

“A-ha!”: How to Visualize Strategies with Complementary Visualizations

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Abstract: This paper first introduces the new paradigm in visualizing indicators, the shift from reporting indicators towards communicating strategies. We argue that organizations should concentrate to visualize the 'big picture' and strategic implications of the collected data instead of decorating collected data. In doing so, there is a designer who illustrated information becomes a communicator who transfers knowledge to recipients. As a result, the complexity arises because each stakeholder has a different educational, functional, or cultural background. To allow them to re-create the knowledge the contents need to be embedded into the context of the recipients, in a way that it can be interpreted and put into meaningful action.

Second, this paper presents theoretical backgrounds on our innate abilities to process visual representations, which allows to thirdly derive a general framework for the implementation of the new paradigm (visualizing strategies). Finally, the framework is put into practice in a real-world case study at Empa where the new paradigm allowed to reach the goal to communicate a big number of indicators to different stakeholders in a way that motivates and leads to action. We found that visualizing indicators plus strategies, i.e. combining the two paradigms, is a fruitful strategy, which can be implemented by using complementary visualizations. The new paradigm, the framework, and the case study are therefore important for scientists in the field of communication, visualization sciences, and statistics and for practitioners as journalists, controllers, or managers.

Keywords: Strategy Visualization, Knowledge Visualization, Visualizing Indicators

1 Introduction: If Indicators are Bricks, what would you build?

"You can only manage what you can measure". This management credo is one reason why organizations today invest heavily in collecting data, the basis for indicators, which are a means for measuring and tracking the implementation of corporate strategies. The investment happens in terms of new information systems and of many working hours to collect, format, and feed in the desired data. While the amount of indicators that want to be reported, a general information overload, lack of time and interest led to the common practice to visualize the indicators. Statistical curves, business diagrams, or management cockpits seem to be the best means to motivate and inform individuals. In presentations, in annual reports, on the website. Next these indicators are compared with the indicators of the competitors by persons such as journalists or analysts. As result lists show the rankings in terms of the indicators, such as the number of publications, PhD. candidates, research projects, and so on. But people are bored. That's why we research in new methods to visualize indicators.

We believe that if your numbers are interesting, you do not need diagrams. We further believe that people are surrounded by information but miss the big picture. The value of these indicators or the meaning of these numbers interests them. They do not want to see pie charts of indicators; they want to see the implications for the future of the organization, grounded in the analysis of these indicators. Imagine two 2000 m runners: The first runner analyzes every 100 meter by analyzing the behaviour and position of his competitors and becomes bronze, he knew it. Another runner knows his mission: Running. She wins. Similarly, organizations spend a lot of capacity for record and report all kinds of indicators, but rarely do they communicate the meaning of these indicators, which would allow to better and faster achieve the strategic goals.

We therefore believe that the discussion on visualizing indicators needs a radical paradigmatic shift: from reporting indicators towards communicating strategies. In short: Forget Cockpits - Visualize Strategies. We consider indicators and other data as raw material (bricks). Instead of presenting the raw material (bricks), we suggest to present what you build out of these bricks (temple), i.e. meaning, implications, actions. We argue that organizations should concentrate to visualize the 'big picture' and strategic implications of the collected data instead of decorating collected data. In doing so, the designer who illustrated information becomes a communicator who transfers knowledge to recipients. The same information needs to be transferred to various stakeholders, experts, non-experts, high- and low-educated persons from the same or different cultural backgrounds with high or low motivation. To allow them to re-create the knowledge needs to be embedded into the context of the recipients, in a way that they can interpret it and put it into meaningful action. This knowledge management process is called knowledge transfer. For successfully visualizing indicators (old paradigm) or visualizing strategies (new paradigm) we can learn from Knowledge Management, which is described next.

2 Learning from Knowledge Management

Knowledge Management is a management perspective that offers theories, strategies, and methods to manage, i.e., to identify, access, share, and create knowledge in organizations, with the aim to help an organization to compete by being more innovative, effective, and thus more profitable. Knowledge Management has its roots in organizational learning (Argyris and Schön, 1978, Fiol and Lyles, 1985, Senge, 1990), strategic management, and information science. The knowledge-based theory sees knowledge as a key productive and strategic resource, which is embedded in an organizational culture, in systems, documents, and individuals. The knowledge-based theory is described by various researchers (Grant, 1996, Nonaka, 1991, Nonaka and Takeuchi, 1995, Spender, 1996).

The knowledge management approaches differ depending on the understanding of knowledge. If knowledge is viewed as an **object**, knowledge management aims to build information repositories. If knowledge is understood as a **process**, the focus is on optimizing the knowledge-intensive processes, e.g., identifying, creating, and sharing knowledge. Knowledge seen as a **capability** focuses on the strategic advantage of knowledge, to build core competencies, and to create intellectual capital. If knowledge is seen as a condition of **access** to information, then knowledge management focuses on methods to identify, retrieve, and gain access to information. Finally, if knowledge is seen as a **state** of knowing and understanding, knowledge management supports individuals to expand their knowledge.

In spite of these diverging understandings of knowledge, all perspectives have in common, that knowledge management is seen as a dynamic and continuous task, with three main objectives: (1) to optimize business processes from a knowledge perspective, (2) to introduce systems for storing, identifying, retrieving, and gaining access to information, and supporting individuals to collaborate, (3) to develop a corporate knowledge culture that motivates employees to envision, create, and share knowledge, alone, in teams, or across units and regions.

What we learn is that the goal of knowledge management is not about introducing new methods, it is about introducing new methods as means to be more innovative and profitable. Therefore in successful knowledge management initiatives the visualization of the big picture and strategy (i.e., building a knowledge culture to be more innovative) is always the nucleus of the communication. We further learn that explicit knowledge (knowledge you can write in a database) is only one type of knowledge and that tacit knowledge (knowing how to swim) is more challenging to be measured. We thirdly learn about the transfer of knowledge, which can occur at various levels: Among individuals, from individuals to groups, among groups, among individuals/groups and an organization. Based on Gupta and Govindarajan (2000) five elements for a successful knowledge transfer can be distinguished: (1) the perceived value of the sender's knowledge, (2) the motivation and willingness of the sender to share his knowledge, (3) the existence and richness of transmission channels, (4) the motivation of the recipient to acquire knowledge from the sender, and (5) the absorptive capacity of the recipient, i.e., the ability not only to acquire but also to use knowledge. To do so, knowledge must be recreated by the receiver, which brings us to the challenge: Individuals who need to transfer knowledge to one or more individuals, from the same or different backgrounds, not only need to convey the relevant knowledge, but also need to convey it in the right context, so it can be used and applied. But luckily, for exactly this challenging process we have a very powerful and yet rarely used skill that can be exploited: Our innate ability to effectively process visual representations.

3 Our Innate Abilities to Process Visual Representations

A majority of our brain's activity deals with processing and analyzing visual images. To understand perception, it is important to remember that our brain does not differ greatly from our ancestors, the troglodytes. At that time, perception helped for basic functions, for example for hunting (motion detection), seeking food (colour detection), or applying tools (object-shape perception). The Gestalt Principles (Ellis, 1938, Koffka, 1935) provide descriptive insights into form and pattern perception, i.e., how we perceive form. But unfortunately they do not offer explanations of these phenomena. Neuroscience help us to understand how visual information is being processed in our brains (Farah, 2000, Goldstein, 2001, Gregory, 1998, Ware, 2000): Visual information processing can be divided into two stages: In the first stage, information is parallel processed in the eye and the primary visual cortex, where individual neurons in specific areas (called V1, V2, V3, V4, MT) are specialized to identify particular features (e.g., orientation, colour, texture, contour, or motion). In the second stage, information processing is divided into two functionally independent complementary subsystems (Ungerleider and Mishkin, 1982) where one subsystem is more important for object identification (~what) and the other for spatial localization (~where).

From a practical perspective several functions of visualizations can be differentiated. They help (1) to address emotions (e.g., advertising), (2) illustrate relations (e.g., maps) (3) discover trends, patterns, outliers (e.g., information visualization applications) (4) to get and keep the attention of recipients (e.g., red line) (5) to support remembrance and recall (e.g., visual metaphors), (6) to present both an overview and details (e.g., zoom able interfaces), (7) to facilitate learning (e.g., instructive videos), (8) to coordinate individuals (e.g., group sketching), (9) to motivate people and establish a mutual story (e.g., story telling or mental images), or (10) to energize people and initiate actions by illustrating options to act (e.g., visual scenarios).

Several studies prove the power of visualizations with regard to these functions. Some examples: (1) Miller (1956) reports that a human's input channel capacity is greater when visual abilities are used. (2) Visual imagery (Kosslyn, 1980, Shepard and Cooper, 1982) suggest that visual recall seems to be better than verbal recall. Yet, it is not clear how images are stored and recalled, but it is clear that humans have a natural ability to use images. (4) Several empirical studies show that visual representations are superior to verbal-sequential representations in different tasks (Bauer and Johnson-Laird, 1993, Glenberg and Langston, 1992, Larkin and Simon, 1987, Novick, 2001). (5) Instructional psychology and media didactics investigate the learning outcomes in knowledge acquisition from text and pictures (Mandl and Levin, 1989), or Weidenmann (1989) who explores aspects of illustrations in the learning process.

The previous two sections introduced theoretical basis for the missing framework.

4 From Visualizing Indicators towards Knowledge Visualization

For an effective transfer and the creation of knowledge through visualizations, four perspectives should be considered. They are based on four questions:

1. What's the goal of using a visualization method? (goal)
2. What type of knowledge needs to be visualized? (content)
3. Who is being addressed? (recipient)
4. What is the best method to visualize this indicator? (medium)

These key questions lead to the Framework for Visualizing Indicators, which is grounded in previous frameworks in the field of Knowledge Visualization (Burkhard, 2004b, Eppler and Burkhard, 2005) as seen in Figure 1.

FUNCTION TYPE	KNOWLEDGE TYPE	RECIPIENT TYPE	VISUALIZATION TYPE
Attention	Know-what	Individual	Sketch
Transfer	Know-how	Group	Diagram
Exploration	Know-why	Organization	Image
Recall	Know-where	Network	Map
Activation	Know-who		Object
			Interactive Visualization
			Story

Fig. 1: The Framework for Visualizing Indicators consists of four perspectives that need to be considered when creating visual representations that aim to transfer knowledge.

4.1 Function Type Perspective

The *Function Type Perspective* distinguishes five functions of visual representations that can be exploited:

- **Attention:** Visual representations allow to get the attention by addressing emotions, and to keep the attention by using visual stimuli, that can be further used for identifying patterns, outliers, or trends.
- **Transfer:** Visual representations help to clarify contents and lead to a better and faster understanding and learning. It can assist for the creation of mental models, which allows integrating and re-constructing the knowledge.
- **Exploration:** Visual representations support the creation of new insights by leading to a-ha effects and illustrating relationships. Information visualization applications allow to find new insights by using computer supported visual systems.
- **Recall:** Visual representations improve memorability, remembrance and recall, because we think in images.
- **Activation:** Visual representations inspire, motivate, energize, and activate viewers and can thus foster discussion or show options to act.

4.2 Knowledge Type Perspective

The *Knowledge Type Perspective* aims to identify the type of knowledge that needs to be transferred. For our framework, five types of knowledge are distinguished which are grounded in the knowledge management literature: **Declarative knowledge** (Know-what, e.g., facts), **procedural knowledge** (Know-how, i.e., knowing how things are done, which is captured in processes, norms of behaviour, standards of practice, settings of equipment), **experimental knowledge** (Know-why, i.e., knowing why things occur which captures underlying cause-and-effect relationships and accommodates exceptions, adaptations, and unforeseen events), **orientational knowledge** (Know-where, i.e., knowing where information can be found, e.g., knowledge sources, libraries, databases), **individual knowledge** (Know-who, i.e., knowing who are the experts). Today, no classification exists that links visualization types to knowledge types.

4.3 Recipient Type Perspective

The *Recipient Type Perspective* aims to identify the target group and the context of the recipient. The recipient can be an individual, a team, a whole organization (one shared culture, internal information) or a network of persons (plurious cultures, internal and external information with different levels of confidentiality). Knowing the context and the educational, emotional, and cultural background of the recipient/audience is essential for finding the right visualization method for the transfer of knowledge. Today, graphic design and information visualization (Bertin, 1967, Tufte, 1990, Tufte, 1997) do not focus on this perspective.

4.4 Visualization Type Perspective

The *Visualization Type Perspective* structures the visualization methods into seven main groups that are derived from the practice of architects to visually transfer knowledge (Burkhard, 2004a, Burkhard, 2004b, Burkhard, 2004c). The seven types are: Sketches, diagrams, images, maps, objects, interactive visualizations, and stories.

Sketches represent the main idea, are atmospheric, and help to quickly visualize an idea (Figure 2). For the transfer of knowledge, sketches have three main strengths: (1) sketches represent the main idea and key features and support reasoning and arguing. (2) They are atmospheric, versatile, and universally accessible and help to quickly visualize an idea. (3) Sketches allow room for own interpretations and foster the creativity in groups.



Fig. 2: A sketch from Leonardo da Vinci represents the main idea of a new concept.¹

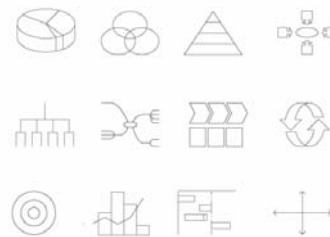


Fig. 3: Diagrams are schematic depictions of abstract ideas which use standardized shapes to structure information and illustrate relations.

In contrast, **Diagrams** are abstract, schematic representations used to explore structural relationships among parts by denoting functional relationship (3). The type of knowledge that is being conveyed by diagrams is analytic. Diagrams are therefore structured and systematic. For the transfer and creation of knowledge, diagrams help to make abstract concepts accessible, help to reduce complexity, amplify cognition, explain causal relationships, reduce the complexity to the key issues, structure and display relationships.

Maps generally consists of two elements: A ground layer representing the context (e.g., a network of experts, a project, a city) and individual elements (e.g., experts, project milestones, roads) that are mapped to this context. Maps illustrate both an overview and details. Fig. 4 presents a fictitious map that improved interfunctional communication of a complex project in an organization, based on the tube system metaphor. (Burkhard and Meier, 2004, Burkhard and Meier, 2005). For the transfer and the creation of knowledge, maps help to present overview and detail, help to structure information, to motivate and to activate employees, to establish a common story, and to ease access to information.

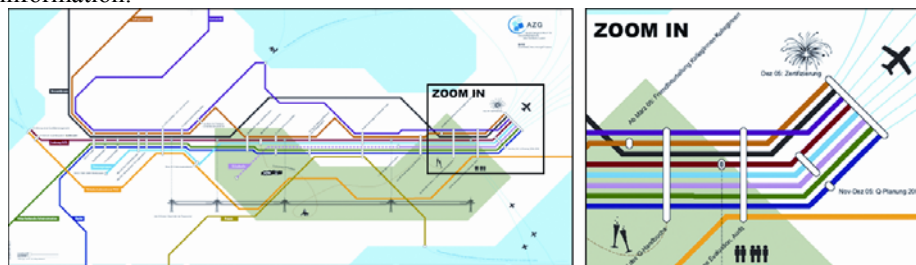


Fig. 4: The Tube Map Visualization uses the power of visual metaphors to improve interfunctional communication of a quality development project. The subway lines represent target groups, the stations project milestones. The map is aligned to a timeline.²

¹ Retrieved on the 20th of august 2004 from <http://www.visi.com/~reuteler/vinci/fly3.jpg>

² Concept and copyright by vasp dataecture GmbH, www.vasp.ch

Images are impressive, expressive, or represent reality. Images address emotions, are inspiring, appealing, motivating, and energizing. Thus, they are widely used in advertising (Fig. 5). Images can be grasped and recalled in less than a second and sometimes be remembered for decades (i.e., key images of the war in Vietnam or Iraq). The same effects can be used for the transfer of business related knowledge, e.g., by using visual metaphors. Visual metaphors support remembrance, lead to a-ha effects, support reasoning and communication. They are instant and rapid, highly instructive, and facilitate learning. For the transfer of knowledge, images help to get the attention (e.g., advertising), inspire recipients (e.g., art), address emotions (e.g., advertising), improve recall (i.e., signs, visual metaphors), and/or initiate discussion (e.g., satirical comic).



Fig. 5: Images address emotions and are widely used in advertising.³



Fig. 6: Objects in this Info-Structure attract people.⁴

Objects in Space exploit the third dimension and allow experiencing materials. Objects in space are helpful for example for information points (Fig. 6), knowledge fairs, or exhibitions, to complement physical and digital visualizations and to show content from different viewpoints. For the transfer of knowledge, objects help to attract recipients, support learning through constant presence, and/or allow integrating digital interfaces.

Interactive Visualizations allow to access, explore, and make sense of different types of information. An example of such a visualization application (Fig. 7) allows the exploration of survey data of the project Science City ETH. This application allows to filter the data by using different sliders and is based on previous work, e.g., Brodbeck and Girardin (2003). To transfer knowledge, interactive visualizations help to fascinate people, enable interactive collaborations across time and space and allow to represent and explore complex data, or to create new insights.

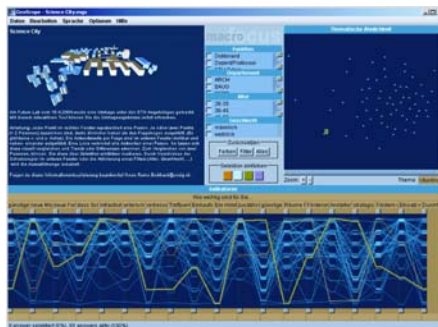


Fig. 7: An interactive visualization of a survey based on the method described in (Brodbeck and Girardin, 2003) allows to get new insights.⁵

Louis Wellington: "Die Forschung ist mein Lebenselixir. Deshalb bin ich aus London nach Science City umgezogen. Denn hier herrschen optimale Bedingungen, um meine Forschung voranzubringen: Zum Beispiel die Dichte an Spitzenforschern, die führende Rolle im Bereich Life Science, ..."

Fig. 8: Different fictitious stories helped to better imagine the individual benefit per stakeholder. An excerpt of one imaginary story.

Stories, the last visualization type, are imaginary (not physical) visualizations that are efficient in transferring and disseminating knowledge across time and space. The use of stories (storytelling) (Fig. 8) allows to transport an illustrative mental image by using spoken or written language, and can be used in organizational practice (Loebbert, 2003). To transfer knowledge, imaginary visualizations complement the other six visual formats and are valuable to establish a shared vision, a mutual story, which motivates and activates individuals.

Concluding answers to these four questions help in finding one or different appropriate visualization types that are used for the transfer of knowledge. It is a structure that helps as a guideline for researcher and practitioners and

³ Image for a seminar on the effective use of visualizations: <http://www.2sekmanager.ch>

⁴ ETH Science City: <http://www.sciencecity.ethz.ch>

⁵ <http://www.macrofocus.com>

helps to identify new approaches or blind spots in research. Next we discuss an example that arose from the application of this framework.

5 Case Study: Visualizing the mid-term Strategy of Empa

5.1 Situation

Since many years Empa systematically tracks and reports with different indicators the growth and evolution of Empa. The visualized indicators were merely used for internal reports (activity and annual report) to different stakeholders (ETH Board, public, internal, rankings) to prove the performance of Empa by providing measurable results. And to offer figures that allow comparing Empa with the other six organizations in the ETH domain (such as the PSI, EPFL, ETHZ, WSL, EAWAG). The motivation first is to do only one's duty and secondly to get recognition and based on it more funds. Until today the reporting was done with traditional business diagrams. In 2004 Empa wanted to go one step further and introduced the new paradigm: From reporting to activating. It was the idea not only to look back, but to analyze the performance and based on it to start strategic initiatives. To do so, the communication of the indicators demands much more attention and needs to be coupled with the communication of the strategic initiatives. That's why Empa learned from the new field knowledge visualization (Eppler and Burkhard, 2005) and engaged the leading knowledge visualization company vasp datatecture GmbH⁶ to develop a customized solution.

5.2 Solution

Finally a poster has been developed that consists of two visualizations that complement each other. The two formats are a Knowledge Map for the communication of the strategic initiatives and second a parallel coordinate diagram of the essential indicators which illustrate why the initiatives are necessary. At the bottom the parallel coordinates allow the direct comparison of the indicators from 2000 until 2004, as seen in Figure 9. Each line represents a year and is constructed by connecting the values of the individual indicators.

At the top the shared beliefs and guiding principles are drawn as high pressure areas with isobars. To support these strategic goals different strategic initiatives are necessary. They are based on the indicators below and are depicted with islands or icebergs that are aligned to the axes (feasibility, impact). The icebergs as metaphor float in the sea and symbolize also the risks of failure. Icebergs have a temporal character but they can also become to established programs (islands). As the islands are strategic initiatives supporting not only one goal, they are placed in between the different high pressure areas they are affecting. As a third element relationships between indicators and strategic initiatives are illustrated by connecting lines. E.g., the number of publications should increase to 200-250 per year and therefore the green line connects the indicator range in the lower graphic with the measures affecting this indicator in the upper map. Measures are e.g. the workshops for writing scientific papers and the increasing number of scientific personnel. Of course, all the research programs are also contributing to a higher scientific output (marked with dotted lines). All these elements create a vivid environment which motivates for exploration and fosters creativity and discussions. The posters can be located at lively places i.e. in the cafeteria or next to elevators.

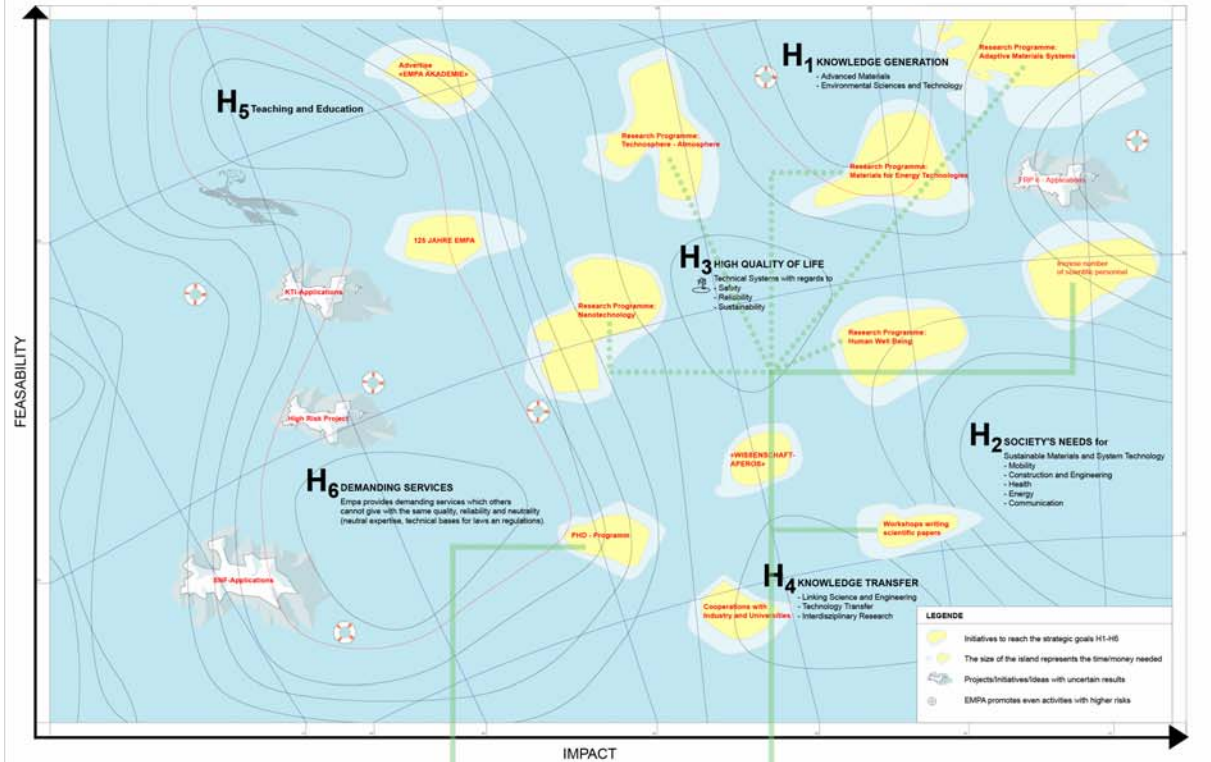
⁶ <http://www.vasp.ch>

Visualize Strategies with Complementary Visualization

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STRATEGIC GOALS and INITIATIVES 2005



The map shows the most important goals of Empa as regions of high pressure. Measures for the realization are marked as islands.

- H₁ Empa generates knowledge in fields of advanced materials and environmental sciences and technology. This knowledge is internationally competitive and essential to society and its economy.
- H₂ Empa meets society's needs for sustainable materials and system technology for mobility, construction and engineering, health, energy and communication.
- H₃ Empa contributes to a high quality of life by its innovative activities with regards to safety, reliability and sustainability of technical systems.

- H₄ Empa's strength lies in linking science and engineering, in interdisciplinary oriented research based on long-term experience, and in the transfer of knowledge to practice.
- H₅ Empa offers its knowledge for teaching and continuing education on an academic level.
- H₆ Empa provides demanding services which others cannot give with the same quality, reliability and neutrality (neutral expertise, technical bases for laws and regulations).

The graphs below show the indicators from the last years. The thick green line indicates the target value to be reached. Follow the green lines to see the measures (in the map) Empa has taken to reach the goals.

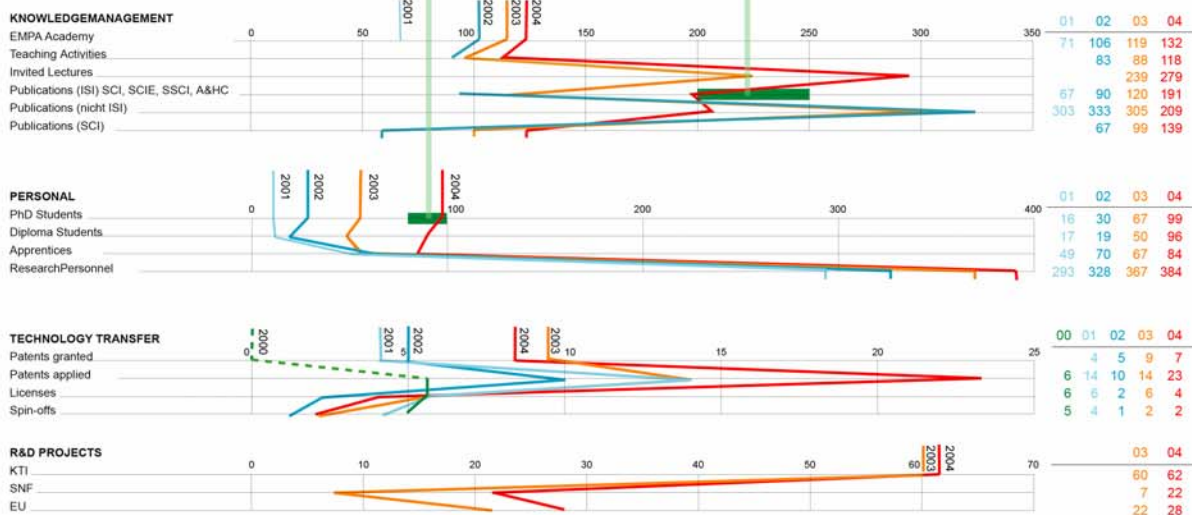


Fig. 9: The final poster combines two visualizations: At the bottom parallel coordinates allow to compare the indicators. Each line represents a year and is constructed by connecting the values of the individual indicators. At the top the initiatives are depicted with icebergs and island that are aligned to two axes (feasibility, impact).

5.3 Findings

The effect of the poster is that it catches the attention, motivates individuals to carefully explore the individual elements, and to support understanding and internalization of the multifaced strategic initiatives. The spatial localization of verbal descriptions of different ideas and concepts helps people to better imagine the measures to reach the strategic goals. As a consequence the map allows to build individual mental models, which then are told by the vision infected individual to other persons by story telling. When we observed the reaction of people to this type of visualization we got always the same answer: it's attractive, in the first step. But to read and understand the information people needed more time and the poster had also to be enough attractive in this second step. So we recognized that this visualization is so provocative that everyone took the second step.

Another finding is that this complementary visualization can be used as a cybernetic model for the yearly planning process.

6 Conclusions

This paper first introduces the new paradigm in visualizing indicators, the shift from reporting indicators towards communicating strategies. As a consequence the designer becomes a communicator who needs to understand his addressees. As a result, the complexity arises because each stakeholder has a different educational, functional, or cultural background. To allow them to re-create the knowledge the contents need to be embedded into the context of the recipients, in a way that it can be interpreted and put into meaningful action. We further illustrated that we can learn from knowledge management on the different types of knowledge and the process of knowledge transfer. Together with backgrounds from visualization research we derived a general framework for visualizing strategies. The framework was then put into practice in a real-world case study at Empa where the new paradigm allowed to reach the goal to communicate a big number of indicators to different stakeholders in a way that motivates and leads to action. We found that visualizing indicators plus strategies, i.e. combining the two paradigms, is a fruitful strategy, which can be implemented by using complementary visualizations.

The new paradigm, the framework, and the case study are therefore important for scientists in the field of communication, visualization sciences, and statistics and for practitioners as journalists, controllers or managers.

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