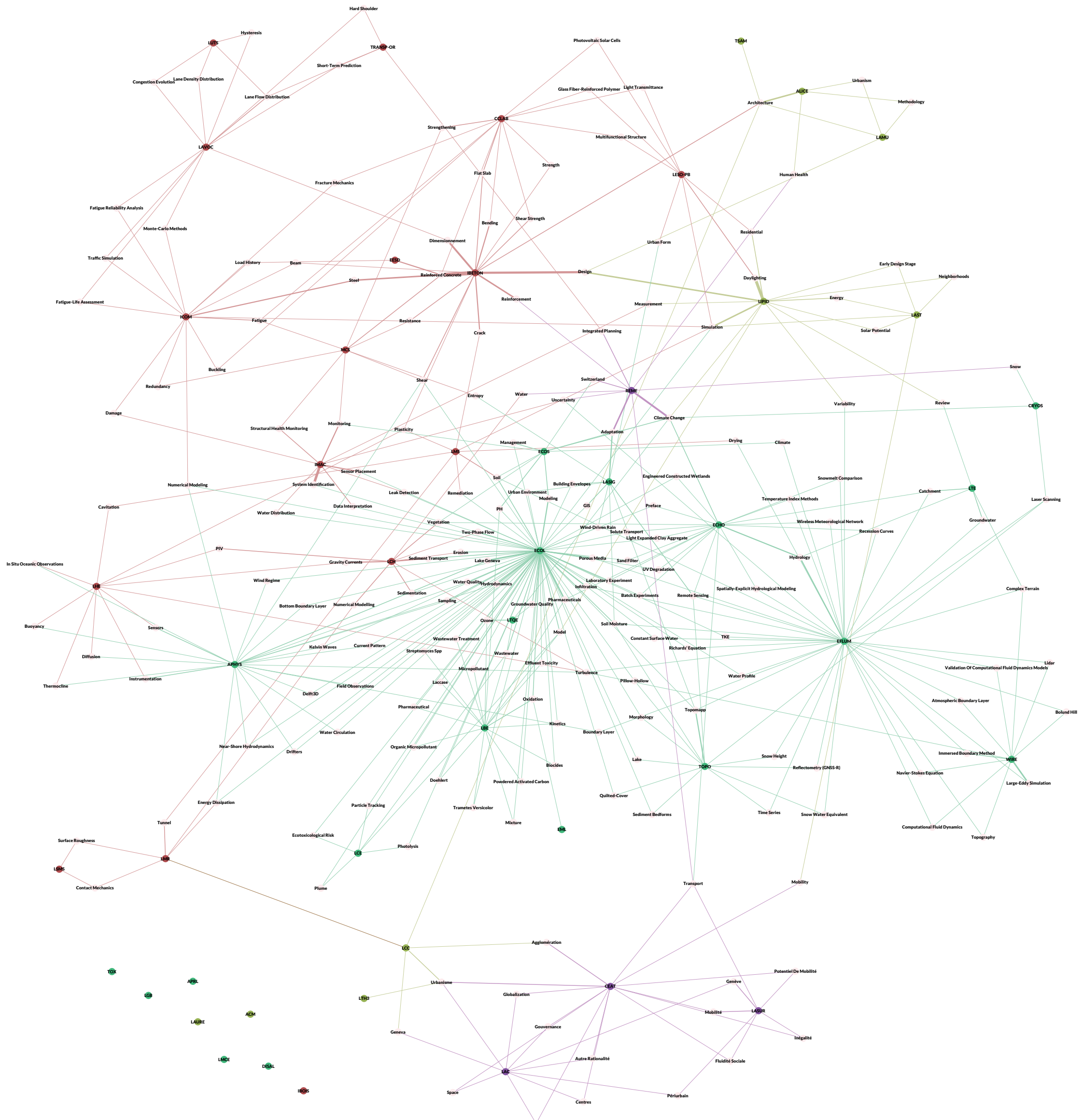


Figure 20. The visualization illustrates a network of laboratories and key-words that are extracted from the ENAC publications.

Inquiring into Individuals

At the beginning, the Affinity Map was intended to be an instrument of evaluation at the disposal of the management. As a consequence, the experiments were focused on laboratories in order to assess professors' productivity. This episode changed audiences of reference transforming the map into a tool of governance open to scholars. Two visible consequences occurred: first, the map was not an instrument to evaluate professors anymore; second, a shift of interests happened, from the professors to the scholars, revealing the complexity of *individuals* that work daily within the ENAC.

The discovery of individuals arose through a specific experiment about accreditations, which revealed all the ENAC members for the first time. The exercise we are going to present herein focuses on the assemblage of laboratories through individuals' data. Accreditation, in particular, allows us to reconstruct laboratories' history using the duration of employment contracts.

The visualization at issue displays ten years of scholars' trajectories through the permanence of members in laboratories (see Figure 21). Trajectories are linear representations of individuals taking place on a temporal axis (Rigal, Rodighiero, and Cellard 2016). Lines are sorted by laboratories and then ordered by time: senior laboratories are on the left at a macro scale, and senior members are also on the left, but at a micro scale. The result is a sequence of laboratories where the height corresponds to the lifespan and the width to the total of members over the years. Below the time-axis, are the curved lines connecting co-authors according to publications.

For the first time during the design process, a visualization reached a level of detail surpassing the limit previously set for the laboratory unit. This resulted in a discussion about the role of scholars in the map, which seemed very relevant. At the moment of the presentation, the team working on the map was delighted to search peers and see how they were represented. Comments resembled 'I know that guy' and 'That lab recruited a lot,' or 'Here I am.' It seemed that displaying individuals was an unexpected information explosion. From there we got that the laboratory's identity does not stay in the acronym, in the professor, or in the publications, but rather in the ensemble of its members. The whole laboratories were now composed of their members, showing an unexpected complexity within the units and individual collaborations.

The question about the whole and the parts that compose the whole was first brought up by Aristotle (Cohen 2000). His very question was when a house can be defined as such. Assuming that a house is composed of stones, when these stones can be called a house? Where is the intimate relation that put together the whole and its elements? We may readapt the same question to laboratories asking ourselves when a group of individuals act as a laboratory. Thereby, the point in this discussion is that a laboratory cannot be examined without considering its members.

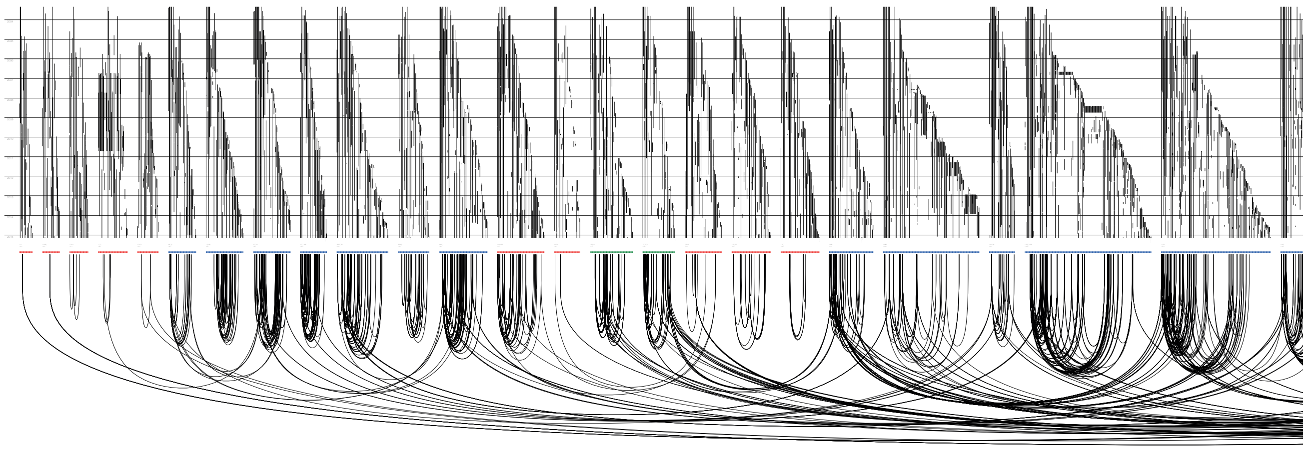
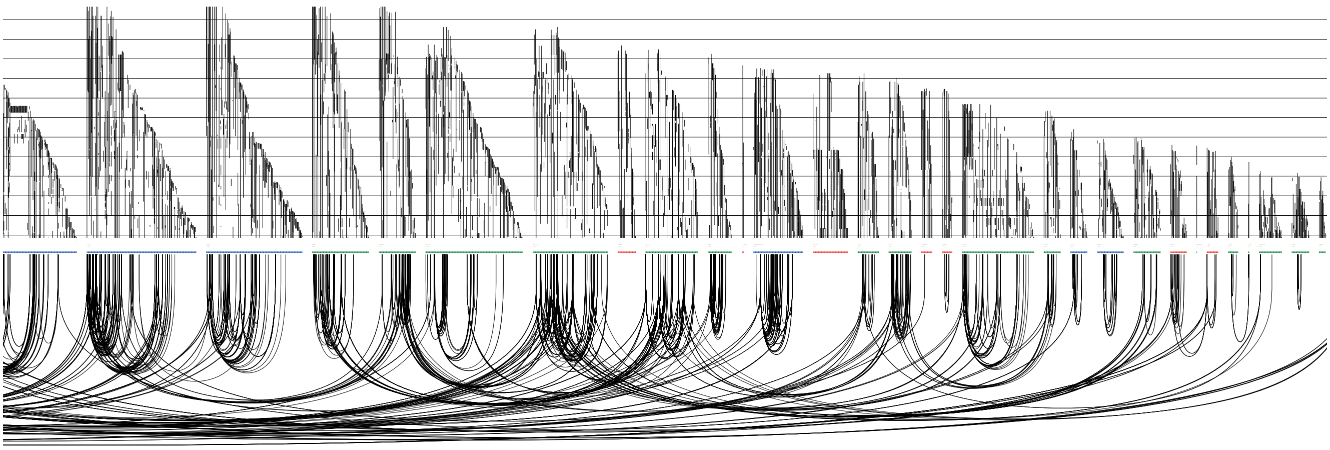


Figure 21. In the upper part, straight lines show the longevity of employees and relative laboratories. In the lower part, curved lines connect scholars by co-authors.



The Gestalt movement more recently reinforced that Aristotelian statement. According to the Gestalt theory, in fact, we live in a dynamic universe, where mutually dependent parts interact with each other (King and Wertheimer 2008, 41–44). The subsidiarity introduced by Aristotle now becomes a complex mechanism of interactive parts that form the whole universe. In particular, Christian von Ehrenfels reformulated the Aristotelian concept by saying that the 'whole is somehow more than the sum of its parts' (Ehrenfels 1937, 523). With respect to affinities, we have to say that a laboratory realizes its full potential when its members work together, and not when they act separately.

More recently, the same concept has been rephrased claiming that 'the whole is always smaller than its parts.' This statement is included in an article that is intended to be a tribute to Gabriel Tarde and his concept of monad; this dramatizes the contrast with the Gestalt theory, thereby reinforcing the actor-network theory that is founded on the actors' individuality (Latour et al. 2012, 591). In that sense, even if we cannot say that the Affinity Map strictly adheres to the Actor-network theory principles, we want to recognize the importance of individuals and their interactions in the laboratory life. The Latourian position is as intellectually solid as the Aristotelian one: individuals are important as autonomous actors and, at the same time, the laboratory is still *more* because makes the most of the collective itself. The famous Gestalt statement might be playfully reformulated in turn by claiming that 'the whole is equally important as its parts.'

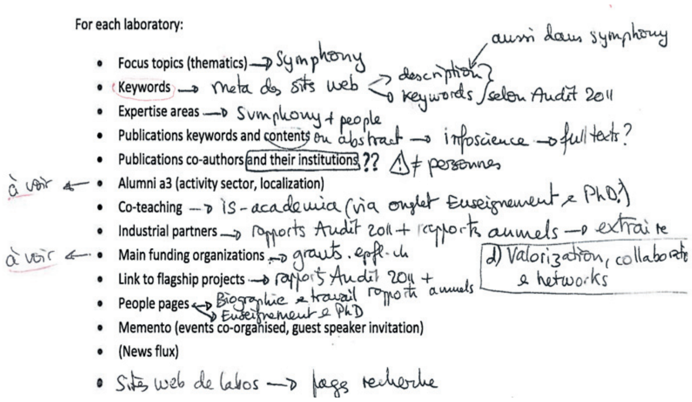
The Affinity Map, at this point, introduces individuals to enrich the laboratories' representation that previously was reduced to simple nodes. Laboratories are no longer simplified and their complexity is finally revealed by the presence of their members and by the way in which they interact. As Norbert Elias pointed out, the attention is to the distance we perceive between society and individuals in social science, but we want to bring the attention to the identity of individuals in data usage (Elias 1991, 6). The ENAC school cannot therefore be represented without its members. From now on, the Affinity Map will employ the representation of individuals to find its own collective identity.

Technical and Moral Constraints

The design process is complex because a lot of constraints contribute to the final outcome. This section illustrates the way we got from data to the graphical design, introducing first the sources of information and explaining how they were managed. Then, we discuss moral constraints such as privacy and ethics, which we used to make the design as fair and transparent as possible. In order to avoid evaluations and comparisons, we preferred a design act to enhance the affinities and the spirit of collaboration.

Sources of Information

The investigation for data took place on the grounds of EPFL, looking into the offices that are responsible for keeping information safe. Accessing data as a member of the organization helped a lot. The same work may be done through web scraping, but this technique, which is based on extracting data from web sites, runs into problems of instability, homonymy, and incompleteness (Marres and Weltevrede 2013, 322). Therefore, we looked inside the institution for available data that were related to the concept of affinity. The investigation started in the beginning of 2014 from a document provided by Claire Hofmann-Chalard, a peer working at the ENAC (see Figure 22). The research was rapidly focused on a few services from that document, which listed available information sources on the campus. This section introduces the services we considered helpful for the map creation.


For each laboratory:

- Focus topics (thematics) → Symphony
- Keywords → meta des sites web → description; → keywords / selon Audit 2011
- Expertise areas → Symphony + people
- Publications keywords and contents ou abstract → infoscience → full texts?
- Publications co-authors and their institutions ?? ⚠ ≠ personnes
- Alumni a3 (activity sector, localization) ← à voir
- Co-teaching → IS-academia (via onglet Enseignement & PhD?)
- Industrial partners → rapports Audit 2011 + rapports annuels → extraire
- Main funding organizations → grants.epfl.ch ← à voir
- Link to flagship projects → rapports Audit 2011 +
- People pages
- Memento (events co-organised, guest speaker invitation)
- (News flux)
- Sites web de labos → page recherche

aussi dans symphony

d) Valorization, collaborations & networks

Figure 22. The document dated August 13, 2013, illustrates available data sources on the campus. © 2013 Claire Hofmann-Chalard

Infoscience

Provided by the EPFL library, *Infoscience* is the institutional archive of the polytechnic that collects and classifies all the publications and makes them publicly available on the web. Its database stores a heterogeneity of publications: journal articles, books, book chapters, conference papers, conference proceedings, posters, reports, patents, public talks, student projects, etc. Each publication is saved as a record that features metadata like authors, keywords, journal, laboratories, etc. Records are further characterized by an abstract, a link forwarding to the publisher, and a PDF file according to relative copyrights. Infoscience derives from Invenio, an open-source software developed by the CERN that supports the Open Archive Initiative. The library encourages the use of Infoscience for two reasons: first, to collect the entire scientific production of the institutions and, second, to make that output publicly available by providing high visibility through research engines on the Internet. Indeed, the EPFL is a signatory of the Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities (EPFL 2017, 42–43).

Is-Academia

All the teaching activities are regulated through another program, called *Is-Academia*. That service consists of all of the bachelor, master, and PhD courses and is accessible to the teaching staff and the students. For teachers, it is a useful instrument to check courses; for students, it is a tool to organize their study plans and collect marks. The service is the teaching memory of EPFL by storing information as courses, accredited teachers, attending students, evaluations, etc. Furthermore, Is-Academia also stores information related to the supervision of doctoral students and postdocs, which is relevant as we decided to show the collaboration within laboratories. Advising therefore completes the triptych of actual affinities, which are completed by publication and teaching.

Grant database

Another important database is related to the use of laboratory funding. Indeed, research projects are managed through the *GrantDB* system. External incomes are stored in that database, which allows administrative staff and researchers to access funding and authorize payments. In terms of evaluation, for the deanship the total amount of funding that a laboratory is able to raise, is of great importance in terms of the financial stability. The information system is maintained by the Research Office working on the campus.

EPFL STRUCTURE

For everything related to the infrastructure of the university, the Vice Presidency for Information Systems (VPSI) is the organization in charge. In particular, they are responsible for one specific service that is relevant to the map, the *Accreditation Management System*. Its specificity is in storing and keeping up to date all the data relative to the EPFL employees. In this database, each individual has a personal ID, called SCIPER, which identifies him with all the other services on the campus including parking and meals. This SCIPER is associated to laboratories through accreditations, which regulate the affiliations of employees and define roles within the organization (i.e. professor, PhD student, etc.). The Accreditation Management System is the means through which it is possible to recreate the laboratory's configuration in a certain period, or the working history of a certain scholar. The information is regulated through the *Lightweight Directory Access Protocol* (LDAP), which ensures a standard application protocol for accessing and maintaining information. More in general, the VPSI manages the organizational hierarchy, which is composed of employees, laboratories, institutes, and schools that are appended in turn to the EPFL.

ENAC ANNUAL REPORT

Last but not least, the most important database for the Affinity Maps is the ENAC *annual report*, which is developed by the ENAC Computer Service unit (ENAC-IT). That service, which exists from 2013 and has been improved over the years, allows professors to complete their laboratory reports through a semi-assisted system that is automatically fed by information sources introduced so far: Infoscience, IS-Academia, GrantsDB, and the Accreditation Management System. The importance of the annual report is about its information completeness that guarantees access to different data in a unique system. For that reason, the Affinity Map relies on a JSON export provided by the ENAC annual report, which will be described in detail in the next section.

Visibility, Validation, and Creation of Data

The *annual report* is a system set up by the ENAC to gather information about its laboratories. That system is specifically addressed to the professors to fill out a report of the work carried out during the last calendar year. To facilitate the work, the annual report is synchronized with other information systems on the campus in order to provide a draft that professors can modify as they wish. That report is particularly important because it is the official document though which professors are evaluated by the deanship. For that reason, its quality is important and professors are requested to make their report as precise as possible.

During the design phase, professors were also aware that the annual report represents the major information source of the Affinity Map. This is particularly relevant as reports are usually for the private use of the school management only, while the map makes them publicly visible. The Affinity Map is important with respect to the report because it sets the level and the aesthetic form of data privacy. Professors are thus demanded to check their reports in the perspective of sharing them. This control is based on an interface that allows professors with three operations, namely *visibility*, *validation*, and *creation*.

Visibility concerns privacy, it is the mechanism used to avoid sharing of sensitive information. For example, professors are requested to list collaborations, which is a type of information that is useful to figure out the extent of the school worldwide, in terms of research and private institutions. However, collaborations may be very sensitive, as may be the case with nuclear research. Professors can therefore choose to hide specific information, thereby protecting the laboratory privacy.

Validation is the activity that allows professors to confirm information available on the EPFL information systems. This action is particularly relevant for publications, which are uploaded by laboratory members through a workflow with very few restrictions. This workflow of the Infoscience platform requests a validation, for instance by the professor or its secretary, to associate a certain publication to a laboratory. However, it happens that publications are validated with no attention by laboratory members. The annual report offers a supplementary check for all publications, allowing professors to prevent the visualization of inappropriate information on the map.

Creation is another operation that the annual report makes available. Creation is important to inject data that would not otherwise exist. For example, it happens that some information about scientific activity is missing from storage systems. For that reason, the annual report helps to create not available information. Data such as external collaborations were specifically created in 2016, and without the creation mechanism these data would still be missing today. The same happens for teaching, the IS-Academia (see page 62) system only collects the EPFL courses and does not consider external ones. It is just through the annual report that these courses can be collected.

These three operations are fundamental for improving information quality. The idea of using an official and validated source of data makes the Affinity Map more reliable. This is important in a time when a lot of visualizations are presented to the audience without transparency. A group of questions have to be addressed by readers themselves in order to assess the foundation of visualizations, for example: where does the data come from? Why produce such a visualization? How is information identified? Who produced the data? Too often the readers stop in front of a beautiful graphic design, without investigating data sources. Answering all of these questions clarifies the visualization reliability (Van Es, Lopez Coombs, and Boeschoten 2017, 178), therefore making the visualization reading a thoughtful act. In this way, we want to charge the Affinity Map with a particular attention to the data quality with respect to its audiences.

Database of Affinities

If the annual report provides the map with the necessary data, these have to be stored in a database for being retrieved. The choice went to *Neo4j*, which is a database that reflects the graph form of the map and gives us great freedom for data extraction.

The Affinity Map database counts human and non-human nodes, which correspond respectively to the ENAC employees and their affinities. Scholars and affinities are linked to each other when an individual performs a certain task. For instance, a publication is a type of affinity node that is related to its author node. If a publication has different authors, its node will be related to different author nodes creating a bridge of authorship. The database is thus searchable in two directions, from either affinities or scholars. For instance, a query can retrieve authors related by affinity.

The database collects around 160,000 individuals over more than ten years of EPFL history, who can be filtered by more than half million of accreditations (see page 63). Taking into account two consecutive annual reports, the Affinity Map counts 24,303 affinities including 2,256 publications, 1,485 courses, 3,352 advising relations, and 17,210 keywords. In addition, between individuals there are 10,674 actual and 17,210 potential affinities.

The Affinity Map of ENAC that will be presented in the next section, concerns a unique annual report that corresponds to the calendar year 2016. Consequently, the listed affinities have to be divided in half to figure out the size of the visualization. Furthermore, it is useful to know that the Affinity Map of ENAC displays 871 individuals, among whom 830 are unique (i.e. scholars might appear in more laboratories in the case of multiple affiliation).

The resulting database collects nodes representing individuals and affinities; these nodes are organized in a two-mode network, which connects two nodes of the same type through a node of another kind (Scott 2000, 40). Afterwards, a hierarchical structure composed by units is placed on the top of that network. These units stay for laboratories, institutes, and schools, replicating the organizational schema of the EPFL where laboratories are linked to institutes, which, in turn, are linked to the schools. At the top of the hierarchy, the schools are connected to the EPFL institution, which works as a root. We might look at the units as the way to reassemble individuals into groups. For instance, the members of a laboratory might be assembled through the specific units and its accreditations, but it is also possible to bring together the members of the same institute. Furthermore, accreditations feature start and end dates, allowing us to retrace the evolution of any collective.

Finally, the technology chosen for the database guarantees a great flexibility. Queries can be addressed to individuals to study their collaborations, or to laboratories to look at the collectives as sums of individuals. The resulting structure facilitates the collaboration analysis at different levels, namely within the laboratories, the institutes, or the school, thereby achieving different levels of detail. Furthermore, the same flexibility enables to host data related not only to the entire institution, but also to different institutions at the same time.

Threshold of Information Privacy

Once the data are structured in a proper database, the information extraction is ready to be tackled. However, there is a major issue: considering that some data are too sensible to be exposed, which would be the appropriate threshold of data privacy?

Open data, open source, and open hardware are recurrent topics of discussion in academia today. Although practices like open archives are increasingly common, not all data can be shared. The philosopher Jacques Rancière opens the debate about privacy introducing the notion of the *distribution of the sensible* (Rancière 2000, 7). For Rancière, the distribution of the sensible is an *aesthetic threshold* between the visible and the invisible, which limits what is shared and what is not (Rancière 2000, 12). The existence of such a threshold is the result of some decisions, which are usually made by a political class and may concern individuals and their personal data. For example, a nation fighting against terrorism has to avoid any leaks that might compromise its efforts. Many elements, in a situation like this, contribute to maintaining data as open or closed, such as diplomacy, stability, power play, or safety (Birchall 2016, 2). The privacy is thus a consequence of political acts and not a direct reason *per se*.

Moral problems such as the generation, recording, curation, processing, dissemination, sharing, and use of data (Floridi and Taddeo 2016, 3) equally affect organizations as well as its practitioners. The EPFL, as organization, has a transparent approach to data: publications, courses, teachers, affiliations, and supervision are publicly available data. Likewise, the data policy of Affinity Map is as clear as possible: *only public data are visualized in the map*. As a consequence, although the data flows throughout a private service such as the annual report, the data employed by the map are publicly available on the Internet and, in a sense, the map relies on the political transparency of the EPFL. For example, publications are accessible on Infoscience for spreading research, teaching activities are visible on the institution's web site to organize their semesters, and supervised PhD students are listed in the professor's personal web pages.

Among the information sources, only one stays on the other side of the privacy threshold. Indeed, the grant database stores very sensitive data, which concern the private funding that laboratories are able to raise. Why is this database so important? Today, about 30% of the EPFL funding is collected from external resources (EPFL 2017, 28) and financial aid makes a real difference for relatively small units like laboratories. Funding means more PhD students, more outcomes, more publications and, in general, more recognition for the laboratory. However, funding may be very different according to the discipline, especially if a laboratory requires the purchase of expensive machinery, as is the case of civil and environmental engineering. That measure can create laboratory comparison and a general resentment against the richest laboratories. The EPFL keeps part of financial data private from the public audience, even if they are internally accessible: for example, the ENAC deanship can access financial data relative to its laboratories. As a result, a public map cannot display financial data, but a private version for the deanship might do so.

Ethic of Design

The Affinity Map is the result of a design process, in which the project has to be contextualized. Designing is a very personal practice since it does not exist as the sole way to create a product. For Enzo Mari, indeed, designing is the personal ability of planning to make a job done (Mari 2011, 7). However, the outcome is always the result of constraints, decisions, and negotiations which include variables such as peers, users, means, ethics, etc. Furthermore, constraints vary in accordance with the type of product. The creation of a lamp, for example, does not encounter the same difficulties compared to a software, which is an object of design for all intents and purposes as well. Digital artifacts have a different design process from industrial objects indeed, and their construction demands specific attentions (Armstrong 2016).

Terry Winograd was one of the first to become aware of the importance of design for software (Winograd 1996). The interest he fostered around scholars widely contributed to making computer scientists sensitive to the importance of concepts such as interactivity and social consequences. Jacques Bertin was also aware of the importance of creating digital artifacts, in particular visualizations, underlining that the act of creation is a responsibility that may be a weighty one (Bertin 1981, 16).

The ethic in design is related to the type of object produced. Among the various aspects that the ethic might comprise, one relevant issue is the *social impact*, which deals with the consequences that follow the release of a product. The social impact stems from a *consciousness* for the design of the product, which concerns the ethical issues that need to be faced during the creation of an object. This can be summarized by asking the right questions. Who am I working for? Who is the final user? Will it be useful? What is the scope? Is it fair to create such an object? What is its impact? In general, the ethic of design relies on the awareness of constraints and powers that influence the outcome, and the consequences when the product is released publicly.

It was evident that the Affinity Map is a sensitive project that includes different risks. One risk is the creation of a visualization that does not correspond to the social reality. To overcome that issue, a lot of effort was put into improving the data quality, and the concept of affinity was extended to give the most heterogeneous representation of all activities that scholars perform daily. Another risk is the creation of an instrument of management and not an instrument of governance. In response to that, a specific care has been employed in the translation between the data and the graphic design of the map. Indeed, the graphic design is the main way to create a balanced map, which might be focused on collaboration only, reducing as much as possible the performance-based representation. Furthermore, the funding sources have been excluded from the visualization because their contribution was pointless for collaborations. Moreover, this exclusion reduces the comparison between laboratories or individuals without losing the contributions that quantitative data can give to the description of the academic practice. However, we are conscious that the design influences our lives as individuals and as collectives (Löwgren and Stolterman 2004, 1), and we tried to create an Affinity Map that might be as fair as possible. Next section will clarify all the graphic design choices in order to make them as clear as possible.

Visualization Principles

The Affinity Map contains some features that improve the classical network visualization. As Manuel Lima shows, today network visualizations are often reduced to a very limited visual grammar that can be summarized in lines, circles, and labels (2011). Indeed, visualizations still use a basic vocabulary to display complex networks, as Moreno did almost one century ago (Moreno 1934). Although a lot of the efforts focus on the algorithms that arrange the node's position (Barabási 2002), few experts are interested in developing visual aspects of networks (Bach et al. 2017). To contribute towards that direction, a series of graphical principles are herein proposed as keys to overcome some specific aspects that still trouble network visualizations and their reading.

The Affinity Map follows a set of rules that regulate its appearance. Maps are indeed the result of specific rules that correspond to strict operations of codification, which are executed by the cartographer. Network visualizations are not an exception, and their shape is codified in an almost regulated representation (Kaplan 2012). The visualization principles introduced here are henceforth the rules modeling the Affinity Map. Defining these principles allows us to create and recreate the same model of visualization, as in the case of maps (Jacob 2006, 28). As a consequence, the Affinity Map is the result of a metric of affinities and a set of graphical principles applied together, integrating aesthetic and rules as in the case of cartographic objects (Woodward 1987).

Hexagonal Patterns

Geometry is first the map itself: it molds the earth in conformity with its image, which imposes a formal and a priori perfection. As this perfect form changes with the development of geographical knowledge, geometry becomes a grid, exterior to the earth, its order organizing disorder of the real (Jacob 2006, 130).

The Affinity Map organizes nodes in hexagons to make order in the chaos of laboratories. Hexagonal pattern arranges nodes regularly, creating equal distances and optimizing the space, as is the case of honeycombs (Thompson 1942, 527) and Islamic tessellation (Critchlow 1976). Hexagonal pattern is replicable and might form a never-ending arrangement, which brings towards potential infinite networks. Applying hexagonal pattern to force-directed graph brings some unexpected outcomes that are exemplified herein.

In network visualizations, nodes might be close to each other and difficult to see at all zoom levels, in particular when they vary in size. Furthermore, it happens that links pass through nodes that do not have any relation with, generating useless overlaps. When visualizations are dense, that issue becomes more and more obvious. With respect to thin noise that might affect networks, the hexagonal grid helps to facilitate the visualization reading. Snapping the force-directed graph to a hexagonal grid enhances readability in situations of high connectivity, without requesting any interaction from the users. Hexagonal patterns allow one node to reach twenty-four other nodes without any overlap (see Figure 23). Stabilizing the network into this grid allows it to improve the reading of nodes' connectivity. Although that solution may sound strange, we have to remember that regular distances in networks are not a totally new experiment (Fruchterman and Reingold 1991).

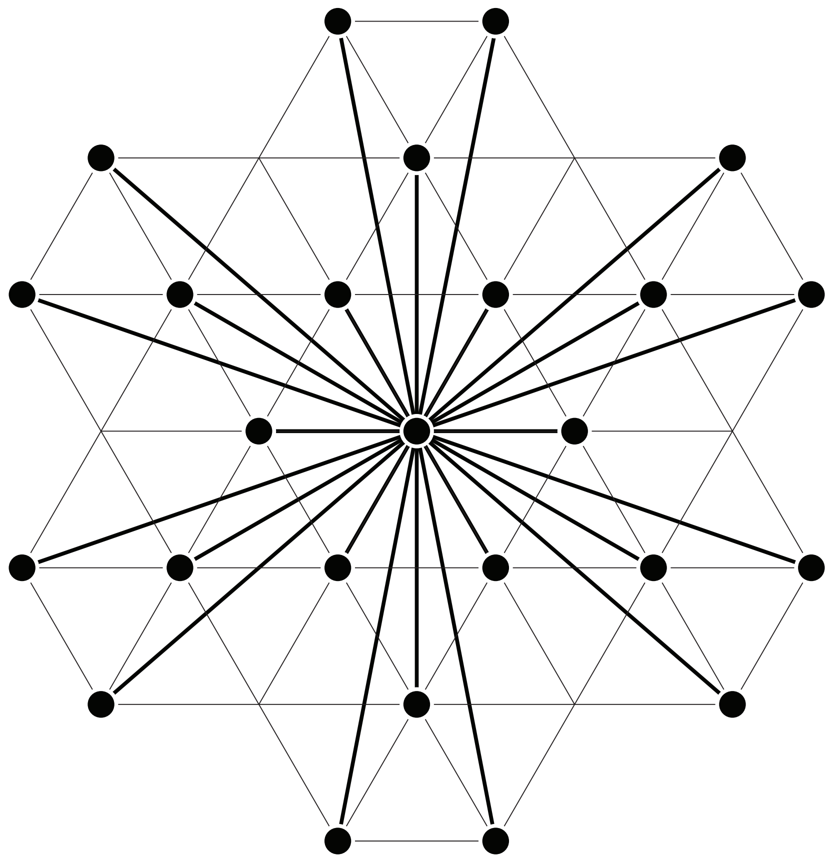


Figure 23. Hexagonal grid connects the central node to twenty-four others without problems of overlapping, improving the network readability.

There is another point in favor of the hexagonal grid, which requires a step back looking at the very central question of the Affinity Map, whose aims are observing affinities and fostering collaboration. The applied forces situate laboratories side by side. Node closeness identifies potential collaborations between laboratories that do not currently collaborate. Furthermore, it is important to present the ENAC cohesion. The gravity force reassembles all the laboratories, even if they do not feature any collaboration. An isolated laboratory would damage the unity of the school without bringing any relevant information. Although we know that a force-directed graph with more appropriate distances between laboratories would be a great tool, we think that the visual unity might play an important role in giving a sense of belonging to the scientific collective.

Does reading truly improve when a network follows a regular grid? A famous experiment of underground mapping shows that it might be the case. Harry Beck, an English technical draftsman working for the London Underground, devised an atypical cartographic projection in the early 1930s (Spence 2014, 4–5). That idea aimed to solve an issue with the London Underground Map, which was difficult to read due to the transport network's growth. The solution proposed by Beck was structured in two distinct steps. First, he equally spaced stations out, in opposition to the reality where stations were closer at the city center and further in suburbs; second, he normalized rails in four possible inclinations (see Figure 24). The public appreciated that kind of map so much that the Beck's idea is still used today, proving the advantage of regular patterns. Yet regular patterns do not only improve reading, they also beautify the aesthetic form like in the case of Islamic art (Critchlow 1976) and digital art (Nicolai 2009).

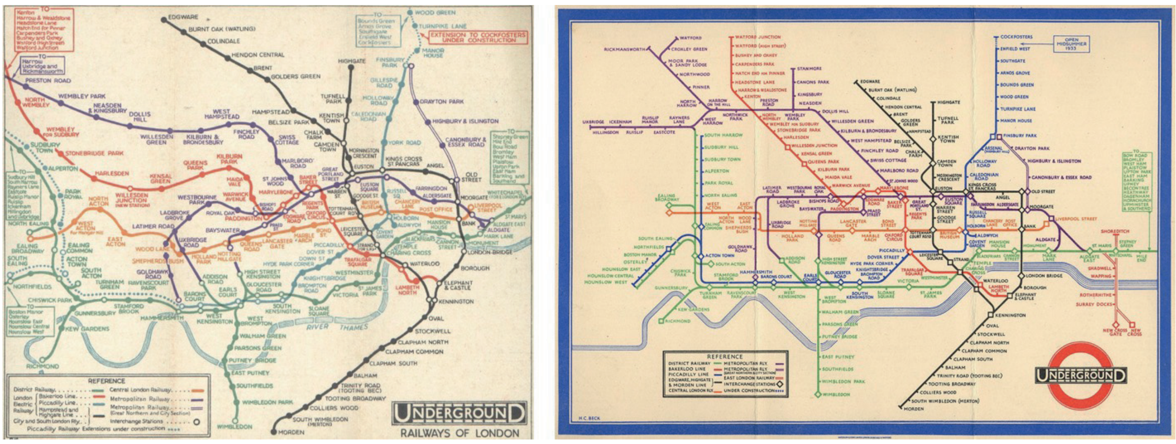


Figure 24. Both maps represent the London underground in 1932 and 1933. The second one presents Harry Beck's modifications, enhancing the visual comprehension of the transports (Spence 2014, 4–5). © 1932–3 Transport for London

The grid still existed in navigation maps since the 14th century when it was placed in the background taking the name of *rhumbline network*. Although at that time the precision was not very accurate, rhumblines were of great help for navigators to identify the course to take. Indeed, rhumblines showed all of the direction towards important harbors, representing all the possible voyages of the ship (Jacob 2006, 127). The portolan chart in Figure 25 employs the rhumbline network to represent all the possible ways to get the harbors of a specific area through the sea. In a sense, the Affinity Map would be the portolan chart of the scholars, indicating all the potential collaborations that scholars may begin. Scholars are therefore invited to discover new paths to foster interdisciplinarity by exploring the affinities that the map makes visible through the network.

In short, the Affinity Map is a network of actual and potential affinities. Through a regular system of grids, the map offers an instrument to measure the collaborations in a regulated space. The grid offers a simplified and more readable way of interacting with the map, making visible all possible collaborations that can be pursued. The distance becomes less precise in favor of an improved readability; this equips scholars with a spatial system that enhances node visibility at the expense of a less precise representation. Measuring thus becomes easier, as the distance between nodes can be measured in steps on the grid: one step for peers who share many affinities, several steps for peers whose interests are opposed.

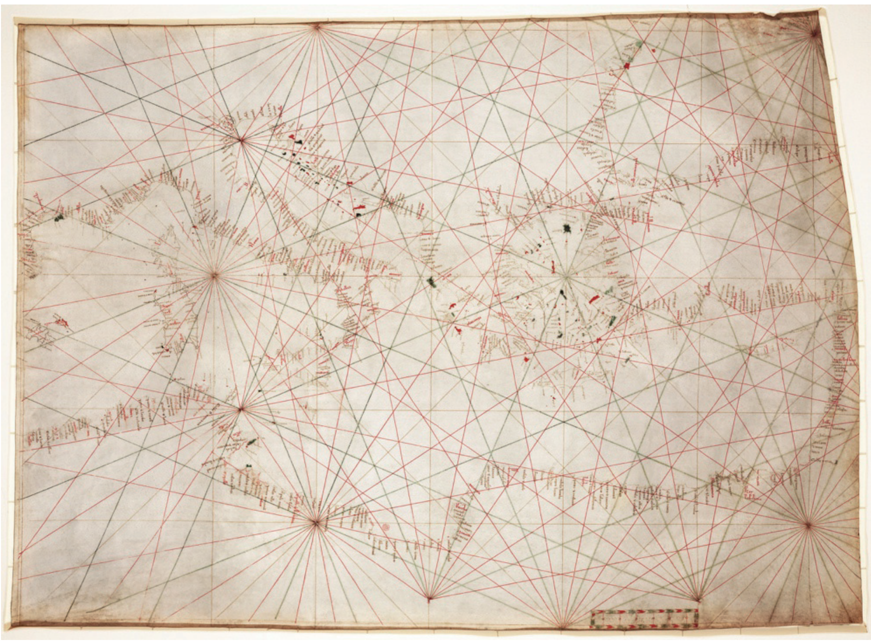


Figure 25. The Library of Congress takes care of the oldest portolan chart, which represents the Mediterranean Sea and its routes during the second quarter of the 14th century. © Library of Congress

Physiognomy of Laboratory

Nodes are more complex objects than they appear to be in today's network visualizations. A different way to draw them introduces a latent potentiality that is still hidden by an elementary graphic vocabulary. Indeed, nodes can be vectors carrying a lot of information.

Since the very beginning of the project, the Affinity Map focused on the laboratory as the pivotal element of the visualization. However, the discovery of the accreditations database revealed the richness of information related to individuals, and the individuals' data immediately brought a more interesting level of detail to the project. Collaboration has been revealed as a two-level activity, for which interactions can take place between laboratories or individuals. As a consequence, the node becomes a place where individuals are grouped, turning towards a type of graphic design that is capable of representing the interaction within a laboratory.

The rings are the graphical elements that separate individuals and laboratories (see Figure 26). Rings are represented as circles that surround laboratory members. Inside rings the visualization is scaled at the individual level, while inside rings the visualization is scaled at the laboratory level. Rings do not have the same appearance, they change color according to the institute: red for architecture, blue for civil engineering, and green for environmental engineering. The chromatic choice was made through the Lab system, a perceptive scale that can be used to create colors of the same intensity (Homann 2009, 33–57). The result is a palette that guarantees a chromatic balance among institutes.

Rings also represent the academic practice of laboratories through their thickness. The affinities of advising, publications, and teaching are quantified into the three rings, respectively from the inner to the outer. Their thickness is normalized according to the average laboratory in order to balance smaller affinities such as courses. The result is a schema that summarizes the academic practice of laboratories, as the first and third rings are related to *education* (advising and teaching) and the second ring refers to *research* (publications). For instance, a laboratory might be oriented towards research when the second ring is thicker. Otherwise, a thickness of the inner and outermost rings clearly indicates a propensity to education. It is important to note that rings do not allow the reader to make a quantitative comparison among laboratories because their total thickness is the same for each of the laboratories. With this representation, it is impossible to determine if a laboratory has published more than another one. These choices demonstrate how the ethical issues we previously discussed were tackled in order to guarantee that the Affinity Map does not become an instrument of evaluation.

The ring has a twofold importance since it works as a shell, creating an envelope around the laboratory to protect its members. This coating forms a shield that the leading professor bears, as he is the only eligible person responsible for the laboratory. Also, in the case that the map is used for evaluation purposes, the professors are indeed the only individuals to be judged for laboratory productivity. Furthermore, the rings make impossible any kind of evaluation between scholars of different laboratories by relativizing their representations.

Penetrating within the node, the laboratory scholars appear. Members are ordered by seniority through the SCIPER identifier, which indicates the first EPFL recruitment through a progressive numbering. The most senior member is situated at noon of the chord diagram, while the others follow a clockwise direction. Positions are interesting when they are associated to the individual roles. For example, a professor is usually situated at noon because of his seniority. However, sometimes a professor might appear at the bottom of the chord diagram because part of its collaborators has been previously employed as master students.

The quantitative characterization of rings also works for individuals equally. Each individual has the same parameters, which are normalized within each laboratory. Each laboratory member is associated to a triad of *arcs,* which represent advising, publications, and teaching, respectively from the inner to the outer. These arcs and the name of scholar represent the individual, and are very effective for identifying the role of laboratory members. For instance, very thick arcs usually identify professors, and a slightly lower thickness identifies senior scientists. It is noticeable how PhDs cover different levels of evolution: at the beginning they are just supervised, then over the years they advance in publications and teaching. On the contrary, secretaries, teaching assistants, and technical assistants often appear completely empty. That does not mean that their contribution is zero; rather, it signifies that digital traces do not give a precise representation of academic practice.

One interesting issue of the map is related to the display of full names. Although billions of individuals make their identity public in social networks such as Facebook, Google, or Twitter (Georges 2009), the same identities are hardly represented in data visualizations for a reason of privacy, as if there was a *fear of appearing*. Such a fear is justified in the academic environment because scholars are frequently assessed in various forms, from their peers to the management, and in different settings, from public talks to private reviews. In addition, the more a scholar is well-known, the more his work is judged by others all over the world. For that reason, the Affinity Map seriously considers the opinion of scholars in order to gradually disclose its visualization, believing that a good design should take care of individuals.

The core of the node shows laboratory collaborations through a Sankey diagram, which belongs to the family of flow diagrams (Meeks 2015, 163). The Affinity Map employs a layout called *chord diagram*, which has become common through the D3.js library for creating web-based visualizations in Javascript (Bostock, Ogievetsky, and Heer 2011). The chord diagram is a circular network representing nodes as arcs around the circumference (see Figure 26). Arcs are connected by chords, whose stem is weighted in percentages and transparency is proportional to the number. As a result, the stems show the number of collaborations and the chord transparency corresponds to the relevance of a specific connection. It is interesting to note that the arcs of a standard chord diagrams usually cover different portions of the circle, according to the total number of connections. In order to represent equally all the members of a laboratory, all their arcs need to have an equal length. This modification of the original code allows the map to draw the scholars more equally, thus giving them the same spatial importance. Furthermore, this solution makes the density of laboratories very easy to perceive.

Finally, the laboratory is completed with its acronym, which is the most visible textual element of the entire map.

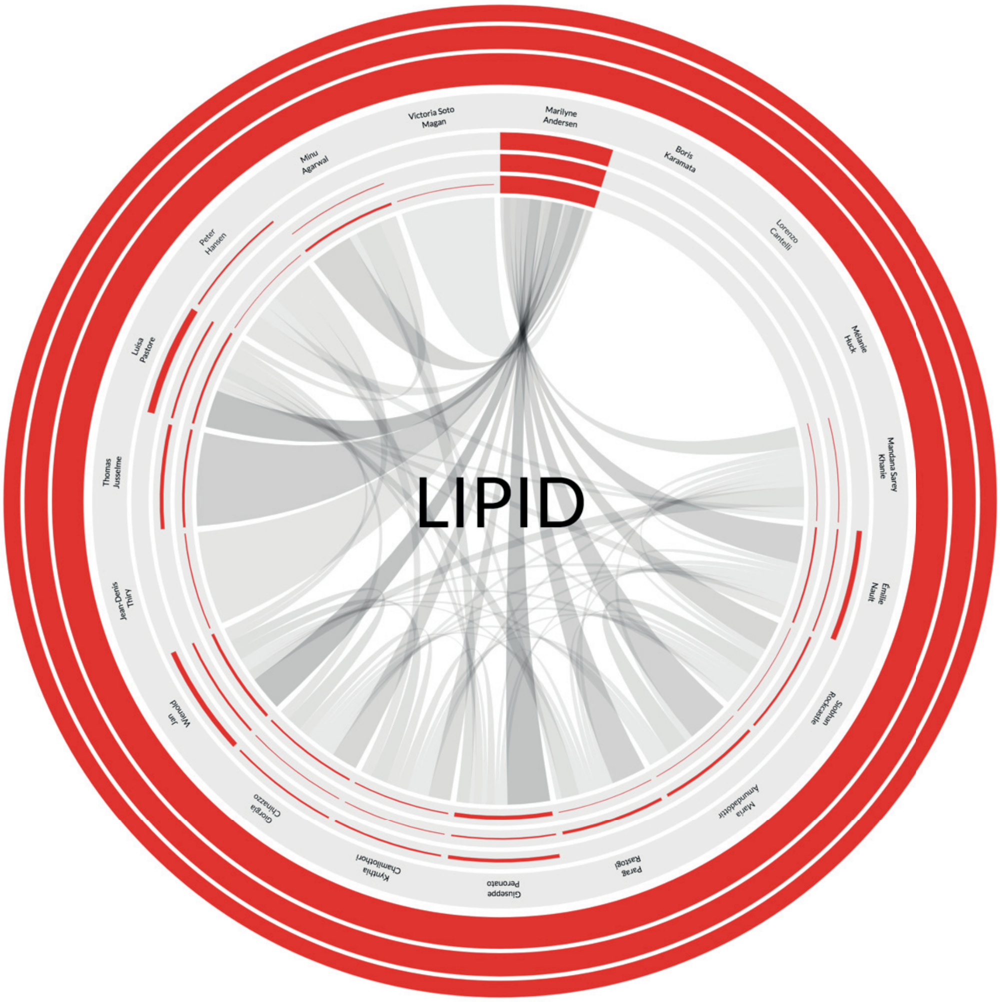


Figure 26. LIPID laboratory is shown as a node embodying individuals and collaborations; Marilyne Andersen is situated at noon as the most senior member.

Zooming Back and Forth

Zoom is the feature that modifies the standpoint of the Affinity Map. The idea is to merge the hexagonal grid and the node layout into a unique visualization, and use the zoom to move between these elements. The map appears thus as a collage regulated by a visual hierarchy populated by laboratories and individuals, which readers see by zooming in and out. Indeed, the zoom moves between two edges: the laboratory where collaboration exists at individual scale, and the school where collaboration happens between laboratories. An infinite number of possible levels of zoom exists between the two extremes, and the map-reading changes according to the elements within the frame (see Figure 27). This means that the map presents an information overload that is managed through the zoom: the more you look into detail, the more in-depth information you get. The famous concept of Ben Shneiderman called *information-seeking mantra* is therefore respected (Shneiderman 1996).

Bringing this concept to its limit, we can figure out the map as an informative space where an infinite-level of zoom returns never-ending details. The *Cosmic View* created by Kees Boeke (see Figure 28) and its remake produced by Charles and Ray Eames, *Powers of Ten*, perfectly give the idea of how the zoom should work (Boeke 1957; C. Eames and Eames 1977; Latour and Leclercq 2016).

There exists another movement of zoom that belongs to visualization panorama. A few years ago, Franco Moretti introduced the concept of *distant reading*, which is popular in Digital Humanities. For Moretti, the distant reading is 'a process of deliberate reduction and abstraction' that empowers literary scholar with visualizations (Moretti 2007, 1). In addition to the common practice of studying in front of books, otherwise called *close reading*, synoptic visualizations appear as new ways to study entire *corpora* of texts. The study becomes a back-and-forth movement between *corpus* and single books, where the general view is the door leading towards the book and the book is the vector to get back to the general view. These spaces are complementary as visualization does not replace close reading, as well as the contrary. In our case study, the Affinity Map does not replace the individual perception of the academic practice: it is rather an instrument to move forth and back between personal interpretation and collective representation.

The ENAC scholars have at their disposal two different movements of the zoom. One takes place within the interface boundaries, where readers move between the individuals and the whole school. The other one takes place between the representation and the environment represented (the Moretti's), where readers move between the academic practice and its representation. To summarize, the zoom empowers the readers to navigate into three informational levels: the level of the laboratory, the level of the school, and the level of the social environment. Readers can move across these levels in order to structure and advance their own knowledge of the working environment.

Figure 27. An example of zooming out from the LIPID *laboratory to a larger context. It is noticeable that the analogy with the work of Kees Boeke.*

Figure 28. Three different moments of Cosmic View *(Boeke 1957, 9–11). The visual language is used to explain the size of the universe. © 1957 Kees Boeke*

Orbiting Satellites

In network visualizations, links are still affected by two issues of representation that respectively concern homogeneity and overlaps. In fact, there is no answer that shows the connections' typology and, although the hexagonal pattern partially solves the overlapping, more graphic solutions are needed in order to improving readability. The Moreno paradigm illustrating friendship has not developed further: circles, lines and arrows still compose the visual grammar of networks. We add the concept of *satellites* as a further feature of the hexagonal pattern in order to advance the reader's experience.

As visible in Figure 29, satellites are objects that orbit around a specific node, indicating all its connections within the map. A single satellite is the reduction of a laboratory; their appearance is thus similar to the nodes, although the general form is reduced: individuals and internal connections are no longer visible in order to concentrate the attention on the rings.

Indeed, satellites have three rings, whose meaning is, from the inside out, supervision, publications, and teaching. However, differently from the laboratory layout, their thickness is proportional to the number of collaborations that exists between the laboratories.

Like standard links, satellite position points to the direction of the connection, but unlike links, their position from the mother node represents the relative distance within the entire network. That means that the smaller the satellite orbit is, the closer the subtended node is. As a result, satellites create an *ego-centered network* representing the summary of all the nodes' connections (Scott 2000, 72). However, contrary to ego-centered networks that are presented independently, the Affinity Map displays all the ego-centered networks at the same time. The reader can therefore see the context of a specific node at a glance, without being obligated to look around the map. By doing that, satellites form a contextual neighborhood of connections, and the map reader no longer needs to follow a line to get to the corresponding node.

Satellites situate themselves in a middle space that exists between the global map and the local laboratories. In a way, they connect the two zoom levels through an intermediate layer, which belongs to both of them and claims a proper independence. When zooming on the laboratories, the satellites show the number and the type of connections. Furthermore, it is possible to read the interdisciplinarity of a laboratory through the institutes' colors that characterize the rings. For example, satellites show if the laboratory collaborations focus on research or education, or take place within or outside the institute. On the contrary, when zooming out towards the map, satellites show more of the general behavior of a specific ensemble of laboratories.

Satellites are a solution for the high connectivity of network visualizations. Indeed, when the network accounts for many links running into each other, reading connections is hard. Since links are not visible in high-connected networks, the nodes position is the only information available to the reading. The satellites are a way to stabilize again the balance between node positions and link connectivity. Furthermore, this solution is suitable to be associated with the hexagonal grid. The use of these two principles assures a major rigor in satellite positions, distributing them on the three axes corresponding to the hexagonal pattern.

Figure 29. The laboratory LIPID features eight satellites, which correspond to its external collaborations. The satellites indicate that the laboratory has several collaborations with all the institutes of the ENAC. In particular, these collaborations concern education, which is represented by advising and teaching activities – respectively shown in the inner and outer rings of the nodes. A special affinity takes place at LAST, with which LIPID shares all collaboration typology.

Keywords as Potential Affinities

In addition to actual affinities, an important effort was put on potential affinities. These correspond to all the possible relations that a laboratory may explore in order to advance in terms of collaboration. This section introduces a method to represent potential affinities.

Keywords are the result of a lexical analysis computed on the entire corpus of ENAC publications that are stored in the Infoscience database. Keyword extraction usually relies on full-text publications, but that was not possible due to copyright infringements on reserved material and the low quality of PDF files. As a result, the keyword extraction was applied to abstracts in order to create potential affinities.

The extraction system is based on a lexical principle: a *textual entity*, which corresponds to a single word, is defined by its difference from the entire corpus. As a result, a set of keywords differentiate an abstract from the entire collection. This method allows for the removal of common words such as definite and indefinite articles. Furthermore, keywords are characterized by a weight that indicates their own relevancy for a specific abstract. This value might applied at different levels. For example, keywords might be calculated according to a set of publications related to a unique laboratory. Considering that the Affinity Map follows a logic related to individuals, the publication abstracts were processed to generate a lexical distance among them. This distance is translated into a network of individuals and keywords that are connected through weighted relations. Succesively, keywords are grouped into laboratories in order to create a structure of potential affinities between laboratory nodes. Why apply the computation to individuals? The main reason is the generation of a certain scalability: keywords for individuals guarantee a map elasticity that can be adapted not only to individuals, but also to laboratories and institutes for further uses.

Once potential affinities were created, there was a displaying issue to solve: how to visualize keywords on the map? The nominal data are very important in visualizations and their use can be fundamental to clarify the meaning (Meirelles 2013, 187). The solution was offered by the hexagonal grid that creates regular triangular spaces where keywords can be accommodated. The idea is to show common keywords between two laboratories when they get close to each other. When laboratories are side by side because of the network configuration, a list of shared keywords is displayed between the nodes in order to show the shared subjects of research (see Figure 30). Furthermore, font color changes according to the type of proximity: black corresponds to actual affinities, while gray means potential affinities. Collaborations are thus easy to identify and the map benefits of another layer of information. Indeed, displaying keywords creates a permeation between two information spaces: the network space that relies on distances between units is integrated with a semantic space that is based on keywords which circulate freely among nodes. Collaborations and subjects of research find a common visualization ground, complementing each other.

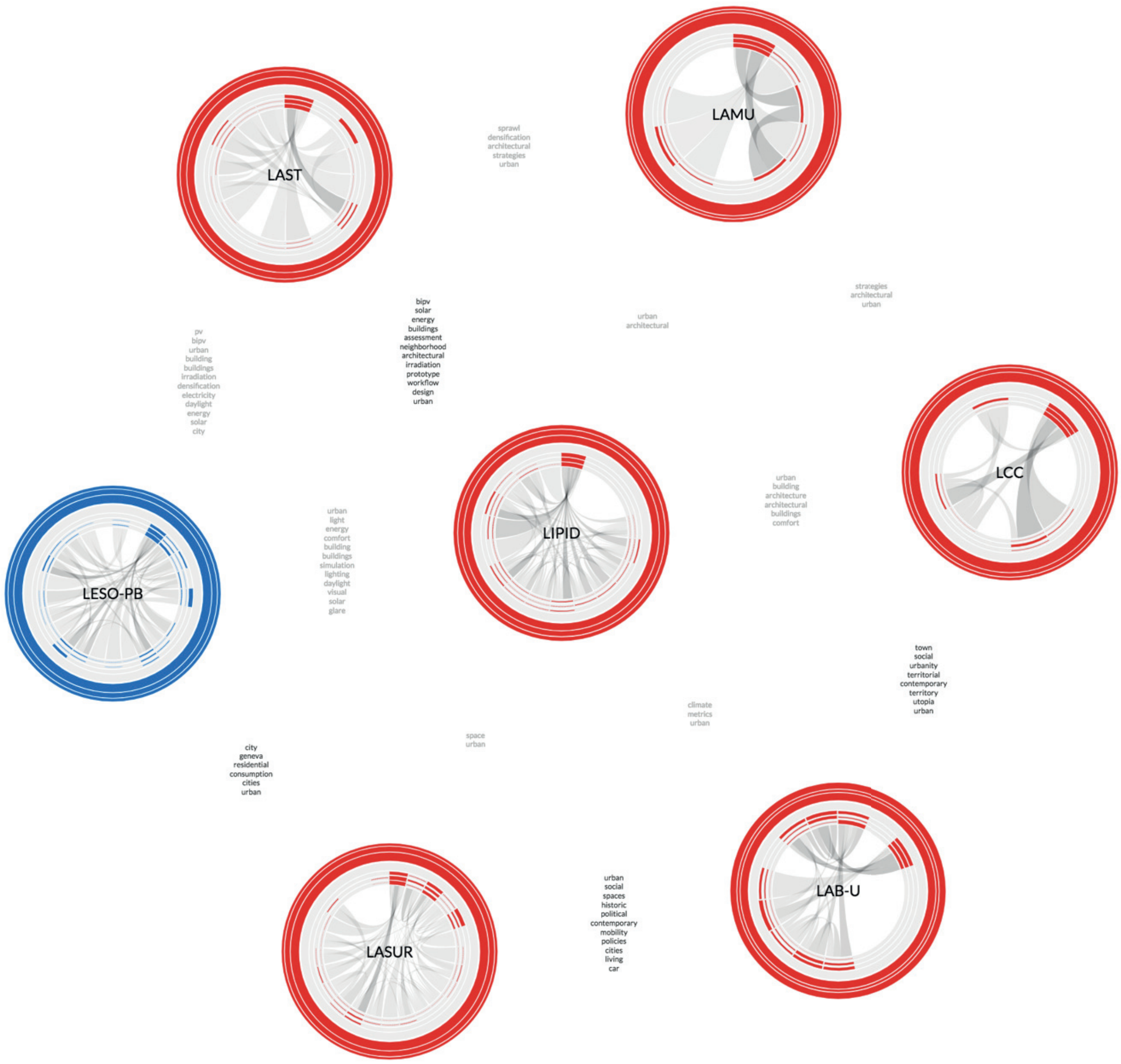


Figure 30. The image shows the LIPID laboratory in its neighborhood, which is composed of six other laboratories. Space between close laboratories is filled with shared keywords, which are in black when a collaboration is ongoing.

Constellations of Affinities

Between the 16th and the 18th centuries a large number of star atlases were printed (Kanas 2007, 1). These atlases were organized according to configurations of stars; each page displayed a particular configuration of stars, making the book a long sequence of constellations. Yet the real meaning of constellations stays in the star recognition. That is a method which reminds us of a particular pattern in the sky used to identify single stars, which were used for sea navigation. Ancient cultures also believed that star alignments were spectacular patterns adopted by gods to tell a story. In a sense, today a configuration of stars, cities, or laboratories is still a way to both refer to single elements and to tell stories.

The Affinity Map is therefore an instrument to see stories. As characters, the laboratories and the individuals have different stories to tell about education or research and, as a result, the map assumes different configurations. The map changes according to the selected affinities indeed, which might be actual or potential.

The resulting constellations feature two characteristics: the position and the intensity of laboratories. If the position is given by network forces acting on the Cartesian plane, the laboratory rings change intensity according to the three actual affinities. When a specific configuration is selected, the relative rings are brighter in both nodes, and satellites are seen as a metaphor of the star brightness.

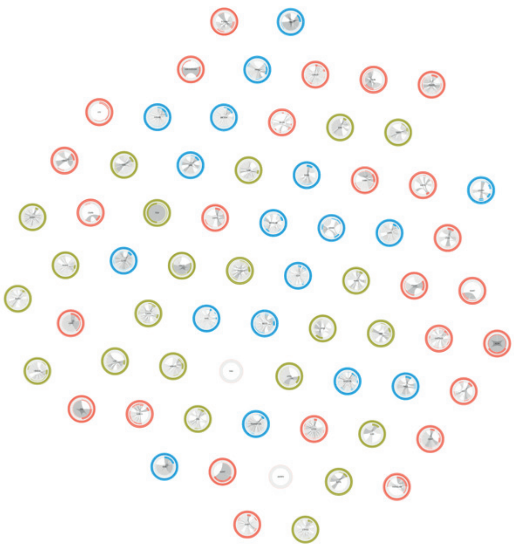


Figure 31. ENAC constellation without links.

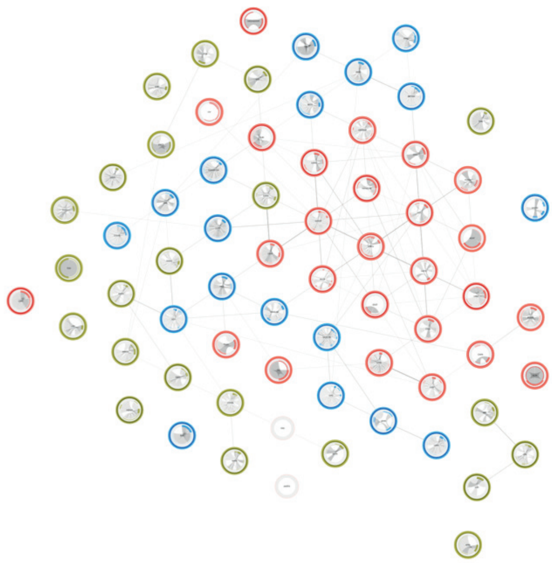


Figure 32. ENAC constellation of advising.

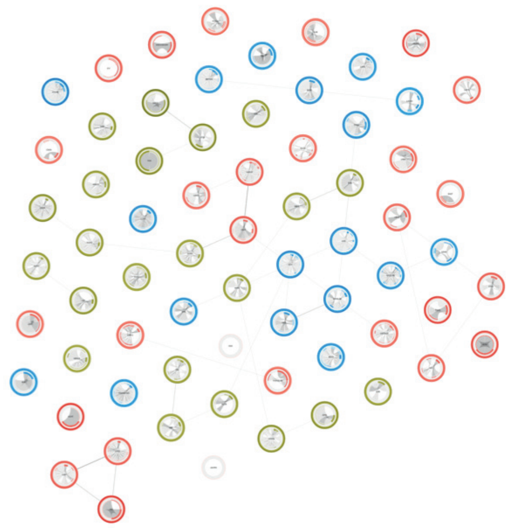


Figure 33. ENAC constellation of publications.

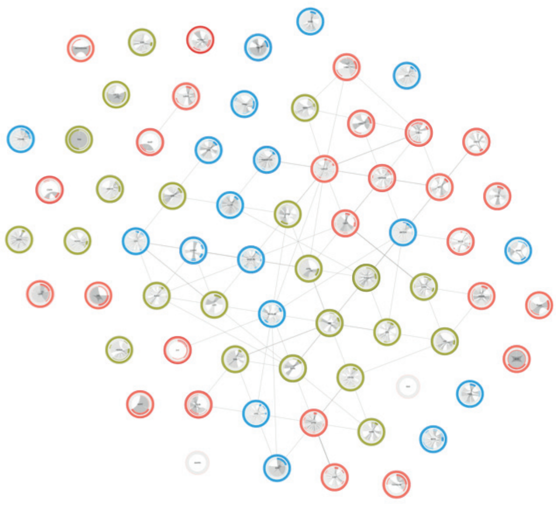


Figure 34. ENAC constellation of teaching.

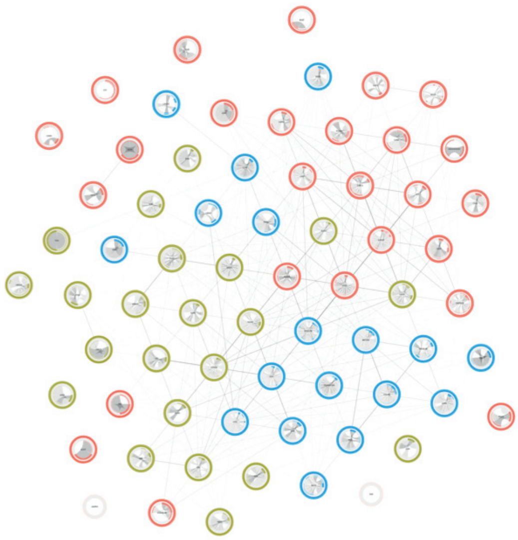


Figure 35. ENAC constellation of keywords.

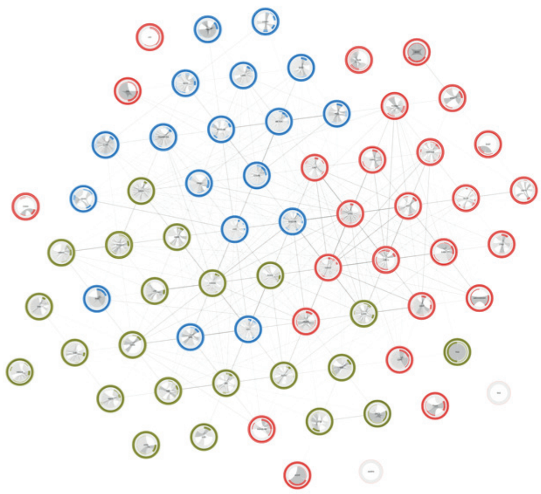


Figure 36. ENAC constellation with all affinities.

Journey from Micro to Macro

The best way to understand the map is to handle it as an instrument. If you are reading this section I hope you have a copy of the map on paper, or otherwise a digital version. Properly preparing to read the map is particularly recommended since the Affinity Map features a high-density visualization. As expected for sophisticated instruments, the map takes time and demands diligence. This section is a short handbook for its use. The map is presented using the movement of zooming out, which begins from Professor Jacques Lévy and ends with an overview of the whole school. This movement goes through the CHÔROS laboratory and the institute of architecture. The specific sequence of figures shows a visual progression from the individual to the whole organization.

Looking at Jacques Lévy

Professor Jacques Lévy is represented through three red arcs, and the same color is used as for the faculty of architecture. The arcs signify, from the inside out, the number of advising scholars, publishing, and teaching activities, for which Lévy has a full score. Jacques Lévy is situated between Monique Ruzicka-Rossier and Boris Beaude. The three peers are arranged in chronological order by clockwise disposition; this means that Ruzicka-Rossier joined the EPFL before Lévy, and Beaude enrolled after. All of them cover different roles in CHÔROS, and that is visible through the relative configuration of arcs. We see that Ruzicka-Rossier is very active in education, Lévy appears as the director of the laboratory, and Beaude has the role of a senior scientist. It is important to note that quantitative data are used to view the roles of individuals, and not for evaluation purposes. Arcs, in fact, are normalized at the laboratory level, making any comparison with other laboratories impossible, and they do not present any tabular data.

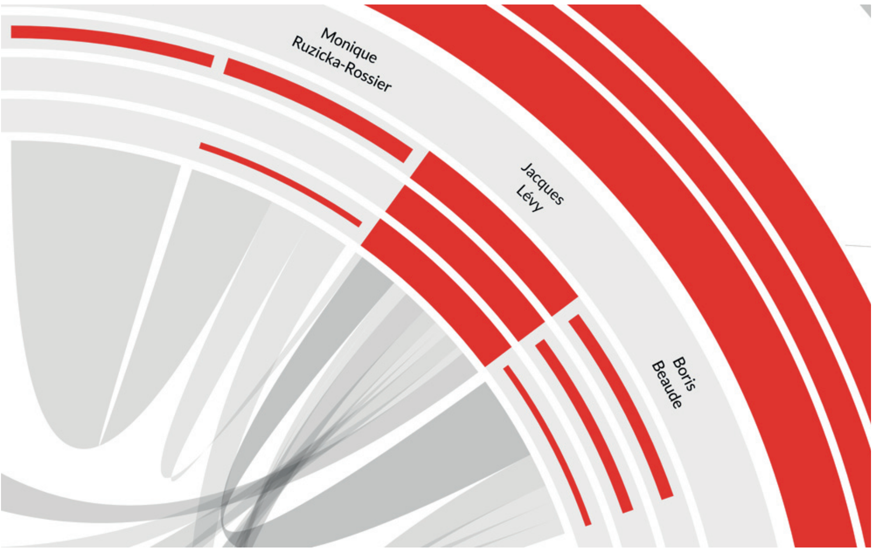


Figure 37. Zooming out from the CHÔROS laboratory 1/7.

Zooming out to CHÔROS Laboratory

The laboratory's image is composed of individuals who are arranged in a clockwise direction starting at noon from their first accreditation. That means that Dominique Von Der Mühll and Patrick Poncet are respectively the first and the last employees that joined the EPFL. Looking at individuals arranged around that circle, who are represented by arcs and names, we notice that different practices exist within the same laboratory. Further, we notice that these practices, quantified with the arcs, help in defining their role within the unit – as usual, the arcs represent advising, publications, and teaching.

Professors such as Lévy usually collect the maximum score in all the quantitative indexes, and senior scientists such as Boris Beaude have slightly lower values. The rest of the scholars belong to postdoc and PhD candidate categories, and they feature at least one affinity of advising towards their director, or towards multiple directors if co-advised. Then, they generally publish at a certain point of their career such as Carole Lanoix, or even teach such as in the case of Mirza Tursić. Their practice may consist of the whole typology, as demonstrated by Jean-Nicolas Fauchille, who over the course of 2016 changed his status from PhD student to senior scientist. However, some of these data cannot be represented, as in the case of the secretary Luana Huguenin who appears *empty*. The case of teaching assistants, who are notably professionals helping professors during courses, is more complicated. Although this case mainly concerns the architecture department, these individuals appear empty even if they are part of the teaching activities.

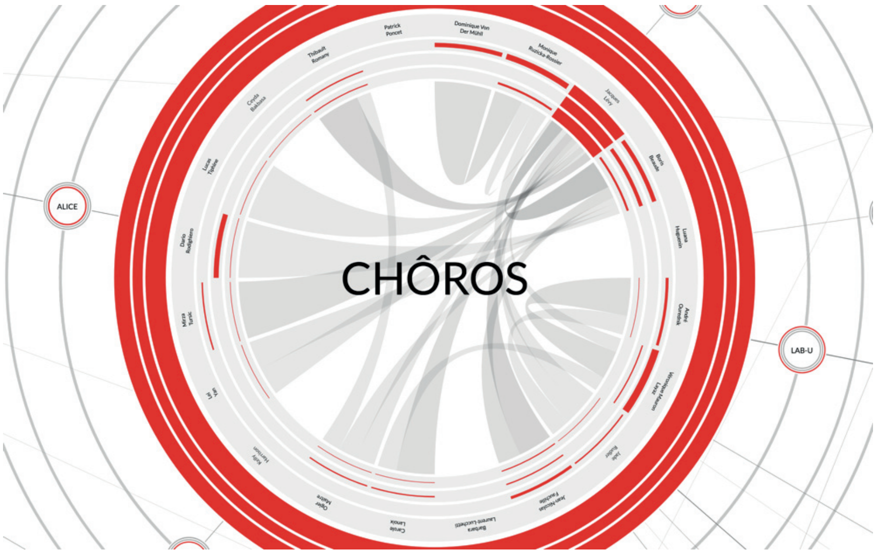


Figure 38. Zooming out from the CHÔROS laboratory 2/7.

Internal Organization

Collaborations within a specific laboratory are visible through a chord diagram that occupies the very center. Looking at these chords, it is visible that Jacques Lévy and Boris Beaude are particularly collaborative with the other laboratory peers and, furthermore, they share different affinities. Lévy also shares affinities with Jean-Nicolas Fauchille, Mirza Tursić, and Thibault Romany, with whom he has more than one collaboration, as represented by the opacity of the chord.

In general, the CHÔROS collaborations are more distributed compared to other laboratories that are professor-centric. A reason for that is the high presence of senior members in the laboratory, herein listed by SCIPER numbers: Ruzicka-Rossier, Lévy, Beaude, Mauron Layaz, and Fauchille, who notably supervise the younger laboratory members.

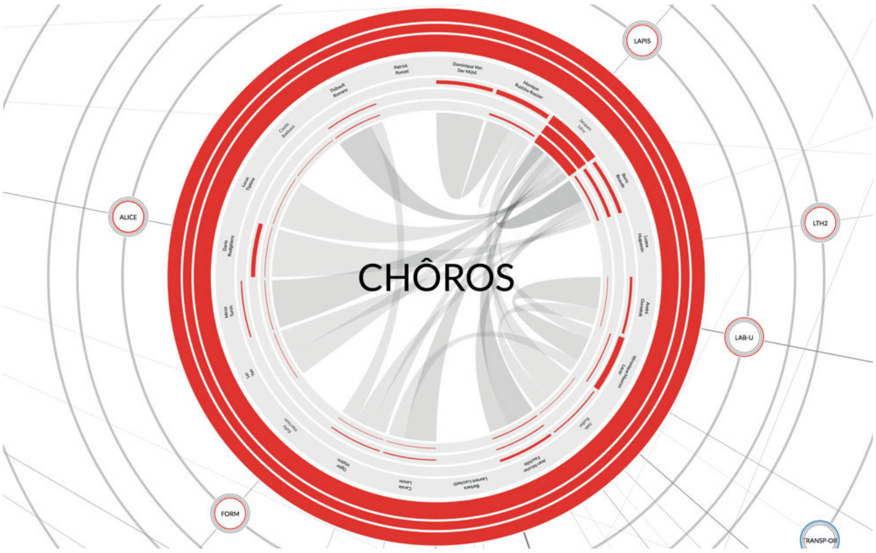


Figure 39. Zooming out from the CHÔROS laboratory 3/7.

Protective chrysalis

It is noticeable that CHÔROS has an inclination towards education, a characteristic that particularly belongs to laboratories that are part of the architecture institute. This is visible through the rings that delimit the laboratory. Indeed, we can deduce the practice of the laboratory from the ring's thickness. CHÔROS is charaterized by a tickness of the inner-most and the outer-most rings, which represent respectively advising and teaching.

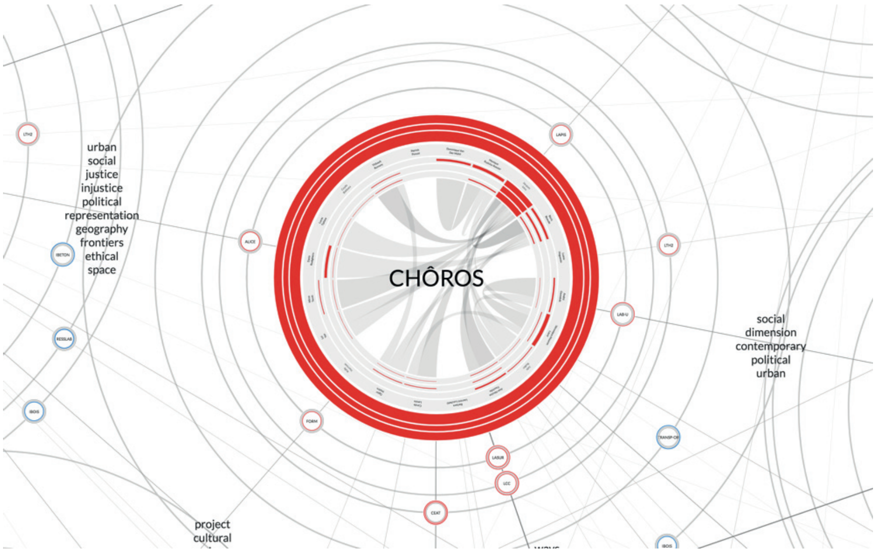


Figure 40. Zooming out from the CHÔROS laboratory 4/7.

External Collaborations

The floating objects outside the rings are the satellites, which represent the collaborations at the laboratory level. Satellites orbit around nodes; this kind of representation helps to see that CHÔROS cooperates with ten laboratories, which mainly belong to the institute of architecture. Looking more carefully at the rings that characterize each satellite, we realize that collaborations are mainly based on advising and teaching activities, and only one publication is the result of a collaboration inter-laboratories. We may claim, thus, that CHÔROS is more oriented to collaborate with other laboratories for everything concerning education.

Figure 41. Zooming out from the CHÔROS laboratory 5/7.

Neighborhood

Zooming out allows us to localize CHÔROS in the context of ENAC school, which is defined by actual and potential affinities. The hexagonal distribution consists of six laboratories, which are associated to the institute of architecture. This situation confirms what was visible through the satellites, that is CHÔROS is well situated inside the institute. The regular space, which is defined by the distances among the laboratories, is occupied by keywords that represent the shared lexicon with other laboratories. Each space between two laboratories is thus defined by the keywords that the two laboratories share. For example, CHÔROS shares keywords with five laboratories: namely LAB-U, LASUR, ALICE, LTH-TWO, and Archizoom. The space between CHÔROS and LASUR is populated with the following keywords: *ways*, *space*, *cultural*, *individuals*, *contemporary*, *political*, *social*, and *urban*. It is interesting to notice that keywords have two slightly different colors to spot actual and potential affinities. In this case, CHÔROS effectively collaborates with LAB-U, LASUR, ALICE, and LTH-TWO, while it has a potential collaboration with Archizoom.

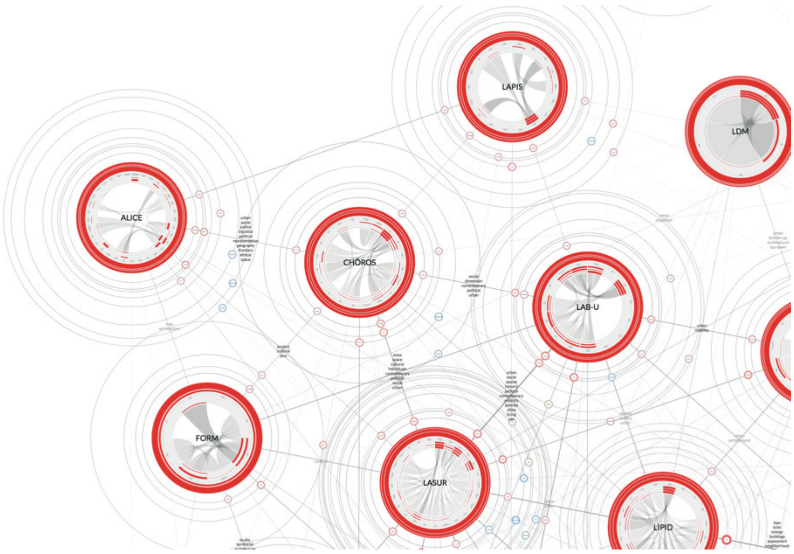


Figure 42. Zooming out from the CHÔROS laboratory 6/7.

Looking at the Whole

Zooming out to view the whole ENAC network, we notice that CHÔROS is well situated in the discipline of architecture. From a further distance, satellites become too tiny to be readable and the focus moves on laboratories' affinities. As previously said we have four types of force, namely three affinities plus the keywords that are calculated from the corpus of publication abstracts. These forces can be activated and deactivated, generating new network configurations that offer different insights.

The publication network reaffirms what was visible through satellites, that is CHÔROS shares only one publication. However, looking at the school configuration, very few laboratories published together in 2016.

The advising network shows that not only CHÔROS, but that all the institute of architecture is particularly active in supervising students. The institutes of civil and environmental engineering do not show the same level of unity.

The teaching network is, on the contrary, particularly mixed. CHÔROS confirms its activity within the institute, showing its strongest connection with LCC and CEAT.

The keyword network, differently from other configurations, situates CHÔROS in a network of potential affinities. That configuration identifies possible collaborations with three laboratories, namely LABA, LAST, and LAMU.

These observations were as objective as possible, but every reading of the Affinity Map is subjective. The next section is dedicated to the readers and their perceptions, insights, and capacity to recognize themselves in a data visualization.

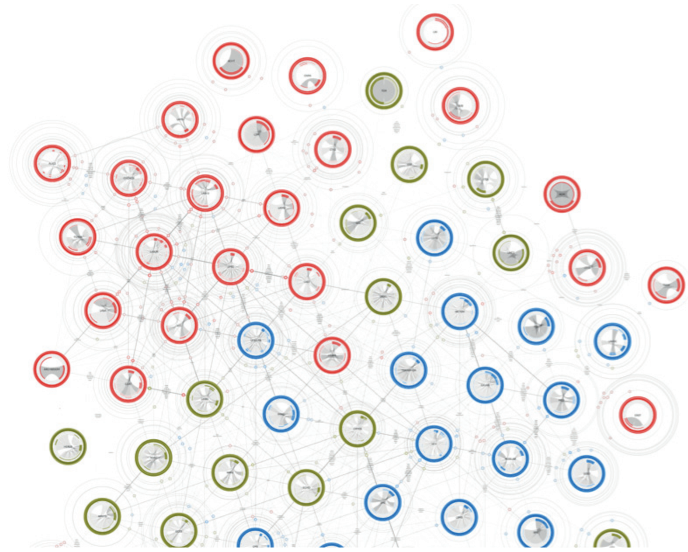


Figure 43. Zooming out from the CHÔROS laboratory 7/7.

Reading

The previous chapters described the creation of the Affinity Map, focusing on the visualization design. This chapter is a shift towards another important subject that occurs when the production of the map is completed, that is the *reading*. Although reading usually has to do with learning from textual objects such as books and journals, even a visual instrument as the map is associated with the action of reading; the aim of reading is the understanding of the visual information presented on the map (see the Oxford Dictionary of English under heading *read*). The choice of this term was justified by the fact that interactions with images are often associated with verbs like seeing, viewing, looking at, observing, contemplating, and eyeing, which do not give the idea of an action aimed at understanding visualizations. The reading is thus intended as the structured action used to learn from the Affinity Map.

The chapter describes the reading of the Affinity Map through three sections. In the first one, we introduce the role of the reader in the visualization lifecycle, and we examine the reader in action, during the act of self-recognition through images. In the second section, this generic framework is tailored to the ENAC case study and its audience, the management, the scholar, and the general public. We also explain how the map design is actualized into physical objects, which we refer to as *actualizations* (Deleuze and Parnet 2007, 148–152). These actualizations have a central role in the interviews realized with ENAC scholar to assess the reception of the map. In the third section, the reading of the audience is analyzed to argue that the interpretation is not simply subjective, but rather it is *collectively subjective*. Furthermore, the importance of the setting of reading is analyzed in terms of the environment that contains the map, with a special attention to the opportunities that each environment offers, even known as *affordances* (Gibson 2015).

Introducing the Reader

Human and non-human actors play main roles in reading the visualization. We discussed the role of the designer and the impact of various constraints within the design process so far, so now it is the time to introduce another main human actor, the *reader*.

The reader is the reason for creating a visualization, as he is the consumer. His role is as important as the role of the designer; indeed, both contribute to making the visualization alive. Marcel Duchamp was aware of the reader, as he reveals in a recording, where he refers to the essence of the art as the relationship between artwork and spectator, which is the aim of each artist (Duchamp 1994). Keeping artwork locked away means preventing this relationship and depriving the artwork of all its meaning. Likewise, visualizations have a sense when this relationship takes place, making the reader the main actor of the representation. Without the reader, the visualization is pointless.

However, the art of reading is not confined into this duality between reader and designer, since its context is larger and richer. For example, Roland Barthes submerges himself in the reading of photography, which is, for all intents and purposes, a representation as much as a visualization (1981). Indeed, his analysis fits photography as well as visualizations. In *Camera Lucida*, Bathes describes him looking at a photograph taken in 1852 of Napoleon's youngest brother, Jerome. This photograph caused interest and curiosity to Barthes but not to his interlocutors, who were uninterested in the phrase he used to express his thoughts, which was 'I am looking at eyes that looked at the Emperor.'

The essence of Barthes' exercise was in breaking down the photographic object into its constituents. Tracing back his phrase, we are able to reconstruct the context of the photograph. The first term he uses is 'I' – that corresponds to the observer, otherwise known as the individual looking at the picture. The 'eyes' word refers to Jerome, the subject of the photograph. Then Barthes attention shifts to the 'Emperor,' which had been reflected in the eyes of his brother, but that also corresponds to all the visages that Jerome encountered in his life. Among these is also included the photographer who took the picture. The portrait is therefore composed respectively by the *spectator*, the *spectrum*, and the *operator* (Barthes 1981, 9). With respect to the visualization discipline, these actors correspond to the *reader*, the *subject*, and the *designer*.

These roles stay for more generic and interchangeable actors: for example, the designer is not necessarily the visualization maker; the visualization maker could also be the mapmaker, the engineer, or the software developer. More specifically, we are not obliged to think to the designer as an individual, the designer could be represented by a team. The very same might even happen for the reader. To think about the reader as a unique individual interacting with a visualization is reductive, especially because a visualization is a tool offered to an audience. The Affinity Map is specifically concerned with the case where the reader is in fact a collective of scholars, namely a scientific organization. In particular, the map represents the collective of scholars as the subject of the visualization itself. Imitating Roland Barthes, we might understand the interest when a reader looks at a photograph representing himself (Barthes 1981, 12). The fusion between the reader and the subject creates a specific configuration, which is illustrated in Figure 44.

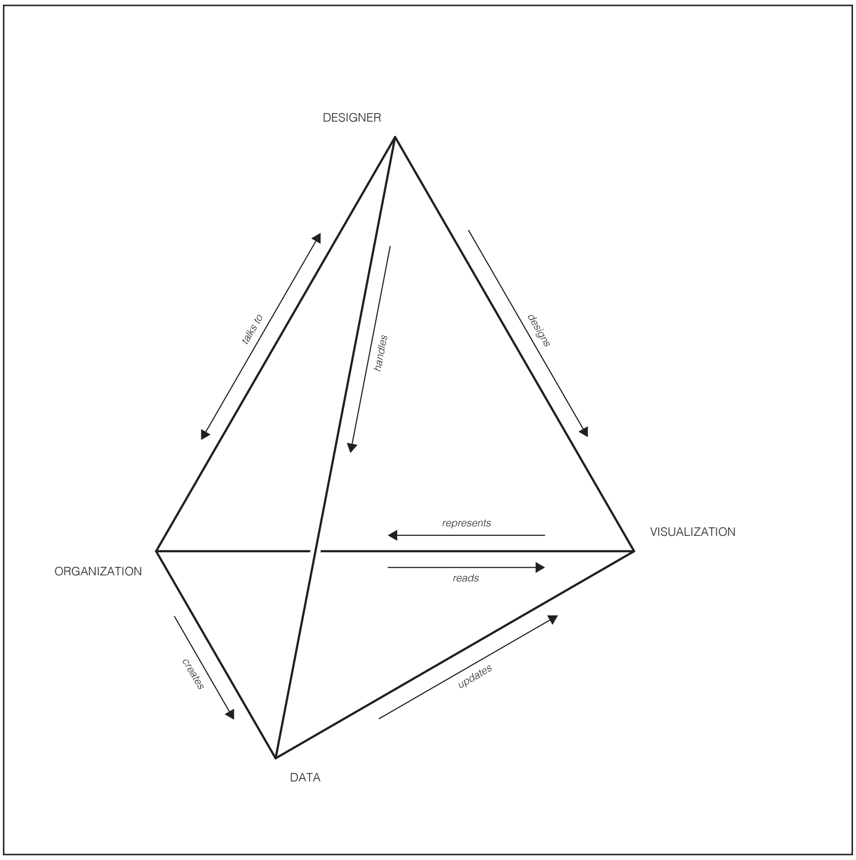


Figure 44. The pyramid of visualization shows human and non-human actors that are situated according to their interactions.

The pyramidal diagram of Figure 44 shows the visualization context, which considers both the creation and the consumption of the map. The figure counts four actors, in clockwise order from noon: the *designer*, the *visualization*, the *data*, and the *organization*. The pyramid illustrates how these actors are intertwined with each other, with specific attention paid to the direction of actions.

The *designer* remixes available data (Manovich 2007), transforming them into visual language, otherwise known as the visualization itself. The term 'remix,' in particular, identifies a manual skill with data, which are the raw material employed for the creation of the visualization. The designer manipulates, transforms, and modifies these data. This operation might be more effective when the designer creates a dialogue with the organization that produces data. In fact, in the case of the Affinity Map, data correspond to the academic practice that scholars perform daily and, in that sense, are a direct production of the organization. Through that dialogue, the designer improves his comprehension of data and helps the organization to improve their quality and richness.

The *organization* is thus in dialogue with the designer to help contribute to the process of design with comments and remarks, as well as to improve the quality and the richness of digital traces through the data. Once the visualization is released, the role of the scientific collective changes, assuming the role of the reader. The scientific collective sees itself in the visualization, which represents the academic practice of the organization.

Non-human *visualization* and *data* are fundamental characters in the visualization pyramid, as they are pivotal elements in the process of translation (see page 5). Indeed, data and visualization coexist almost like in a symbiosis relationship, which represents the connectivity between the social reality of the scientific organization and its representation. The next section will disentangle the profiles of the designer and the reader in two cycles, which can converge towards a unique and continuous movement that illustrates the lifecycle of visualization.

Visualization Lifecycle

At ENAC school, the process of design is presented as a sequence of operations. Bruno Munari (1983, 35) illustrates this sequence step by step: the definition of the problem, the constraints, the data analysis, the creative process, the model, and the tests, until there is a final solution.

Furthermore, that design process might be turned totally or partially into an iterative one in order to improve a specific sequence. For example, the pencil we use to take notes is the result of centuries and centuries of design iteration. Conversely, the visualization today is the result of a design process that takes place in a shorter period with more iterations.

This process is summarized in the left side of Figure 45. Simply put, the visualization cycle is organized in four steps: (A) the collection of digital traces, which comprise all the data associated with a specific subject, (B) the design, which is intended as the process that gives shape to the artifact, (C) the materialization, which is the transformation of the plan into digital or physical form in order to make it accessible, (D) the visualization, which is the outcome of this cycle.

As previously stated, this outcome can be modified by further iterations when the product does not live up to the expectations. On the opposite side, as shown on the right side of Figure 45, the reading cycle is organized as well into four steps: (A) the reading of the visualization gives information to the reader, modifying or confirming his perception of the subject represented, (B) the comprehension enriches the reader and, consequently, modifies his practice, (C) the practice is transformed into digital form, (D) these digital traces can be employed to create visualizations.

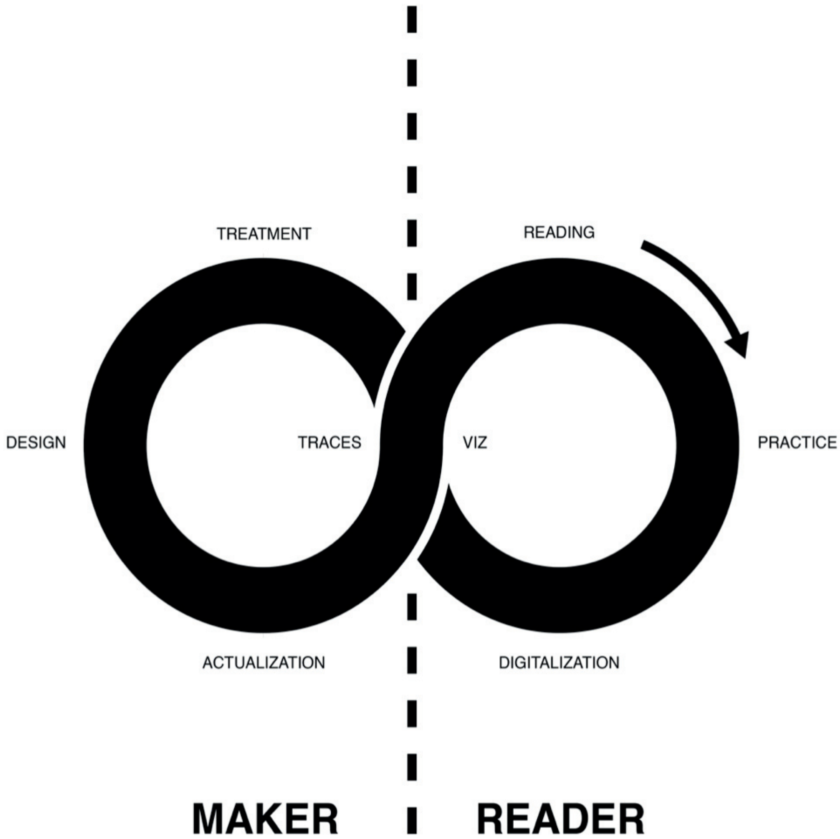


Figure 45. The cycles of design and reading, on the left and the right of the image, are mix into a unique diagram that shows their mutual influence.

In Cultural Studies, this cycle is commonly used to depict the relation between the representation and its interpretation, which is generally applied to images such as advertisements or television (Johnson 1986; S. Hall 1997).

The two cycles are joined in a unique diagram that we call the *visualization lifecycle* (see Figure 45). This approach reinforces the duality that exists between the creation and the use of visualizations, identifying an overlap where digital traces and visualization occupy the same position in the Cartesian space. This overlap represents the *correspondence* between the data and the visualization, which are two sides of the same coin (Latour 2013, 71). These spaces that present a break in the continuity are related by two operations, the projection and the reading, both of which correspond to different directions. The projection is the correspondence created by the designer through a process of data transformation, whose outcome is the map. However, opposite to the designer correspondence, it exists the reader's correspondence, which produces the personal correspondence from the sign on the map to the memory of the reader. For example, Bruno Latour refers to the reading as the action that infuses the signs on the map of meaning (2013, 79). This double-directed connectivity creates an alignment between the mapmaker and the reader, creating a *continuity* that brings together the two spaces.

The Affinity Map already infuses its signs with a semiotic correspondence to individuals, laboratories, and affinities, integrating a connectivity *a priori* (Atkin 2006; Rodighiero 2015). However, the correspondence brings a more human approach to the map reading by placing emphasis on the individuality of the reader. The next section will explore the intimate way through which each individual relates to the visualization, making each map interpretation unique.

Humanistic Approach to Interpretation

Representation and digital traces creates a correspondence that runs in both directions. While one correspondence results from the design process, the other is the consequence of the action of reading. The interpretation, which is unique to all of the readers, takes place in a space that is embraced by the visualization and the reader. Indeed, there is not just one way to look at a visualization, because reading does not just correspond to looking at just one object; indeed, as Berger states, 'we are always looking at the relation between things and ourselves' (Berger 1972, 9).

Therefore, there is also more than one way to interpret a visualization and there is no absolute right or wrong way to read it (Rose 2001, 101). Each reading differs from the other because each individual and each day are different. Hal Foster refers to what we call reading as the *visuality*. In the preface of *Vision and visuality*, he defines the *vision* as the physical operation that human beings perform when they look at something, and the *visuality* as a social and historical conscience that composes the *culture*, which is employed to understand an image (Foster 1988, IX). Doing that, Foster places a division between the nature and the culture, the body and the psyche, the vision and the visuality. However, the division between the body and the psyche is not a threshold that can be identified easily. In fact, an experiment that goes back to the fifties demonstrates that the frog's eyes are capable of basic cognitive operations by perceiving specific movements (Lettvin et al. 1959; Halpern 2014, 199–200). As a consequence, the body and the mind cannot be divided, the eyes and the brain are organs that work in synchronization. We prefer to say that vision and visuality are two meanings of the same action, corresponding respectively to the acts of looking and interpreting images.

This emerging question about the role of interpretation, captivates scholars from different disciplines, ranging from cartography to digital humanities. The geographer John B. Harley claims that the map is not rooted in scientific positivism because the representation does not correspond exactly to the reality (Harley 1989, 2) and the reader has to be aware of that mismatch. As a result, the reading becomes looser leaving room for interpretation. The only way to reinforce the reading stays in through the correspondence that bring together the representation and the reader. Also the visual theorist Johanna Drucker refers to the interpretation as a 'subjective expression of perceived phenomena' (Drucker 2011§ 14), saying that *subjectivity* – or individual culture, if we want to use the words of Hal Foster – influences the approach to any visualization.

Recently visualization has progressed and new visual languages have been introduced. As a consequence, a renovate sensitiveness is needed in terms of approach of reading (Lupi 2016) and education (Dondis 1974).

Self and Collective Recognition

With respect to the visualization, one major aspect that affects the Affinity Map reading is self-recognition. This is a basic operation of reading that interests a specific case: when the reader is represented in the visualization (Rodighiero and Cellard 2016). As in a city map, the individual looks at their own position, and it is natural for the reader to then locate itself in the visualization and start the reading from there.

Roland Barthes was fascinated by the semiology and the meaning of the photography, and the role of its subject. Indeed, photography is an asynchronous technique that transforms the individual photographed into an object (Barthes 1981, 13). The portrait is an experience that differs from looking in the mirror. When the mirror gives you back an image of yourself, you are in control of it because you decide when, where, the position, the lighting, the duration, etc. When you are the photographer's subject, there is a practitioner in front of you who decides the general setting of the shot; you do not have control anymore. Likewise, a visualization is a third-party production as well; you do not control it, but you can comprehend the mechanism behind it. That mechanism therefore might be *transparent*. You can understand the metric, for example, that regulates a visualization and better comprehend the meaning of your situation. With respect to photography, Barthes was displeased because his photograph did not represent the Barthes' own self (Barthes 1981, 12). But the photography becomes clearer when he understood the purposes and the point of view of the photographer (Barthes 1981, 27–28). This transparency of intention is fundamental to create empathy between the reader and the designer.

Once the intentions and the metrics of the visualizations are clear, the reader can look at his situation and analyze it: is my position appropriate or not? That is a fair question that the map designer should have posed to himself. The evaluation of one's own position is an important operation because it deals with a general agreement from the reader of the map. If his position is fair, the reader can agree with the visualization, otherwise the sentiment is negative and the visualization does not correspond to his point of view for many reasons: a metric error, the incompleteness of information, or a reality that cannot be accepted.

The Affinity Map is more complicated than that. In fact, the map provides a representation of a *collective of individuals* and the reader is composed by the sum of all the individuals represented. As we wrote in the second chapter, the Affinity Map represents a collective of research that comprises almost one thousand scholars. That means that each of them is a potential reader of the map and recognizing the Affinity Map as a collective agreement is required.

Furthermore, the recognition does not have an impact only on individuals, but also on laboratories. As a result, an agreement at three different levels exists, which interests the individuals, the laboratories, and the whole school. But how is it possible to obtain a collective agreement? For example, the laboratory's representation might be agreed upon by its members or a professor in the role of leader. The same might be true for the entire map: there is the opinion of all the professors as well as the opinion of the management. Figure 46 summarizes the possible configuration of reading.

Since it was difficult to collect the opinion of ENAC scholars in the form of a questionnaire, we preferred to prove the collective agreement through interviews. Despite the number of interviewees was limited, interviews brought precise observations and interesting reflections. The next section will illustrate the structure of interviews, the selected audience, and the outcomes.

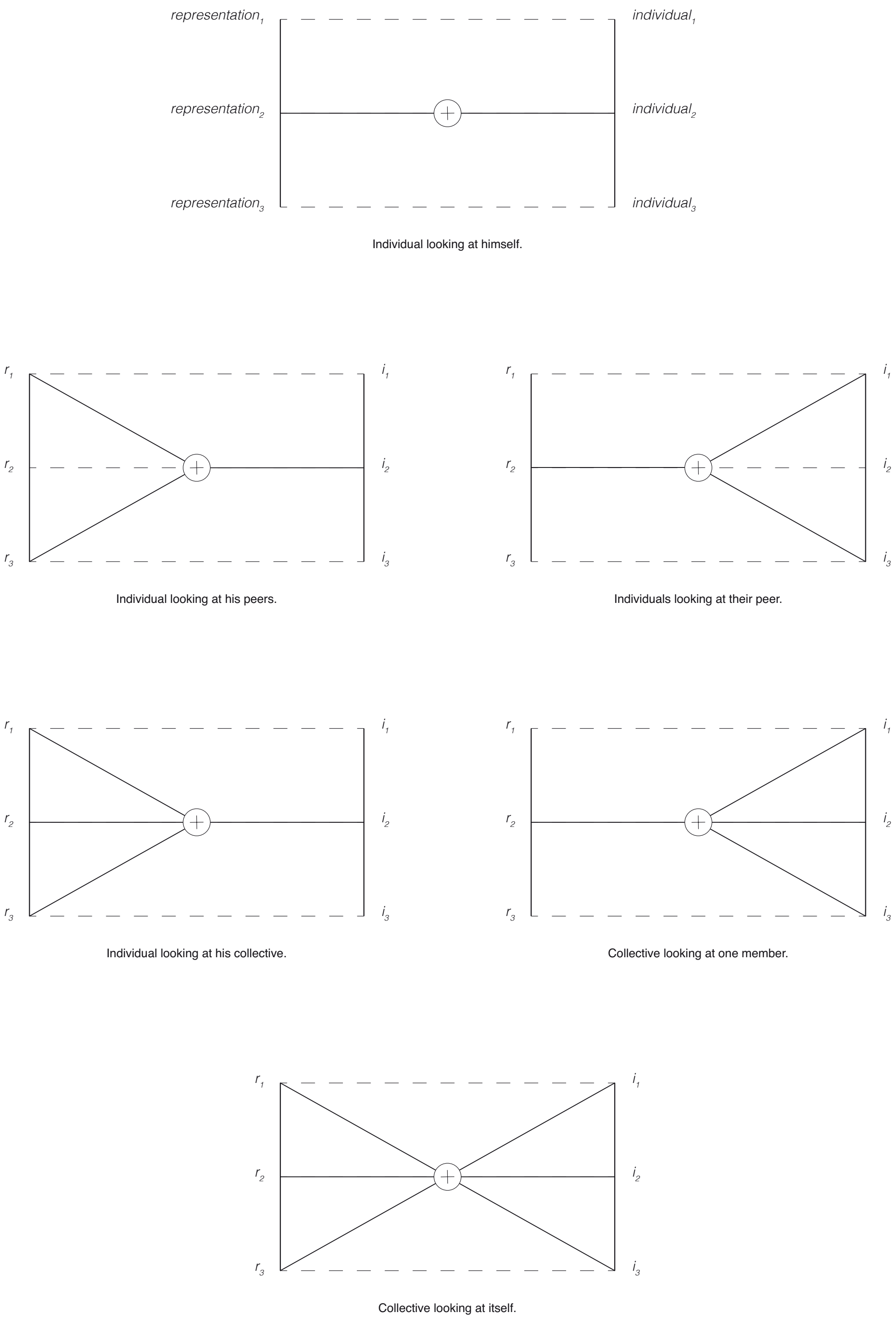


Figure 46. At the top, the simplest example is when the reader looks at himself. At the bottom, there is the example of when a collective looks at itself. In between, all the other possible configurations are shown when the subject is an individual or a collective, and the object might be an individual or a collective.

Validation of the Map

Maps are objects of great accuracy and precision, but their intrinsic value is only accessible through their use. Maps are created for specific uses and the Affinity Map is not an exception. Their use is a crucial moment, especially when the readers are the subject that the map represents. Communication towards an audience is the aim of each instrument (Bertin 1981, 22). The map, in this case, requires a *social consensus* (Jacob 2006, 13), which recognizes, in turn, the work of the mapmaker. Furthermore, the agreement might bring forward the creation of a common vision and a stronger identity of the collective. (Bernard 2013, 867)

The Affinity Map is thus addressed to a specific section of the public or, more precisely, to different audiences that the academic field concerns. Actually, we identified three types of audiences for the map, namely the scholars, the management, and the public external to the ENAC. The map introduced in these pages is conceived especially for scholars, but nothing prevents to address it to all the audiences. This section first illustrates the three audiences and their needs, and then describes the process that produced a judgment of the visualization. To achieve this, we organized a series of interviews with ENAC scholars. We explain hereinafter the interviews and the conclusions that can be drawn.

Audiences and Their Needs

The Affinity Map offers its audience a synoptic gaze on the actual and potential affinities that exist within the ENAC. In particular, we identified three types of audiences, namely the scholar, the management, and the public external to the school. It was requested to these audiences to relate themselves to the map in an effort to understand the visualization. This is an obligatory step for reading intrinsic information and making further elaboration possible in order to obtain what Bertin called *extrinsic information*: all of the information that is not shown by the visualization that can be inferred by readers to fulfill their own needs (Bertin 1981, 9). Hereinafter we introduce these audiences and their needs, why the map is addressed to them, and how they are supposed to manage their extrinsic information.

Scholars

The scholars are the main readers of the Affinity Map. This group corresponds to all the individuals that appear on the map. In particular, in our case study of ENAC, this is comprised of scholars such as professors, senior scientists, postdocs, doctoral assistants, teaching assistants, etc. They have different needs, a fact that is particularly true for the professors who are responsible for their own laboratories.

First of all, professors have to localize their laboratory. Then, they have to reflect on the situation of the laboratory. As previously discussed, the laboratory position relies on laboratory affinities, actual and potential. To better understand these affinities, they have a dynamic visualization at their disposal, which allows them to study not only the general arrangement, but also all the configurations relative to each affinity. Through interaction it is possible to evaluate the centrality of a certain lab according to the type of collaboration. For example, with respect to actual affinities, a laboratory might be focused on education and, at the same time, be marginal in the activity of research. Otherwise, the position of a laboratory can be evaluated according to potential affinities. The configurations of actual and potential affinities can be compared in order to understand if the global position of a laboratory can be improved. Indeed, a crucial need of professors is to comprehend the actual position of the laboratory in order to improve it through new forms of collaboration.

Furthermore, the position can be checked according to satellites and keywords that define the type of affinity in detail. This verification is a fundamental part of the interaction between the reader and the mapmaker because it can provide useful information about the quality of represented data. For example, there could be a missing collaboration or an error in the keywords computation.

Then the reading can focus on individuals. At that level, the professors can look within their laboratory and see the distribution of tasks, the number of members, and the general configuration of collaboration in the unit. Even if that could appear unneeded for the professor, as he constantly collaborates with all the members, looking at individuals might be more helpful to the other members that have a partial view of the laboratory, especially when a laboratory is large. Indeed, even if the professor is usually the hub of the laboratory because his signature is often required, a doctoral assistant may use the Affinity Map as a way to understand more obscure parts of the laboratory. For example, he might realize that he can write an article with a colleague that is not the professor, or see how other doctoral assistants work. The comparison at the level of a doctoral student is important for understanding academic practices and, eventually, imitate them by, for example, advising a student or collaborating on teaching activities.

At the same time, all the scholars are invited to compare their laboratory with others in order to grasp the diversity of configurations. Professors are the reference point within the laboratory, but more senior scientists might have a major role. Laboratories can be bigger or smaller, disclosing a size that might be an index of the fundraising capacity, even though this is an insight more useful for the management. However, the Affinity Map is, first of all, an instrument for discovering individuals, laboratories, and actual and potential affinities. The main need of all the scholars is to understand the academic practice as well as the different practices that exist among disciplines, and get a hold of information that could be useful to be better at their jobs.

The management

The management of the ENAC corresponds to a small group of individuals that make decisions about the school. These individuals are, first of all, ENAC scholars and they look at the map from two points of view. As scholars have different profiles, the directors have different duties that depend on their position. For example, a director can be interested in an institute for research activities, or in the section for education, or in the whole school, as is the case with the dean. Although the interests might be different because of the size of the group directed, we assume that the management shares the same needs and we refer to the dean to exemplify this argument. Furthermore, as discussed in the second chapter, the dean attended the design process in which she represented the final user; for that reason, the management has been associated to the profile of the school dean.

The very first issue that affected Professor Marilyne Andersen from the initial drawings was the desire for an instrument to see the organization of the ENAC. Since the very beginning, she was interested in seizing a view of the ENAC at a glance, which is a chief characteristic of maps. Visualizations, as maps, provide the opportunity to step back and become detached from any social context (Jacob 2006, 32). The Affinity Map offers a synoptic view of the school in order to work as an instrument of control on the school (Foucault 1975).

The needs of the management are different; they consist of planning, anticipation, and decisions. In that sense, the Affinity Map wants to extend its purpose in order to work as an instrument supporting the task of decision-making. Indeed, the visualization can bring extrinsic information, but more than that, it is also an instrument to demonstrate and to support decisions (Boechat and Venturini 2016; Hoyningen-Huene 1987). The decisions, however, do not involve a single individual, but rather a team. Within the team, there are discussions aimed at reaching an agreement and, in this context, the map is a useful instrument to share the insights and to demonstrate proposals. The visualization works as a mediator in the decision-making process, covering the role of a non-human actor (Latour 2005). For example, during the design phase, visualizations were printed and discussed around a table until a decision was reached.

The reasoning can shift to more practical issues that interest the dean. For instance, the identification of empty spots is easy, leaving room for discussions about the creation of new laboratories. Otherwise, a map might justify the closedown of a laboratory, which is a very rare event. That extreme case concerns a *modus operandi*, rather than a criticism on its interdisciplinarity nature. But the map might be helpful in splitting laboratories to help with the rapid increase of a certain research subject, establishing the creation of a new academic position.

Although we took care to avoid this type of interpretation, we cannot avoid evaluation. However, the sole intention was to evaluate collaborations only. Indeed, if the Affinity Map was an instrument of evaluation, it would be an instrument to evaluate collaborations. With that in mind, it is easy to spot laboratories with very few connections, but there are few major things to point out. First, new laboratories do not have many affinities and it is obvious that this is a lengthy process. Second, the map represents one calendar year and, obviously, judgment should be taken over a larger time span. Third, the map shows only collaborations internal to the school, which means that for the moment a laboratory might work with other units of the EPFL, but this is not visible in the current version. However, the point in this section does not concern limits of the maps, rather it concerns the need for a thoughtful use of the map from the management class, which has to understand the benefits of the visualization, but also its limits.

Scholars and directors are then part of the same organization, and they have to work together in order to improve its education and research quality. In that sense, the common need is to have an instrument that can help governance beyond the covered role; an instrument that might be able to support the top-down as well as the bottom-up decision-making, even if the decision to be taken is different.

External public

The last audience to address is the public external to the school. Even if the Affinity Map interests ENAC scholars, some considerations can affect an external audience. The external public varies according to general knowledge of the ENAC school. We can identify four types of audiences: the ENAC students, the EPFL scholars, the academic scholars, and the general public.

The interest of ENAC students is to orientate themselves in the academic environment, which might be extremely complex at the first glance. For them, it is relevant to have an instrument that can be used for situating professors in a semantic space. Indeed, they can see the research topics of the ENAC professors, and use the map to choose an interdisciplinary internship.

One need for EPFL scholars is to obtain a deeper understanding of the ENAC. It is evident that if a value on interdisciplinary collaboration exists, very different fields of research might bring very unusual results. Furthermore, the other deans might be interested in having the same tool, or even employing a map that is able to cover the EPFL.

The academic scholars that work outside the EPFL might benefit from a general presentation. For example, an effort to incentivize collaborations between the EPFL and the ETH of Zurich exists today. The Affinity Map might indicate the right partners for specific inter-institutional collaborations.

Finally, the general public who visits the ENAC wants an idea about the investments of public funds in education and research. In that sense, transparency is a recurrent term in political institutions today. Indeed, architects such as Norman Foster use the concept of transparency to create public buildings. The Reichstag in Berlin, which houses the German parliament under a glass dome, and the London City Hall, which is the center of political activities in the city, are very good examples of transparency (Foster 2011). Furthermore, the museums built within the campuses and the public exhibitions of science that institutions organize are spreading more and more frequently. Their aim is not only to make the science public, but also to attract the most excellent students and scholars.

However, for the time being the Affinity Map has been conceived for the ENAC scientific collective and a common agreement is needed to make the map public. To that end, considering the difficulty of this challenge, the first step has been done through interviews conducted with a sample of ENAC scholars. The next section illustrates the progress of these interviews.

Interviews Structure

A series of interviews with ENAC members allowed us to assess the Affinity Map. We selected nine subjects according to their institute and role in order to have homogenous feedback. In particular, we chose three types of positions: the full and tenure-track professors that equally direct a laboratory, and the senior scientist that often is the closest collaborator of the professor. The main reason for this choice is the seniority, which ensures a better knowledge of the school and more relevant feedback. Table 2 introduces the interviewees in a grid organized by roles and institutes. Their names are represented by letters to ensure their privacy.

	Full Professor	*Tenure-track Prof.*	*Senior Scientist*
Architecture	A	B	C
Civil Engineering	D	E	F
Environmental Engineering	G	H	I

Table 2. Interviews are aimed to assess the Affinity Map. This table summarizes the ENAC scholars selected for these interviews.

Interviewees were aware of the Affinity Map as well as all the ENAC members since the beginning. Indeed, the project was introduced to the scientific collective, and each year an update illustrated the further developments in official events such as the ENAC Research Day and the general assembly, which respectively took place in May and October. In particular, during the ENAC Research day of 2016 a static version of the Affinity Map was introduced and, one year later, the interactive version was published online to the whole ENAC collective. When interviews took place, between June and July 2017, the interviewees were informed about the current developments, and they had had access to the digital version for several weeks.

Meetings were organized so that even in the cases where scholars did not interact with the visualization a conversation could still take place. Two objects were used during the meetings, a laptop featuring the most recent version of the Affinity Map and a sheet with the set of questions to drive the conversation. Interviews took place in the individual scholars' offices to facilitate a comfortable setting, and the interviews were conducted by myself.

The interview structure followed table 3, which is organized in four sections. Three sections focus on different map levels: respectively for the individuals, the laboratory neighborhood, and the whole organization. The last section dealt with audiences and the possible use of the map in different contexts. The first part of the interview was structured in order to understand whether the information displayed on the map was appropriated, and the second part was left intentionally open to allow the opportunity to focus on the most passionate subjects of interviewees.

	Questions
Individuals	1. Did you see yourself?
	2. Do quantitative indicators represent your role?
	3. Is the laboratory structure appropriate?
Neighborhood	4. Do satellites represent ongoing collaborations?
	5. Do you collaborate with surrounding units?
	6. Are keywords appropriate?
Organization	7. Is your position appropriate?
	8. And your institute's position?
	9. Is the map accurately representing the school?
Usage	10. Is the map useful for you?
	11. Is it an instrument of governance?
	12. Is it useful for a generic public?

Table 3. Interviews were organized through a precise schema in four parts: the first three parts concern the graphical representation and the assessment of information, and the fourth part was inherent to the map usage.

Results

Table 4 illustrates the results of the interviews. There, questions intersect the answers in order to indicate whether the scholar's general satisfaction was positive or not. Furthermore, the asterisks correspond to specific remarks related to these answers (see table 5). These tables summarize the global outcome of the interviews, and specific commentaries that enriched the general feedback with relevant reflections. The following text analyzes the results question by question.

Scholars have no problem finding themselves on the map (see Question 1). However, some of them did not agree with their representation due to two different problems (see Question 2). In one case, an error of metadata caused disagreement with a professor (E-2). Indeed, his personal literature referred to his string name rather than his SCIPER number. As a consequence, the Infoscience system did not return any of his publications and the relative measure on the map was zero. During the talk, we traced the problem back to the laboratory member that was responsible to the data input. Once the error was fixed in Infoscience and the map updated according to the new values, the professor agreed with the representation. In two other cases, we came across an exception in the academic practice (B-2 and F-2). Indeed, the two scholars did not have many publications because during the previous year one was writing a book, and the other spent a lot of time in programming. Although the visualization was correct, we faced two limits of the map: one affects whether all of the publications are being equally considered, and the other underlines that we did not consider programming as an affinity.

Question 3 is about the laboratory structure. Although the laboratory diagram correctly represents individuals and collaboration, different issues emerged. First, some individuals do not correspond to their representation because, for instance, the position of teaching assistants is not translated into traces: only professors and external lecturers are associated with the courses. As a result, teaching assistants are not quantitatively represented by data (see B-3). Second, the programming and committee affinities are not visible on the map. In the first case, we did not make the decision to use these traces; in the second case, digital traces do not exist (see F-3 and H-3). Third, a problem with programming was solved (see E-3). Fourth, a professor brought up the question of synchronization since the current map corresponds to the previous year (see A-3). Although that limitation, we have concluded that a delayed but validated visualization is still better than a not validated real-time visualization.

Question 4 confirmed the data quality we used for affinities, since no major remarks concerned the satellites. It is interesting how, again, the map allows scholars to spot a problem related to sources, specifically in the IS-Academia repository (D-4). Furthermore, a scholar stressed the fact that we show only affinities within the ENAC (G-4). That issue will be tackled in a further development, in which the context will shift from the school to the entire EPFL, showing collaborations with laboratories external to the ENAC. From a technical point of view, we have already collected the metadata of EPFL collaborations; that means that the next vision of the map can show affinities within EPFL, enriching the overall context and the interdisciplinary potential.

While question 5 confirmed the correctness of actual affinities, question 6 created a commentary concerning keywords. In general, the interviews validated the keyword method we employ, confirming a special interest in them. A couple of interviewees complained about the approximation of information (A-6 and B-6). However, it has to be said that the two cases correspond to laboratories that usually publish in French, when the keyword extraction works with the main language, which is English. Unfortunately, we have not been able to solve the problem of the French minority since the extractor works to its maximum with a large quantity of information. Despite that technical limit, scholars encouraged us to improve the keywords quality with several suggestions we will consider for the next developments (C-6, H-6, and I-6).

The positions of laboratories and institutions, and the global organization, are correct (see questions 8, 9, and 10). Although there are no major comments about that point, it is very important to underline that the map fulfilled one of the major objectives, which is situating laboratories according to their affinities.

Finally, interviewees demonstrated interest for the three audiences, who interact with the map differently (see questions 10, 11, and 12). It is important to identify that scholars see the Affinity Map as a tool for governance, remarking about its usefulness for scholar evaluation (F-10) and self-evaluation (C-10). Then, a group of scholars focused on the arrangement based on potential affinities, which relies on a sort of serendipity and can really foster collaboration (E-10). They recognized, without any doubt, the benefits that such a map might bring for management (E-11, H-11 and I-11), suggesting improvement that might see the map adapting to incorporate directors (A-11). Finally, they appreciated the map as a public way to present the collective to an external audience (G-12 and I-12), maybe simplifying it so it is more easily understood (A-12).

	Questions	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*
	1. Did you see yourself?	yes	yes	yes	yes	yes	yes	yes	yes	yes
Individuals	2. Do quantitative indicators represent your role?	yes	no*	yes	yes	no*	no*	yes	yes	yes
	3. Is the laboratory structure appropriate?	yes*	no*	yes	yes	no*	yes*	yes*	yes	yes
	4. Do satellites represent ongoing collaborations?	yes	yes	yes	yes*	yes	yes	yes*	yes	yes
Neighborhood	5. Do you collaborate with surrounding units?	yes	yes	yes	yes	yes	yes	yes	yes	yes
	6. Are keywords appropriate?	yes*	no*	yes*	yes	yes	yes	yes	yes*	yes*
	7. Is your position appropriate?	yes	yes	yes	yes	yes	yes	yes	yes	yes
Organization	8. And your institute's position?	yes	yes	yes	yes	yes	yes	yes	yes	yes
	9. Is the map accurately representing the school?	yes	yes	yes	yes	yes	yes	yes	yes	yes
	10. Is the map useful for you?	yes	yes	yes*	yes	yes*	yes*	yes	yes	yes
Usage	11. Is it an instrument of governance?	yes*	yes	yes	yes	yes*	yes	yes	yes*	yes
	12. Is it useful for a generic public?	yes*	yes	no	yes	yes	yes	yes*	yes	yes*

Table 4. Questions and interviewees are organized in order to get a general view of interviews. The asterisks correspond to relevant commentaries, which are shown in Table 5.

	Commentary
A-3	The laboratory structure is appropriate even though it belongs to the past.
A-6	Keywords are appropriate, but too generic.
A-11	A map of one unique institute would be useful.
A-12	A simpler map can be useful for the general public.
B-2	Although the publication indicator is right, it does not represent the exception where a book publication took a lot of time.
B-3	Teaching assistants are not represented by quantitative indicators.
B-6	Keywords are generic.
C-6	A dynamic version more focused on keywords would be great.
C-10	The carpet was a beautiful way to show personal contributions.
D-4	A missing collaboration with an external institute was immediately spotted.
E-2	The publication index was missing due a problem of metadata that was identified and repaired.
E-3	The laboratory was merged with the previous one working on the same topic; the problem was fixed.
E-10	The keywords map is more useful because unexpected compared to the ongoing collaborations.
E-11	The map is more useful to the management, even though its value to spot errors on the data sources is visible.
F-2	The fact that there are no publications that year does not mean that the scholar did not publish at all.
F-3	It would be nice to see collaborations through programming.
F-10	It is a tool for scholars' self-evaluation.
G-3	The map represents quantity and not quality.
G-4	There are no external collaborations.
G-12	The map is a very nice way to present the school.
H-3	Jury committees might represent another type of effective affinity.
H-6	It would be nice to see keywords at epfl scale.
H-11	Evaluation is unavoidable for tenure-track positions.
I-6	Potential collaborations are relevant.
I-11	It is useful for the creation of interdisciplinary groups.
I-12	Favorable to the map publication for public use.

Table 5. Most relevant commentaries of interviewees are here summarized, extending the meaning of Table 4.

Actualizations in Environment

As we wrote at the beginning of the chapter, the visualization is a complex artifact that involves human and non-human actors. Among them we count the mapmakers, the readers, the represented organizations, the digital traces, etc., but the list could be longer. The more we deconstruct the visualization, the more we discover the intricate patterns that encompass it. All along the design process, the digital traces contaminate the method and the designer works to stabilize the visual rules that govern the map; as a result, the map takes shape a little bit at a time to enter into the *actualization* at last (Deleuze and Parnet 2007, 148–152).

The actualization is the procedure that transforms the visualization into an object of interaction. Through actualization, we choose the object the readers will interact with, among the *virtuality* of all the possible shapes. Although the virtuality is employed today to describe the immaterial universe of the Internet, the meaning that we use corresponds to the infinite shapes that visualization can assume (J. Lévy 2013d, 1090). Thereby, actualization is the way in which visualizations materialize themselves, becoming tangible objects.

The tangible objects make the interaction possible. The reading happens through the intimate relation between the object and the reader. Although the reading might seem a cerebral and abstract behavior, it is actually very physical. Once we are aware that reading takes up space, we have to think of the reading as an action that takes place in an *environment*. We argue that the environment where the reading happens is a matter of great importance, especially if the visualization is to be used to address different audiences and usages. Designers should not only have control of the visualization, but also of the context in which the reading happens. For example, the private and the collective reading might fit to different environments such as a private office or a public space. Consequently, the same object might change its features according to the installation site, and the environment plays a key role in defining the *affordances* of that object (Gibson 2015, 119). It seems clear to us, therefore, that visualization not only involves more actors, but that its actualization also significantly affects the reading within the environment.

This section illustrates the actualizations of the Affinity Map, which includes an online version, some posters we employed during design, and a very large map produced *ad hoc* for the ENAC Research Day in 2016.

Intimate, Personal, Social, and Public Distances

Once the visualization is actualized, the reading becomes possible, as the visualization is finally a tangible object that readers can interact with through indirect and direct actions. *Indirect actions* use visualization as a mediator in order to succeed in a specific aim, namely for information discovery and recall, vision extension, decision-making, knowledge creation, planning, prediction, recognition, presentation, demonstrations, and justification. Some of these aims belong to the private sphere, but more of them are social, that is to say, they are acts of communication between individuals. Indeed, indirect actions are used by groups of readers for communicating in social contexts such as discussions, conferences, meetings, etc. On the other hand, *direct actions* extend the reader's abilities through the visualization by pointing fingers, taking notes, writing glosses, underlining texts, drawing lines, etc. Direct actions are the way through which readers can accomplish indirect actions; for example, the gesture of pointing fingers is related to the intention of making someone else aware about a specific insight into the visualization.

Both actions change according to the actualization and the physical environment where the interaction takes place. Indeed, the interaction between readers and actualization takes place in a specific *environment*, which corresponds to a physical space. The combination of actualization and environment defines what the reader is able to do in a given setup. For example, the Affinity Map has been actualized as a browser application, which is often contextualized in an office. Readers modify the map through various controls in order to re-actualize it according to their needs. The individual relation with the screen implies an *intimate distance* (E. T. Hall 1990, 116) where the reader is so absorbed by the visualization they have the sensation of being alone (Kaplan 2015). That is the case for mobile phones, tablets, and often even desktop computers, whose use occurs from a short physical distance. Such a configuration promotes a personal exploration that limits interactions with other readers (see Figure 47).

When the device is shared, the reading becomes collective and fosters dialogue between individuals. A few readers can have a discussion together in front of a visualization on a computer screen, which works as a communication mediator between individuals. The readers and the visualization mutually interact at a *personal distance* (E. T. Hall 1990, 119). In this scenario, both the direct and the indirect actions are powerful ways that favor the circulation of information among the actors. For example, when a reader points out a detail, he sparks off or refocuses a discussion (see Figure 48).

Figure 47. Mobile phones and desktop computers are designed for intimate reading. © 2016 Alain Herzog

Figure 48. Personal computers can be used simultaneously by a small group of individuals. In this context, pointing a finger is a standard gesture of personal reading. © 2016 Alain Herzog

The wider the screen is, the more different readers can join the discussion. Large media such as posters augment the social confrontation. Although posters and desktop computers might be similar, the poster opens the conversation to larger groups that can interact at a *social distance* (E. T. Hall 1990, 121). Posters can be hung on the wall or laid down on a table to create different settings. Many meetings we did during the design phase were organized around a table where visualizations were laid down on the table, in the middle of a gathering. Furthermore, gestures cover a key role in the communication between readers and the poster's materiality encourages people/readers to write on it, take notes, sketch and draw connections between visual elements. Again, the wider the size of the support, the larger the audience involved by the collective dialogue (see Figure 49).

During the ENAC Research Day that took place in 2017, we used a large television to showcase the Affinity Map (Grasso et al. 2003). That setting was particularly interesting because the dynamic version of the Affinity Map was introduced for the first time and, consequently, the audience was very curious. The ENAC scholars were invited to locate themselves on the map and talk with us. We had plenty of useful discussions that day, but we also observed the way of interacting with the map. Contrary to the social distance we experienced during the meeting, there was a briskness of movement between the actors. All throughout the day, the group of readers was continually changing and being replaced by new actors. The installation was at the center of an exhibition that contained various scientific experiments. Readers were allowed to stroll among the installations, stop for a while and view them, and then keep moving again. As a consequence, the environment empowered readers to step back from the discussion, and look at a reading from the outside (see Figure 50). Introducing a *public distance* between the reading and the observer produced a distant view of the reading itself (E. T. Hall 1990, 123). That position allowed the reader to be a passive actor within the discussion and hear what other readers were saying.

The reading setting is therefore defined by the characteristics of the actualization, the environment, and the *reading distance*. A different experiment we had created the previous year, during the ENAC Research Day 2016, has been particularly meaningful because it created a mix of different readings. Indeed, on that occasion a version of the Affinity Map was printed on a tarpaulin, creating a visualization of 250 square meters. In the next section, we illustrate this experience and its interaction.

Figure 49. Media dimension affects the size of the group that can interact simultaneously. A poster can be easily placed at the center of a conversation between four readers, which is an example of social reading. © 2016 Alain Herzog

Figure 50. A moment of discussion that took place during the ENAC Research Day 2017. Cyril Veillon, the director of Archizoom, discusses the representation of his unit with some peers. Their position is public as much as their reading. © 2017 Alain Herzog

Affinity Map as Carpet

In 2016 the ENAC deanship was interested in revitalizing a regular public event called Research Day. With the idea of creating an event that would involve the scholars, the deanship was determined to organize a day that would recreate the spirit of cohesion. The chosen subjects for the event were interdisciplinarity and collaboration. From that perspective, the Affinity Map had to be developed with respect to those subjects.

Let us look back on a previous experience. During the Digital Humanities conference organized in Lausanne in the summer of 2014, we had the opportunity to experiment with different kinds of actualizations. Indeed, the network image we employed as the conference logo was actualized in different ways such as posters, book covers, flyers, t-shirts, mugs, etc. (Rigal and Rodighiero 2014). That network featured a high density of nodes, collecting all the authors who attended the conference and arranging them by co-authoring and keywords (Rodighiero 2015). One very interesting actualization of the DH2014 logo was the carpet. It was a round sticker measuring five meters in diameter that we placed in front of the entrance on the first day of the conference. It was so large that it could display all the authors' names on a single surface. These names were the key for the social interactions that followed. Indeed, scholars were invited to walk the carpet and search for their names. Through this simple act, attendees found themselves by locating their names on the carpet and, at the same time, their names were part of the conference symbol, which created a sense of belonging to the collective.

The idea was to reproduce the experience of the DH2014 for the ENAC Research Day. For that event, we created a large print that measured about 250 square meters, reproducing one configuration of the Affinity Map. The map featured almost one thousand scholars arranged around seventy laboratories. The carpet was composed of three tarpaulin prints measuring 5 x 15 meters that were produced by a company located in Lucerne, which specialized in large printing.

The carpet was a site-specific installation conceived for the SG building at EPFL. The SG is the main building for architecture, which is one of the ENAC institutes. As its use was developed with the students in mind, the building features different facilities such as classrooms, workshops, and meeting spaces, all which ensure a high attendance. In particular, right after the entrance there is a balcony that provides an overview of a very large foyer, and the foyer sees three floors merged together and measures approximately 300 square meters. This foyer was the space that hosted the Affinity Map carpet. As visible in the renderings of Figure 51 that were created to simulate the experience, the size of the visualization is impressive compared to the height of the people, and the balconies offer unusual opportunities to interact with the map.

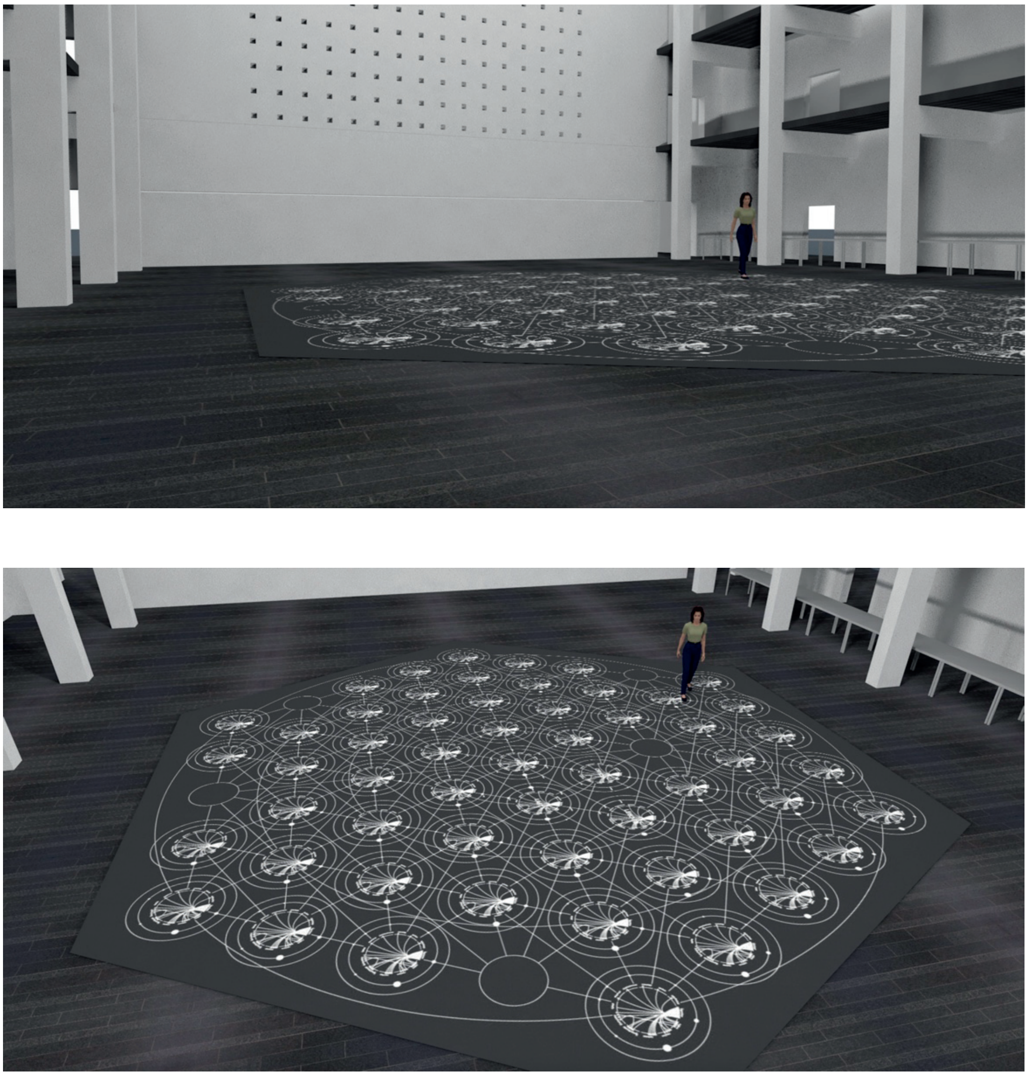


Figure 51. The renderings show the Affinity Map carpet situated in the SG building foyer. The large floor and the balconies offer specific affordances for reading the visualization. © 2016 Claudio Leonardi

Christian Jacob writes about a specific example of *map floors*, which the astronomer Giovanni Domenico Cassini created during the seventeenth century (Jacob 2006, 94). The large planisphere was drawn using new methods of measurement and readers were invited to walk over it, and to read and verify the information. The success of the installation was worth a visit by the king of France, Louis XIV. Contrary to the previous actualizations of the map, the Affinity Map carpet invites individuals to walk in a social space, encouraging their movement and creating a social space of reading. Although Rudolf Arnheim thought that horizontal visualizations discourage detached contemplation because of its closeness (Arnheim 1982, 13), the balcony offered a solution to this problem as readers could choose their standpoint. Do you remember Indiana Jones in the Venetian library of *Campo San Barnaba*? He was searching for the Grail Knight's tomb which was indicated by the number *ten*; he was finally able to identify it from the library balcony, as the number ten was visible on the whole of the floor (Spielberg 1989 min28).

As the writer Jonathan Swift moves his character Gulliver among words of different scales (Swift 1800), the interaction with the map floor might happen at two *distances*, which correspond to two scales. At one scale, the reader is small and walks on the map; at the other scale, the reader looks at the map from the balcony, and is able to grasp the whole image at a glance. As a result, the reading changes according to the distance; indeed, details are visible when the reader is close to the map, and the whole map is visible when the reader is far from it. As Gulliver experienced being smaller or bigger, likewise the reader can decide to be 'smaller' and remain among the readers on the map, or to be 'bigger' and stand farther from the map on the balconies. In the SG foyer, the two scales exist in the same environment, allowing both close and distant reading. As a result, the reader can decide if they want to be a human actor walking on the map, or a spectator looking down at the arrangement of the readers on the map, or both, since the environment encourages the readers to move around.

Figure 65 depicts me on the Affinity Map just after putting the parts together. My position was chosen according to my second laboratory affiliation with CHÔROS, which corresponds to the big red circle under my feet. This photograph clearly illustrates the ratio between the sizes of the individuals compared to the carpet, which actually measured 15 x 15 square meters. Its size fit the foyer dimensions exactly and used the entire width of the printer, which was five meters. The photograph shows the two levels of balconies that encircle the foyer from three sides. Finally, the foyer was particularly ideal because it is a way station that many people pass through to get to their classrooms or have a meal. In the next section, we will illustrate how the Affinity Map carpet and its environment introduced some relevant behaviors.

Figure 52. Affinity Map carpet and myself. This photograph shows the ratio between a person and the entire visualization, as well as the structure of balconies that empowers readers with a detached view. © 2016 Alexandre Gonzalez

ENAC Research Day 2016

All the scholars were invited to the ENAC Research Day, which was organized into different activities to encourage interdisciplinarity and collaboration. The discovery of the Affinity Map was one of these activities. Attendees were divided into groups and encouraged to read the map on rotating shifts. We were there to explain to each group how the information was selected, treated, and projected, in order to clarify the decisions that we made during the design process. In particular, we wanted to open the project to the whole collective, thereby introducing the final users to the digital application that would have been released one year later.

As illustrated in the following figures, the carpet was finally presented to the public, who was invited to its reading. Scholars selected their positions on the carpet and balconies. As the photograph shows, the reading was a social action. Individuals were free to move, changing standpoints according to their will by walking through the environment. In this special setting, the scholars on the balconies were able to look at the whole view and the arrangement of their peers on the map. That allowed an overlap between two spatial systems: the laboratories, visually arranged in the map, and the readers, physically distributed on it. Readers on the carpet organized themselves in two ways, by individual and by collective reading. The collective reading was particularly interesting because it provided an opportunity to have a joint discussion about the map. In that sense, the map acted as a mediator for a contemporaneous discussion about the representation and the collective itself. The installation therefore leads to two interpretations: one focuses on the *visual representation* of the scientific collective, and the other focuses on the *performative representation* of the scholars that interact with the map. The reading was a social representation of human and non-human actors.

During the interviews, a member of the ENAC told us, ‘I found the carpet wonderful because I see that I am involved in the scientific community; it makes me amused and encourages playing.’ This is interesting in the general sense of making visible what is invisible. Indeed, most of the academic practice is not visible, and the installation encourages readers to have a larger understanding of their own peers. Furthermore, the reading is not a passive activity anymore; it is acting and reacting in a social space.

We argue that the most interesting aspect of the carpet consisted of all of the discussions that it created. Indeed, looking at various photographs, we see readers interacting and talking. Although we were not able to follow these discussions, we try to recreate the atmosphere of that day through this photo gallery, which illustrates some moments from the ENAC Research Day.

Figure 53. The Affinity Map carpet was presented to the scholars during the ENAC Research Day that took place in May 2016. © 2016 Alain Herzog

Figure 54. This photograph was taken from the opposite side, showing the balcony openings from which ENAC scholars identified their peers on the carpet, who were in turn searching for them. © 2016 Alain Herzog

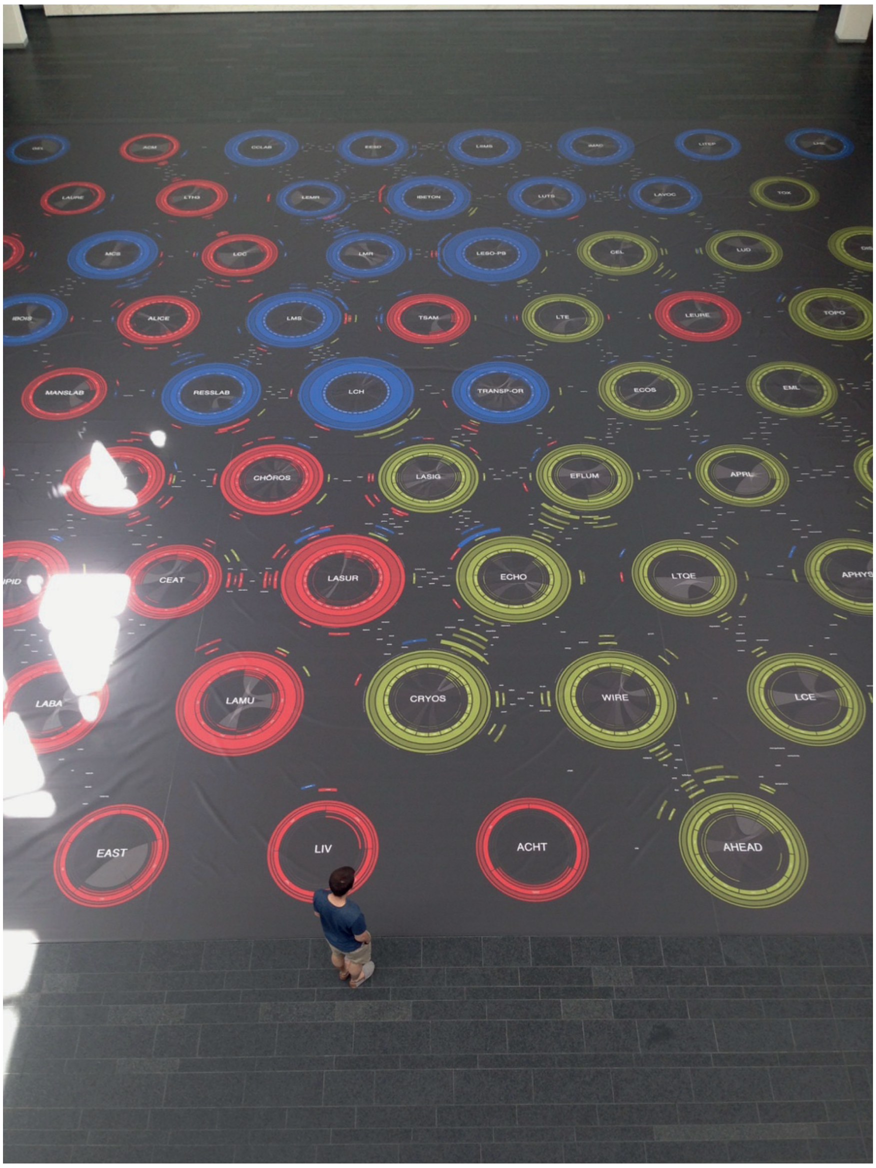


Figure 55. The first visitor interacts with the carpet, hesitating to walk on it.

Figure 56. Before the official opening, some students found their professor on the map.

Figure 57. The ENAC Research Day came, here are the first readers looking at their laboratory and commenting. © 2016 Alain Herzog

Figure 58. Some scholars are looking at the movements of their peers on the map. © 2016 Alain Herzog

Figure 59. A scholar with a double affiliation shows that his laboratories are spatially close. © 2016 Jean-Denis Thiry

Figure 60. The map starts to get crowded. This photo shows the gesture of people pointing with their legs, which was quite common. © 2016 Alain Herzog

Figure 61. This photograph depicts the organization of readers in several groups having related discussions. © 2016 Alain Herzog

Figure 62. As is visible in this photograph, the view from the balcony totally changes the perspective on the map. © 2016 Alain Herzog

Figure 63. From the balcony, another instance of scholars having a discussion is visible; this discussion is taking place between architecture and civil engineering, who are identified by their laboratory colors. © 2016 Alain Herzog

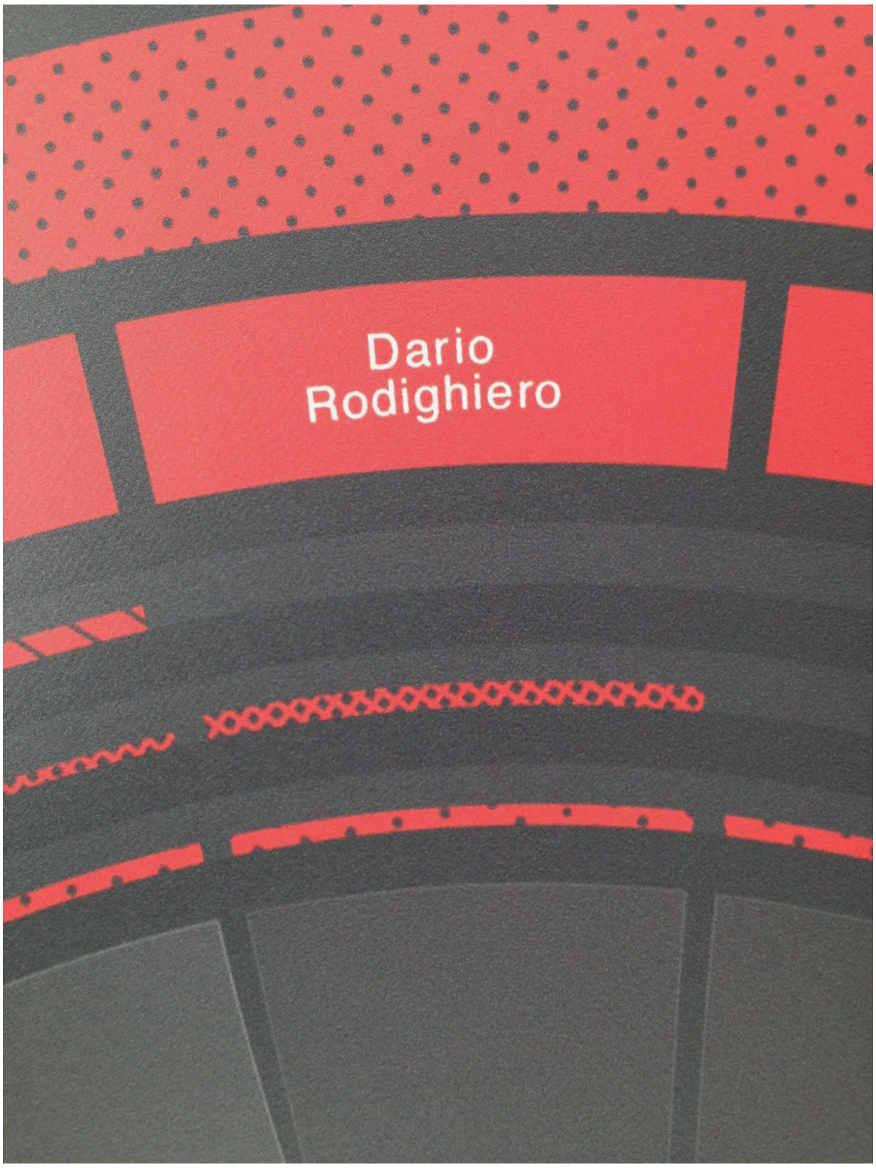


Figure 64. Myself on the map. The quantitative data recognizes me as a PhD candidate with publications and no role of lecturer.

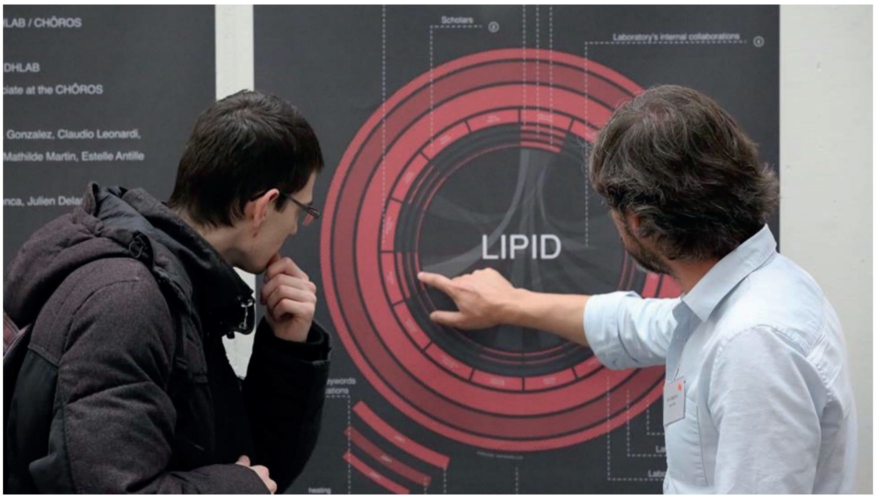


Figure 65. A legend for reading the map was on the wall to make the visual grammar clear. © 2016 Alain Herzog

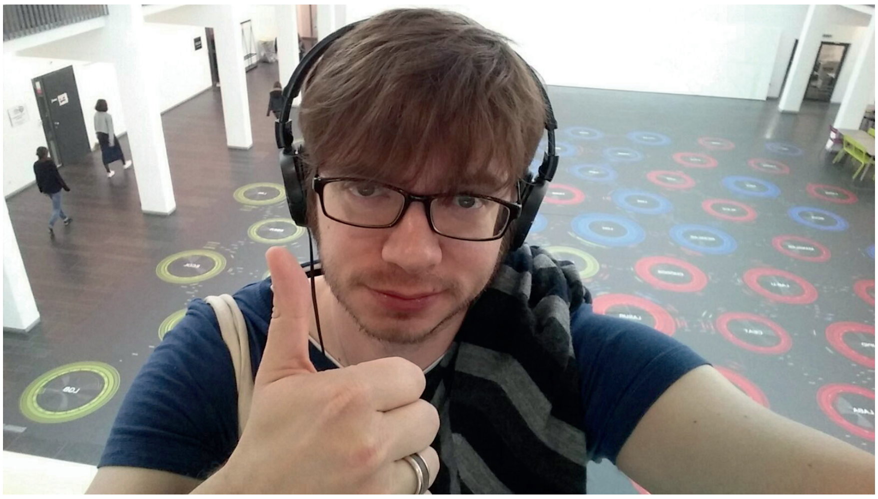


Figure 66. My best friend Yannick Rochat took a selfie with the carpet few days after the official presentation. © 2016 Yannick Rochat

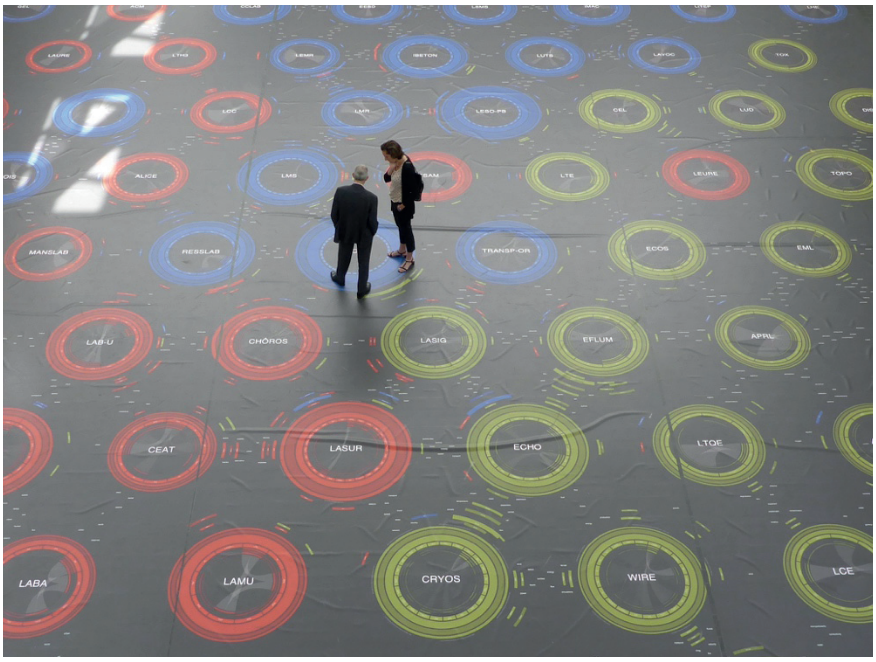


Figure 67. The dean of the ENAC*, Marilyne Andersen, shows the map to the next* EPFL *president, Martin Vetterli. © 2016 Alain Wegmann*

Figure 68. Marilyne Andersen and myself walking on the carpet some week after the ENAC *Research Day 2016. © 2016 Alain Wegmann*

Figure 69. The tarpaulin was reemployed for the production of around 150 bags that the ENAC gave as a present to their scholars. As one bag bore more names, the distribution of certain bags triggered a discussion. This is the bag for the architect Dominique Perrault. © 2016 Martin Gonzenbach

Collective Reading and Distributed Cognition

The various actualizations suggest that the visualization is a collective activity where multiple agents contribute to the reading. With *collective reading*, we intend to take an approach to visualizations that equally considers the actualization as well as the individuals. Furthermore, the collective reading reflects the way in which individuals organize the reading into groups. This organization is not only based on the arrangement of the individual in a space like the example of the carpet, but also in the way through which they select their interlocutors.

Among the readers and the visualization there is a greater or lesser distance, which we defined by classifying it into four types, namely intimate, personal, social, and public distance. Although the original classification proposed by the anthropologist Edward T. Hall was applied just to the distance between individual, we applied the metric also to non-human actors such as visualizations. Using a logic that is reminiscent of the Actor-network theory, we applied the concept of distance between human and non-human actors (Latour 2005).

Table 6 offers an overview of the relation that exists between this distance and the actualizations we studied for the Affinity Map. With respect to our observations, the intersections show the level of compatibility between a materialization and its way of reading. The outcome demonstrates a perfect combination between the size of the support and the relative distance exists. For example, the down-left movement of an imaginary diagonal in the Table 6 shows how mobile phones are inclined to result in an intimate reading, and how the carpet favors a public reading. At the same time, the specular diagonal shows how the same mobile devices are hardly used in a public reading, whereas the carpet is open to all the breadth of reading.

	Intimate	*Personal*	*Social*	*Public*
Mobile phone	high	medium	low	low
Desktop computer	high	high	medium	low
Poster / wall screen	high	high	high	medium
Carpet	high	high	high	high

Table 6. This table illustrates the compatibility of the actualizations with the four types of reading distances. It is noticeable how the public distance can hardly be applied to small actualizations, such as the mobile phones. On the other side, large actualizations are compatible with all of the distances.

Let us refer to the desktop computer setting, in which the reading is *personal*. In this configuration, we have two readers and an actualization of the map on the screen monitor. Each individual is connected to the visualization through the reading in order to extract information from it. The readers, on the other hand, communicate through a discussion, which is the dialogue to reflect, agree or disagree, and exchange information. The discussion is an opportunity to debate about personal learning and different visions in order to acquire knowledge.

With respect to different actions of reading, we encounter a *distributed cognition* (Hutchins and Klausen 1995). This signifies that the knowledge of the school is kept by the scientific collective itself, and the visualization acts as a mediator to facilitate the *circulation of information* (Rodighiero 2016). The information is movable and floats between individuals and groups through the material and the environment (Hollan, Hutchins, and Kirsh 2000, 176). The concatenation of dialogues, the passage of information, and the new insights introduced by reading are part of the same circuit that creates and modifies the common knowledge.

Vision and information modify our culture, in a daily movement of regeneration (Gay 1997). With culture, we change perception and opinions, and we share a knowledge base with individuals that belong to the same collective. Our perception about visualizations is therefore the result of many components that make up our culture, our working environment, and our daily experiences. Through the reading we can improve our personal knowledge, and through the discussion it is possible to improve the capacity of the reading itself.

Conclusion

This thesis solved a problem of governance through design. In particular, that approach wanted to solve the issue of visualizing a specific organization, which arose when the future dean Marilyne Andersen tried to draw the ENAC structure. Visualizing large organizations according to the affinities of their members is a problem that interests corporations as well as large academic institutions. The concept of affinity stays between the actualization and the potential of the social ties for structuring the organization from the inside. Although the interactions between many individuals are difficult to understand, social scientists and cartographers are trying to find a way to represent the environment through the ties between individuals, beyond the common organizational chart. In the specific context of university, the Affinity Map proposed a new method of visualizing the affinities between scholars, which can be employed to other case studies outside the academic environment.

Main contributions of the thesis

With respect to the various scientific metrics, we argued that the academic metric cannot be limited just to the literature written by scholars and a few other activities they engage in. The daily practice of scholars corresponds to a complex network of collaborations that is particularly difficult to describe. Our study underlined the fact that academic practices are translated into *digital traces* partially, and that the efforts of tracing the academic activities must go further than just solely looking at publications and citations. Following the characterization of the different kinds of collaboration (advising, publications, and teaching), we revealed the plurality of *affinities* within the ENAC collective. Our aim was to make visible the affinities that are normally hidden. We also emphasized the distinction between actual and potential affinities; the former was useful for depicting the current state of the collaborations, and the latter were useful to predict future collaborations.

We introduced a method to display these affinities, which required particular attention to their multidimensional and multi-scale nature. We introduced the *rings* to overcome the mono-dimensionality of links that networks represent through lines. The rings are able to quantify multiple values associated with both nodes and connections. They inform us to whether a laboratory is more involved in education or research, or whether a connection is the result of a common publication. Although our approach was based on the actor-network theory, we embodied the organizational hierarchy within the map: colors, nodes, and arcs represent institutes, laboratories, and individuals respectively. Furthermore, the map focused on the organization of both the school and the laboratories, according to the level of the zoom. These visual principles also made the network more readable, reducing the network connectivity.

The *satellites* reduced the entire network around each node. Even focusing on a node, the reader does not lose the perception of the whole network. The Affinity Map was built on a system of single ego-networks that qualify and quantify each laboratory context. The reader no longer has to look around in order to study the links of a single node, as the satellites also report the distance of each corresponding node according to the entire network.

The Affinity Map relies on a *hexagonal pattern*, which simplifies the network through the creation of a regular arrangement that improved its readability. A set of forces constrained and limited the proximity between nodes creating homogenous spaces. This arrangement was used to display the keywords that help to clarify the semantic proximity of laboratories.

The Affinity Map was released in various actualizations, of which the *carpet* was the most notable. Specifically created for the ENAC Research Day, the carpet was a 250-square-meter walkable visualization that scholars were invited to explore and read. Interactions with the carpet were specific and we classified them in four categories. We noticed a) an intimate reading when scholars look for themselves in the map, b) a personal reading when two scholars discussed a specific detail on the map, 3) a social reading when the discussion involved more individuals, and 4) a public reading when the scholar becomes part of the map and can be observed by others.

In this thesis, we stressed the importance of the design, which is intended as the ability and the sensibility of solving a specific problem. This approach was important for studying the academic environment and creating a discussion about the problem of representing the academic practice. Furthermore, the design was equally important to evaluating and discovering the affinities for the map construction. Indeed, the relative digital traces were scattered and unavailable; the solution to this problem requested a lot of work in order to have them at our disposal. Our design brought about the discovery of data through visual results, and helped us to choose which further steps to take. Design also covered a crucial role in the actualization of the map, trying to experiment different solutions to make it available to the users. In a very special sense, the design was a way to acquire, evaluate, translate, and visualize the academic practice.

Through the design process we were able to understand the importance of the individual who was barely considered at the beginning of the project. Indeed, the individual has a double function as he is represented in the map and he is also the reader of the same map. We understood the importance of the individual as a scholar when we observed the ENAC through ten years of data, and we understood his importance as a reader when we saw the collective of research interacting with the map. Designing and reading are two sides of the same coin, for which designers and readers are asked to contribute. Designers, scholars, managers, organizations, technologies, materials, data, digital traces, and actualizations are all active actors in the lifecycle of the visualization.

Possible scenarios for further uses

The Affinity Map is applicable to different organizations that match the following three parameters. First, organizations have to entirely rely on individuals, who are the smallest element of the map that characterizes social ties. Second, these individuals have to be described by actual and potential affinities in order to study the actuality and the potentiality the organization. Third, in addition to a level of self-organization, individuals have to be associated with an organizational structure that is based on an arborescence; for example, the ENAC school depends on laboratories and institutes, which respectively corresponds to clusters and color codes.

The Affinity Map solves the problem of visualizing those collectives that are based on social interactions, can be described through actual and potential affinities, and are characterized by an organizational structure. This section proposes few examples that match these parameters, discussing further uses of the Affinity Map that differ from the ENAC case study.

RESEARCHGATE, A SOCIAL NETWORK OF SCIENTIFIC LITERATURE

The first example is a social network of scientific collaborations. ResearchGate is, indeed, a web site that is addressed to scholars in order to share and give visibility to their scientific literature. Its publications are characterized by collaborations that can be used to define the actual affinities and, likewise the ENAC case study, the potential affinities can be computed from the abstracts of these publications. Furthermore, the relative institutions or their countries can compose the hierarchical structure. The visual result would be a map based on ResearchGate members grouped by institutions, or country. Visual elements could be situated on the map by actual and potential affinities between individuals and institutions, or countries. Finally, keywords could represent the subject of research on the map background.

JOINT RESEARCH CENTRE OF EUROPEAN COMMISSION

Institutes of research rely on similar characteristics. The Joint Research Center, for instance, is characterized by a structure organized by projects, which are associated with internal institutes in turn. Its researchers are requested to do research within specific projects, which rely on specific axes of European Union law. Actual affinities are identifiable in publications, standards, patents, projects, and proposals. Potential affinities might correspond to expertize, but we can also imagine these relations based on personal loans, which are centralized by the JRC scientific library. The map output would be a visual network about projects situated in the space according to affinities. Keywords could be based on legislation associated with each project in order to create a legislative background for the map. That would give a whole view of ongoing research projects, and the effort repartition in the institution.

THEATRE OF VIDY, THE CIRCULATION OF ACTORS AND DIRECTORS

A theater season is characterized by several spectacles, however, for a simple spectator is impossible to see the relations between actors and directors. The idea, in this case, stays in creating a map of spectacles for the theater of Vidy, which organizes around seventy representations each year. Each spectacle involves a large staff that includes the director, its collaborators, and its actors. Although these individuals are grouped by the spectacle during the current season, their collaborations date back in the past. Using these collaborations, we would like to map the personal trajectories that bear remarkable similarities between spectacles. Several of these actors, indeed, have previously played together, which is a way to translate actual affinities. On the other hand, their potential affinities could be identified by their educational careers or by the roles that are used to play. The result is a map of the spectacle arranged by lifetime collaborations. This map should be able to show spectacles according to actual and potential collaborations, differentiating representations by type through a color code. Keywords might be used to clarify lexical proximity between close nodes.

MATCHING SYSTEM FOR THE REPUBLIC OF LETTERS

The Republic of Letters is an information system based on correspondence between important figures of the past. These individuals sent tons of letters over centuries, creating a topographical network of intellectual and political affinities. The correspondence was sent from person to person, but also from city to city, and from country to country, contributing to the creation of a hierarchical structure of letters. Of course, these letters have also a content, which cannot be mapped on topographical maps. The content of these letters offers the opportunity to calculate potential affinities on the base of the letter contents. Potential affinities can be identified through the text-mining system employed in the Affinity Map, creating relations by content similarity when correspondence never existed. The resulting map would be relevant for two reasons: first, affinities will be structured by individuals and cities, unveiling a topological approach of relations within and between cities; second, the map about potential affinities might create a map of the correspondence that never took place, creating a disposition of common topics. Finally, keywords can depict a background based on topics.

EUROPEAN CLOSENESS OF CITIES

One of the most important individual assemblies is represented by the city. City dwellers give birth to agglomerates that can be very different. However, cities are part of a network deeply interconnected because of economic exchanges, traveling connections, or correspondences between people. Yet cities are also related by similarity; common religions, traditions, cooking, habits, or literature can exemplify closeness in other terms. According these examples, cities are urban agglomerations characterized by actual and potential affinities, respectively corresponding to constant exchanges and cultural identity. Considering, for example, European cities as a potential subject of the map, the result would be a map of Europe situating cities by general closeness. It would be an instrument to see exchanges between cities, cultural similarity, and both together in order to discover common affinities. This map could be used for monitoring the circulation of individuals, for instance, and studying these movements to comprehend the evolution of Europe in terms of individual mobility.

PRIVATE COMPANY

One last use of the Affinity Map concerns private companies, whose structure is characterized by employees, affinities between them, and a strong organizational structure. Email messages, phone calls, chats, and other types of communications might enrich actual affinities. On the other hand, potential affinities might correspond to the expertise of the same employees. The usefulness of the company map for the management would be enormous in order to optimize the organization of work and spotting the pivotal group of employees.

Cohesion of a scientific collective

The Affinity Map as a tool was intended to visualize the ENAC collaborations in order to stimulate new ones. However, the map is also an image that represents the unity of the collective of research. That image has been validated through a design process that encouraged scholars to contribute and check the accuracy of the map. The Affinity Map was a project open to the entire ENAC, whose individuals contributed through interviews, discussions, and emails. Probably the collective agreement was the most ambitious goal of the entire project.

The social process of map development started when Professor Marilyne Andersen presented to the ENAC her idea to produce a map of the school. The idea was transformed in a research project, to which I contributed as a doctoral assistant. The openness of the design process can be identified in these steps, which summarize the interaction with the members of the school:

- First interviews (January 2014);
- Update at general assembly (September 2014);
- Update at general assembly (September 2015);
- Map presentation at ENAC Research Day (May 2016);
- Update at general assembly (September 2016);

- Map presentation at ENAC Research Day (May 2017);
- Map publication (May 2017);
- Second interviews (Summer 2017);
- Update at general assembly (September 2017).

The social process of design was characterized by a constant communication during four years. Constancy was assured by the regular updates provided during the general assemblies, which represented the moment to share the current state of the project and the next steps. Besides public communication, ENAC scholars actively contributed to the design through interviews and public discussions. Interviews were organized at the beginning and end of the PhD period to talk respectively about the expectations and the final map. Public discussions were mainly related to the map presentations during the ENAC Research Days. While interviews were a more formal way to collect information, the public debate was able to voice more visceral opinion. In particular, the public debate was a way not only to observe reactions, but also to stimulate discussion between scholars. Does visual representation is an appropriate method? Does the school is correctly represented? Does the map assess the academic environment? Which data are relevant to visualize affinities? What is the threshold of privacy to respect?

The process of design becomes, in this way, a political action. ENAC Scholars are invited to attend the process and be active in the creation of the map. Indeed, that idea of the city-state was based on the active contribution of citizens to political life. During the ENAC general assembly of 2015, the ENAC scholars asked to be considered as potential users of the map; the deanship agreed and relaunched the offer involving the ENAC scholars in the design process. The laws that drive the construction of the map are thus the result of an open negotiation between all the actors. In particular, scholars contributed to the map design through their private interviews, public discussions during presentations, and correspondence. All the proposals and suggestions were not only considered, but also implemented during the development. The result is a map that is based on the principles of equality and fairness.

The Affinity Map is not only the representation of a collective of research through their affinities, the map is also the representation of a collective design. Through all the steps we enumerated before, the Affinity Map has been transformed in a collective process of design. The cohesion of the ENAC is not in the map itself, but rather in the process of design. Although the process of design is not reproduced in the map, the map is its result; scholars that actively attended the process can think about the process when they look at the map. In other words, the map represents the cohesion of the ENAC.

Perspective for further developments

The Affinity Map was appreciated by the scholars and the management of the ENAC, and the project will keep going. This part illustrates some limits we encountered during the project, introducing new perspectives to foster a discussion and think about further developments.

Enriching affinities

The wish we expressed since the beginning was to collect as much affinity as possible, but we had to select the most relevant and high-quality digital traces. We were able to collect more data than what was actually employed in the map as grants and external collaborations are ready to be mapped. However, we are aware of the effort that follows the creation of data in terms of time and economic investments, and of the errors and the lack of quality that occur during the treatment of the digital traces. In any case, we put a lot of effort into making the Affinity Map as accurate as possible.

Describing the academic practice may be an exercise without ending. For that reason, it is important to define the limits of the relevancy and the privacy of data used to identify affinities. For example, one activity that was not translated in digital form concerns the committee memberships. The esteem for peers that scholars develop within the academic network is visible when committees are established; it is natural that a good synergism is repeated. However, this information is not shared except for thesis defenses and, in any case, it is not structured to be used in data analysis. On the contrary, some actual affinities are digitalized and ready to use, but some issues related to the privacy prevent the use of this information. The conversation through emails could be relevant to spot actual collaborations. However, opening these data might be problematic and, usually, its use is preceded by their anonymization that makes our mapping of individuals ineffective.

Potential affinities might also be enriched further. For example, library loans and personal readings might be relevant in order to discover common interests. The text-mining process can drastically improve through the access to full articles that are currently restricted by the low quality of PDFs and copyright issues. The displaying of keywords, for instance, can also be improved. Keywords associated to each laboratory are still hidden, and there is no way to understand how the subjects circulate in the collective. The Affinity Map represents today the right compromise between the qualitative and quantitative aspects of academic practice.

Mapping larger collectives

The Affinity Map was conceived in a controlled setting, which is composed of a precise number of individuals and affinities. Does the mapping still work in a different context? Would the mapping still be valuable in larger collectives and units? Could its hexagonal pattern progress endlessly? What will be the graphical balance with different parameters?

It would be really interesting to apply the visual method of the Affinity Map to new collectives in order to check its resilience. We think that the hexagonal pattern might be a valuable approach for arranging a large number of nodes, as its structure is intended to be limitless. Lines between nodes are still important visual elements to verify their closeness, but it is also true that lines are useless when they connect nodes that are very far apart; this just creates visual noise. A recent mode for drawing lines consists in fading them out in the central section to solve the visual noise with transparency. However, satellites are innovative elements that do not encounter this problem and, in addition, create a context for the node's connectivity. Nevertheless, the satellites will require some adjustments in larger contexts, such as the distance between the node and the satellite that has to be regulated according to the available space.

In any case, the visualization had a limit *a priori*. Indeed, if we tacked some issues with displaying through the mapping design, the fact that we use a flat surface is a great limitation. A high-connected network often presents a problem that interests two nodes displayed at the opposite edges, but which are still connected. That happens because network displaying is based on a non-continuous space. Now let us imagine a contiguous space as a sphere; we do not intend to display the network around the volume of the sphere, but project the network on the surface of the sphere. The sphere surface allows us to project a map on a never-ending space and by doing that we completely remove the problem of defining network boundaries. It might be interesting to create an Affinity Map globe where no laboratories are forced to be at the limits of the visualization.

Another visual choice that works well is represented by the chord diagram; indeed, it has been very interesting to think of nodes as more complex visual objects. However, this specific typology of the Sankey diagram might not be appropriate for larger units. With that in mind, a recurrent hierarchical structure might be worth a further experimentation. We could figure out how to use the same hexagonal arrangement within the nodes; that would create a system of networks within the networks without limiting the number of iterations, which for the Affinity Map is fixed at two levels. Furthermore, that would allow us to redefine the nodes, which will not just have to be the laboratories but, for instance, also the institutes. As we saw from our contributions, rethinking is a fundamental aspect of design that mutates according to the limits and constraints of each project.

Temporal dimension

Would a time-based version of the map be interesting? Probably yes, but why? Indeed, the research process is quite slow if we think about the time scholars wait to get funding or publish a paper. Furthermore, some affinities are not distributed during the year, but rather related to specific periods, such as during the courses. As a consequence, a time-based version of the Affinity Map for real-time use might be less interesting than a long-term one.

Moving back and forth in time the Affinity Map is possible. For example, studying the trajectory of a laboratory through the years is a very interesting idea. Did a certain laboratory change its position? Does that depend on specific collaborations? Is this a position that will endure over time? All these questions are very relevant in terms of governance because they concern decisions and expectations. For example, it might be relevant to study the trajectory of a new laboratory created as a bridge between different disciplines. Or, on a different scale, studying the institute configuration might be useful over the long-term as a way of understanding the creation of new collaborations or the prevention of breaks within the school.

PUBLIC AUDIENCE

Another interesting subject to explore concerns the general public. We concentrated our attention on the ENAC members, who were the user most concerned with the map. However, the impact from the public audience still has to be explored.

In this context, we isolated two possible ways of doing so. One way is identified in the carpet: does the carpet represent an appropriate way to present a scientific collective to a general audience? Did the visualization have to be simplified in order to make it more readable? Another way that will be explored during next few months is the publication of the map on the Internet. Since the Affinity Map is already available within the ENAC, the online publication is aimed to give visibility to the research. That opportunity will lead us to new observations and certainly to more results. The names of the scholars on the map will be hidden. That decision was made in order to avoid any kind of evaluation of the ENAC, bearing in mind the fact that the Affinity Map is always an incomplete translation of the academic practice. However, professors' names will be visible at the center of their laboratories. The boundaries of the scholar's desire for privacy is still blurred. Indeed, on one hand there is a fear of public judgment that we were made aware of during the various discussions and, on the other hand, there is a pleasure in seeing one's own name publicly visible because of the attention. Obviously, the general opinion is to keep very detailed data within the institutes and use generic ones for the sharing with the public. For example, potential affinities do not entail the same problems of actual affinities. Exhibiting individuals and their relation to the public is a very complex work as the representation is differently perceived each reader.

Social impact

Last but not least, it would be interesting to study the impact of the visualization on scholars. As we wrote in the first chapter, the academic practice has been modified by scientific metrics that have been introduced for other purposes. Today professors are recruited if they published in journals with a certain Impact Factor, and if they had a considerable h-index and sufficient number of citations. Indeed, even scholars use the same indicators in their curricula vitae, feeding the same evaluation metric that is criticized by them. Although we put many efforts into finding the right balance of the visual representation, we cannot prevent an evaluative use of the map. In that sense, it would be interesting to see if a visual methodology will be further explored. If a metric of interdisciplinarity will be employed for selecting new employees, will the scholar use it? Otherwise, might the map be used to demand promotions at work? Maybe time will tell the answer to these and other questions, but for the moment it is important to understand how the presence of these metrics is negatively affecting the research. The fact that the literature and public image are more central in recruiting scholars shows that the activities such as teaching and supervision are underestimated. One of the interests of the Affinity Map is to underline the various affinities of the scholar and, accordingly, give proper weight to the tasks he has to fulfill.

In five years, we might see whether the Affinity Map had a social impact or not. We might see the growth of digital traces to better describe the academic practice. We might look at the propagation of similar visualizations. We might watch the affinities as a new form of metric. But most of all, we might measure the impact on all of the individuals involved in the design and reading of the map, and how scholars, the management, and the public audience changed their behaviors and their perception according to new representation methods.

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Annexes

Illustrations

Tables

Equations

Abbreviations

- CTI, Commission of Technology and Innovation
- D3js, Data-Driven Documents
- ENAC, Faculté de l'Environnement Naturel, Architectural et Construit
- EPFL, École Polytechnique Féderal de Lausanne
- IF, Impact Factor
- MARC, MAchine-Readable Cataloging
- MCA, Multiple Correspondence Analysis
- SCI, Science Citation Index
- SCIPER, 6-digit unique EPFL identification number
- VPSI, Vice Presidency for Information Systems of EPFL

ABBREVIATIONS OF ENAC LABORATORIES

- ACHT, Architecture, Criticism, History and Theory
- ACM, Modern Construction Archives
- ALICE, Design Studio on the Conception of Space
- ANTFR, Fribourg unit
- APHYS, Physics of Aquatic Systems Laboratory
- APRL, Atmospheric Particle Research Laboratory
- Archizoom
- BPE, Bioenergy and Energy Planning Research Group
- CCLAB, Bioenergy and Energy Planning Research Group
- CEAT, Urban and Regional Planning Community
- CEL, Central Environmental Laboratory
- CHÔROS, Laboratory of Geography
- CNPA, Laboratory of Digital Culture for Architectural Projects
- CRYOS, Laboratory of Cryospheric Sciences
- DISAL, Distributed Intelligent Systems and Algorithms Laboratory
- EAST, Laboratory of Elementary Architecture and Studies of Types
- ECHO, Laboratory of Ecohydrology
- ECOL, Ecological Engineering Laboratory
- ECOS, Ecological Systems Laboratory
- EESD, Earthquake Engineering and Structural Dynamics Laboratory
- EML, Environmental Microbiology Laboratory
- FAR, Laboratory of Construction and Architecture

- FORM, Laboratory for architecture as form
- GEL, Geo-energy Laboratory
- HERUS, Laboratory on Human-Environment Relations in Urban Systems
- IBETON, Structural Concrete Laboratory
- IBOIS, Laboratory for Timber Constructions
- IMAC, Applied Computing and Mechanics Laboratory
- LAB-U, Laboratory of Urbanism
- LABA, Laboratory Basel
- LAMU, Laboratory of Architecture and Urban Mobility
- LAPIS, Arts of sciences laboratory – Archives of imaginary
- LASIG, Geographic Information Systems Laboratory
- LAST, Laboratory of Architecture and Sustainable Technologies
- LASUR, Urban Sociology Laboratory
- LAVOC, Traffic Facilities Laboratory
- LBE, Laboratory for Environmental Biotechnology
- LCC, Construction and Conservation Laboratory
- LCE, Environmental Chemistry Laboratory
- LCH, Hydraulic Constructions Laboratory
- LDM, Media and Design Laboratory
- LEMR, Laboratory of Experimental Rock Mechanics
- LESO-PB, Solar Energy and Building Physics Laboratory
- LEURE, Laboratory of Environmental and Urban Economics
- LGB, Laboratory for Biological Geochemistry
- LHE, Environmental Hydraulics Laboratory
- LIPID, Laboratory of Integrated Performance in Design
- LIV, Informatics and Visualization Laboratory
- LMCE, Environmental Chemistry Modeling Laboratory
- LMS, Soil Mechanics Laboratory
- LSMS, Computational Solid Mechanics Laboratory
- LTE, Environmental Remote Sensing Laboratory
- LTH2, Theory and History of Architecture Laboratory 2
- LTH3, Theory and History of Architecture Laboratory 3
- LTQE, Laboratory for Water Quality and Treatment
- LUD, Joint Professorship on Solid Waste Treatment
- LUTS, Urban Transport Systems Laboratory
- MANSLAB, Laboratory for Spatial Manufacturing

- MCS, Structural Maintenance and Safety Laboratory
- RESSLAB, Resilient Steel Structures Laboratory
- SBER, Stream Biofilm and Ecosystem Research Laboratory
- SUB, Laboratory of Underground Architecture
- SXL, Structural Exploration Lab
- TOPO, Geodetic Engineering Laboratory
- TOX, Laboratory of Environmental Toxicology
- TRANSP-OR, Transportation and Mobility Laboratory
- TSAM, Laboratory of Techniques and Preservation of Modern Architecture
- WIRE, Wind Engineering and Renewable Energy Laboratory

Curriculum Vitae

Dario Rodighiero
Date of birth: 8 July 1977 Vicenza, Italy
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Mobile: +41 77 416 54 91
Private email: fumoseaffabulazioni@gmail.com
Portfolio: www.dariorodighiero.com

Summary

Dario Rodighiero is a designer with a special affinity for Digital Humanities.

He is currently a PhD candidate at EPFL in Lausanne, where he is attending the Architecture and Sciences of the Cities doctoral program. Prof. Frédéric Kaplan, director of DHLAB at EPFL, and Prof. Boris Beaude, member of the Institute of Social Sciences at UNIL, are his thesis advisors. Dario regularly takes part in research projects with the DHLAB, as well as with CHÔROS, the geography laboratory directed by Jacques Lévy. His research is supported by the ENAC faculty and by Prof. Marilyne Andersen, dean of the school.

In Paris, Dario joined the AIME team, led by Prof. Bruno Latour at the médialab of Sciences Po. He also contributed to the CHI in 2013, where he was part of the committee and collaborated with Prof. Wendy MacKay.

Dario has also been an information scientist at the European Commission's Joint Research Centre, and a scholar at the University of Milan-Bicocca, where he has contributed in a teaching capacity for seven years. His profile has grown through various exciting collaborations, namely with the CERN in Switzerland, XEROX Research Centre Europe and INRIA Saclay in France, the FAO, Central National Library of Florence and Domus Academy in Italy, Fraunhofer in Germany, and the British Geological Survey in England.

Museums are a strong interest of Dario's that he has incorporated into many of his Digital Humanities research projects. Indeed, his digital installations have so far been exhibited at the Bonnefanten in Maastricht, Archizoom in Lausanne, Triennale in Milan, and GAMeC in Bergamo. In 2016 he acted as the curator for a lighting installation at the Rolex Learning Center in Lausanne for the *Nuit des musées*.

Works

– Doctoral Assistant dhlab, epfl (2013 – ongoing)
– Designer and developer médialab, Sciences Po (2012–2013)
– Product designer at Certilogo, Internet-media startup (2010–2012)
– Information scientist at JRC of European Commission (2006–2010)
– Teaching assistant at University of Milan-Bicocca (2002–2008)
– Interaction Designer at University of Milan-Bicocca (2002–2004)
– Designer and developer. Self-employed (2001–2006)

Education

– PhD in Science (2017) at EPFL, Switzerland *Subjects: Data Visualization, Digital Humanities, Social Science, Architecture*
– Master in Theory and Technology of Communication (2010) at University of Milano-Bicocca *Subjects: Psychology, Visual Communications, Humanities*
– Bachelor in Computer Science (2006) at University of Milano-Bicocca *Subjects: Programming, Architecture, Mathematics, Physics*
– Professional photography (2002) at Istituto Italiano di Fotografia in Milano *Subjects: Reportage, Landscape, Portrait, Still-life, Post Production*

Exhibitions

– Curator. Retro-projection exhibition at *Nuit des Musée*s *de Lausanne September 2016. Rolex Learning Center, EPFL*
– Scientific collaborator. Aldo Rossi: The window of the poet. Prints 1973–1997.
June – November 2015. Bonnefanten museum, Maastricht
February – March 2016. Archizoom, Lausanne
April – July 2016. GAMeC, Bergamo
– Designer. Community: Italy. Architecture, city and landscape from the postwar period to 2000
November 2015 – March 2016, Triennale, Milano

Association memberships

– Alliance of Digital Humanities Organizations (ADHO)
– International Council of Museums (ICOM)

Publications

BOOK

- D. Rodighiero. The Analogous City, The Map. Archizoom, Lausanne, 978-2-8399-1667-7, 2015

BOOK CHAPTERS

- A. Rigal, D. Rodighiero. Méduse, vers des visualisations plus complexes que le réseau. Chronotopies chronotopics: reading and writings in a world on move. Elya Editions, 2017
- D. Rodighiero, G. De Michelis The Homer's list or how classifications can be displayed on tablets. At International UDC Seminar: Classification & Visualization. Ergon Verlag, 2013
- D. Rodighiero and M. Halkia. Mapping for multi-source visualization: Scientific Information Retrieval Service (SIRS). In Proceedings of the 13th International Conference on Human-Computer Interaction. Springer, 2009

JOURNAL ARTICLES

- D. Rodighiero, F. Kaplan, B. Beaude. Mapping Affinities in Academic Organizations in Frontiers, on revision in 2017
- D. Rodighiero and L. Cellard. Self-Recognition in Data Visualization: how people see themselves in social visualizations in PubPub, 2016
- D. Rodighiero. Representing the Digital Humanities Community: Unveiling The Social Network Visualization of an International Conference in Parsons Journal of Information Mapping, vol. VII, num. 2, 2015
- A. Rigal and D. Rodighiero. Trajectoire d'une représentation cartographique en réseau in Cartes & Géomatique : Temps, Art & Cartographie, vol. 1, num. 225, p. 33-41, 2015
- D. Rodighiero. Visual(izing) Data in Contour Journal, 2015

CONFERENCE PAPERS

- D. Rodighiero. Circulation of Opinions in Visualization Reading. International Working Conference on Advanced Visual Interfaces (AVI 2016), Bari, Italy, June 7–10, 2016. CEUR Workshop Proceedings
- A. Rigal, D. Rodighiero, L. Cellard. The Trajectories Tool: Amplifying Network Visualization Complexity. Digital Humanities 2016, Krakóv, Poland, 12–16 July 2016
- D. Rodighiero. Guidelines to Visualize Vessels in a Geographic Information System. In Proceedings of 14th International Conference Information Visualisation. IEEE, 2010
- M. Motta and D. Rodighiero. Il Thesaurus del Nuovo soggettario interpreta SKOS. Associazione Italiana per la Documentazione Avanzata (AIDA), 2010
- C. Ferigato, G. Merlo, D. Panfili, and D. Rodighiero. Role of thesauri in a scientific organisation. In Networks of Design: Proceedings of the 2008 Annual International Conference of the Design History Society (UK) University College Falmouth. Universal-Publishers, 2008

Workshops

- D. Rodighiero. Reading Data Together. VVH 2016 – 1st International Workshop on 'Valuable visualization of healthcare information': from the quantified self data to conversations., Bari, Italy, June 7–10, 2016

Thesis

- D. Rodighiero. Il tesauro non è un dinosauro
  Master's thesis in Library Science and Interaction Design
- D. Rodighiero. Visualizzare i dati nella ricerca di informazioni d'archivio attraverso le chiavi di spazio e tempo
  Bachelor's thesis in Information Visualization

Reviewer

- The Latent Image, the 5th International Conference on *Transdisciplinary Imaging at the Intersections of Art, Science and Culture* at the University of Edinburgh an Edinburgh in 2018
- *Converge: Disciplinarities and Digital Scholarship* the AIGA Design Educators Conference hosted at the University of Southern California in June 2017
- *Visible Language Journal* by the College of Design, Architecture, Art, and Planning, University of Cincinnati in 2014
- *Digital Humanities Quarterly* by the Alliance of Digital Humanities Organizations from 2015

Committee memberships

- VVH 2016 *Valuable visualization of healthcare information* in Bari, Italy
- DH 2014 *Digital Humanities conference* in Lausanne, Switzerland
- CHI 2013 *Conference on Human Factors in Computing Systems* in Paris, France

Teaching

- Teaching assistant at the University of Milano-Bicocca for 7 years
- Teaching assistant at the EPFL for 4 years

Advising

- Loup Cellard, master student in social sciences at École Normale Supérieure de Lyon in 2015. Afterwards PhD candidate at the University of Warwick
- Emina Boudemagh, bachelor student in physics at EPFL in 2015. Afterwards master student at the ETH of Zurich

Invited speeches

- Business School Lausanne. Switzerland, December 2017
- Delft University of Technology, Faculty of Architecture. Netherlands, December 2017
- University of Applied Sciences Northwestern Switzerland, Academy of Art and Design. Basel, Switzerland, October 2016
- CERN, Academic Training Lecture Regular Programme. Geneva, Switzerland, March 2016
- EPFL, Inaugural lecture of the exhibition *Aldo Rossi, La finestra del poeta*. Lausanne, Switzerland, February 2016
- University of Lausanne, Journée de la visualisation des données. Switzerland, March 2015
- EPFL, ENAC General Assembly in September 2014 at Lausanne, Switzerland
- Polytechnic University of Milan, Nurturing Design Sciences with Humanistic Knowledge. Italy, June 2014
- Biblioteca Nazionale Centrale di Firenze, Renaissance of Thesauri. Florence, Italy, September 2008

Projects

- Affinity Map (2013–17) with Frédéric Kaplan, Boris Beaude and Marilyne Andersen at EPFL
- An inquiry into the modes of existence (2012–13) with Bruno Latour at médialab at Sciences Po
- DIME-SHS (2013) at Centre de Données Socio-politiques of Sciences Po
- Habitele (2012) with Dominique Boullier at Médialab of Sciences Po
- Vessel Detection System (2010) at Joint Research Centre of European Commission
- Scientific Information Retrieval System (2006–09) at Joint Research Centre of European Commission
- Authentication Service (2010–12) at Certilogo
- MILK (2001–04) in collaboration with the XEROX Research Centre Europe and the Fraunhofer Society