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Visual Knowledge Transfer between Planners and Business Decision Makers

A framework for knowledge visualization

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Keywords: Decision Making, Knowledge Transfer, Visualization Types, Interfunctional Communication, Business Knowledge Visualization, Information Visualization

Abstract: The transfer of knowledge between planners and business decision makers can be improved when planners combine traditional visualizations with business knowledge visualizations. Today architects and urban planners use visualization methods such as sketches, diagrams, drawings, renderings, models and animations to illustrate their projects. While spending an enormous amount of time to illustrate a project, almost no time is used to illustrate business relevant information that decision makers need (i.e., revenue models, risks, return on investments, project phases). Consequences are information overload, misinterpretation or even misuse of information. Juxtaposing the visualizations that planners and decision makers use reveals a major gap: Both groups use different visualization types and are not familiar with the visualization types of each other. This paper stresses the importance to expand the visualization types of planners with business knowledge visualizations. First, it discusses the functioning of visual representations for the transfer of knowledge. Second, it introduces a general knowledge visualization framework. Third, it illustrates examples from an innovative office that improved knowledge transfer with decision makers in urban planning projects. We found that combining traditional visualizations with business knowledge visualizations reduces the information overload, prevents misinterpretation, increases the information quality, improves communication and as a consequence improves decision making. We found that decision makers pay extra for these visualization types, which therefore is a new source of income for planners. The results have implications for the education of future architects.

1. INTRODUCTION: IMPROVING KNOWLEDGE TRANSFER AND DECISION MAKING

The transfer of knowledge is a core process in knowledge management and difficult to manage (Probst, et al., 1997). It can be improved by exploiting our innate abilities to use visualizations, as described by (Dürr, et al., 2004, Eppler, 2003, Eppler, 2004, Nonaka, 1991). The transfer of knowledge between planners (i.e. architects or urban planners) and business decision makers (i.e. investors, developers, marketers) can be improved, when planners combine traditional visualizations with business knowledge visualizations, which we define as: "*Knowledge visualization examines the use of visual representations to improve the transfer of knowledge between at least two persons*". The presentation of an architectural or urban planning project is a decisive milestone, with the following difficulties:

- *Information depth*: Trade off between an overview and details.
- *Limited time*: Limited time, attention and capacity of the recipients.
- *Different background*: Difficulties of decision makers to understand the visual representations of planners.
- *Relevance*: Providing the relevant information for decision makers.

Today planners use an enormous amount of time to illustrate a project, but almost no time to illustrate business relevant information that decision makers need for decision making. Issues such as revenue models, financial implications, risks, marketing potentials or effects for tourism are rarely mentioned or even visualized, which can cause three consequences: *Information overload*: Decision makers cannot identify the relevant information. *Misinterpretation*: Decision makers cannot understand, evaluate and interpret the information. *Misuse*: Decision makers cannot use or misuse the information for decision making. We found that combining traditional visualizations with business knowledge visualization is a promising approach that increases the communication quality (effectiveness, motivation), increases attention, reduces information overload and as a consequence improves decision making.

This paper first presents a theoretical background on the potential of visual representations. Second and third, it presents the visualization types of planners and decision makers. A juxtaposition reveals a major gap in the use of visual representations. Fourth, a framework for knowledge visualization is introduced. Finally a scenario of it's use is presented by discussing new examples from an innovative urban planning office.

Apart from the framework and new visualization approaches for planners, the paper presents a new research direction and a new value proposition for planners with implications for the education of future planners.

2. FUNCTIONING OF VISUAL REPRESENTATIONS

This section presents an overview of visualization research for an understanding of our innate abilities to process visualizations, which can be exploited to improve the transfer of knowledge.

2.1.1 General Advantages of Visual Representations

A majority of our brain's activity deals with processing and analyzing visual images. Images are pre-attentive and processed before text. In comparison to text, visual images need less energy to be consumed. Alesandrini (1992) presents five advantages of abstract images: They are instant, memorable, automatic, global and energizing. Several empirical studies show that visual representations are superior to verbal-sequential representations in different tasks, i.e. to illustrate relations, to identify patterns, to present both an overview and details, to support problem solving and to communicate different knowledge types (Bauer and Johnson-Laird, 1993, Glenberg and Langston, 1992, Larkin and Simon, 1987, Novick, 2001). The use of visual metaphors is effective for the transfer of knowledge (Nonaka, 1991). Eppler (2004) describes six advantages: (1) to motivate people, (2) to present new perspectives, (3) to increase remembrance, (4) to support the process of learning, (5) to focus the attention of the viewer and (6) to structure and coordinate communication.

2.1.2 Visual Cognition and Perception

Miller (1956) reports that a human's input channel capacity is greater when visual abilities are used. Our brain has a strong ability to identify patterns, which is examined in Gestalt psychology (Koffka, 1935). Visual imagery (Kosslyn, 1980, Shepard and Cooper, 1982) suggest that visual recall seems to be better than verbal recall. It is not clear how images are stored and recalled, but it is clear that humans have a natural ability to use images. Instructional psychology and media didactics investigate the learning outcomes of text-alone versus text-picture: (Mandl and Levin, 1989) present different results in knowledge acquisition from text and pictures. Weidenmann (Weidenmann, 1989) explores aspects of illustrations in the learning process. Cognitive neuroscience discusses the underlying cognitive components of picture processing (Farah, 2000).

This section presented an overview. The next two sections illustrate how planners and business decision makers use visual representations.

3. VISUALIZATIONS OF PLANNERS

This section presents the five main visualization types that planners use: Sketch, Diagram, Image, Model and Interactive Visualization.

3.1 Sketch

A sketch as seen in Figure 1 is defined as: "*Traditionally a rough drawing or painting in which an artist notes down his preliminary ideas for a work that will eventually be realized with greater precision and detail.*"[1] A sketch represents the main idea and key features of a preliminary study. Sketches are atmospheric, fast and universally accessible. Sketches help to quickly visualize an idea. For the transfer of knowledge sketches are a versatile and always accessible visualization method, i.e. for meetings or presentations. The use of a pen on a flipchart attracts the attention and supports reasoning and arguing. Sketches allow room for own interpretations and foster creativity.

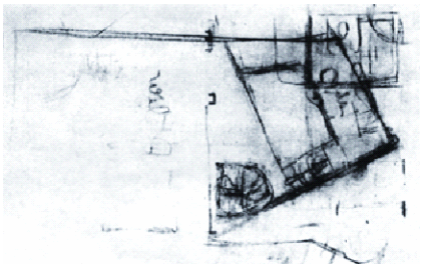

Figure 1. The **Sketch** by Le Corbusier outlines the concept of a new building. [2]

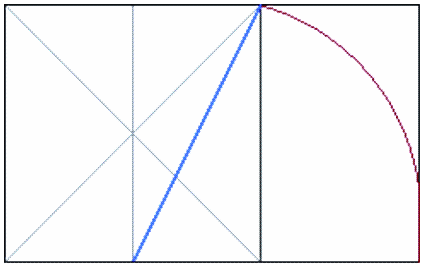

Figure 2. This **Diagram** represents the construction of the Golden Section.

3.2 Diagram

Garland defines a diagram as a "*visual language sign having the primary purpose of denoting function and/or relationship*" (Garland, 1979). Diagrams as seen in Figure 2 are abstract, schematic representations used to explore structural relationships among parts. Architects use diagrams to explain concepts and to reduce complexity. Drawings such as sections and

[1] Sketch. Encyclopædia Britannica. Retrieved August 4, 2003, from Encyclopædia Britannica Premium Service. http://www.britannica.com/eb/article?eu=69864

2 Retrieved August 4, 2003, http://www.strath.ac.uk/Students/Architecture/ciam/ciam1.html

plans belong to this category. For the transfer of knowledge diagrams help to reduce complexity, amplify cognition and explain causal relationships. Diagrams help to structure information. In contrast to sketches, they are precise and determined.

3.3 Image

Kemp defines images as: "*representations which are primarily concerned with impression, expression or realism.*" (Kemp, 2000). An image (Figure 3) can for instance be a rendering, a photograph or a painting. Doelker distinguishes different functions of images. They can be "*registrative, mimetic, simulative, explicative, diegetic, appellative, decorative, phatic, ontic or energetic*" (Doelker, 1997)[3]. For the transfer of knowledge, images help to get attention, inspire recipients, address emotions, improve recall or provoke discussions.

3.4 Model

Physical models bring together architectural plans and sections and enable to see a project from different viewpoints. Physical models allow materials to be experienced and the design of complex buildings to be controlled (Figure 4). For the transfer of knowledge models help to attract recipients, support learning through constant presence or integrate digital interfaces.

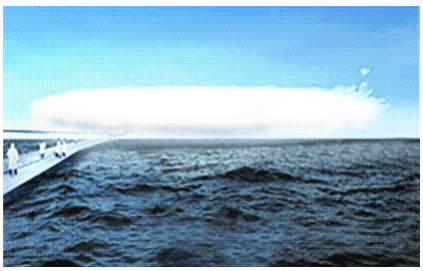

Figure 3. An atmospheric **Image** of the "blur building" addresses emotions.[4]

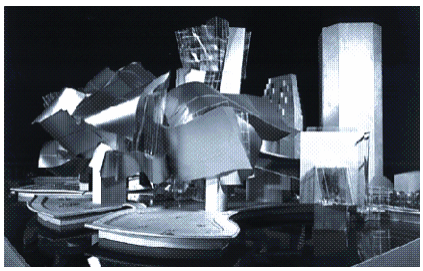

Figure 4. A physical **Model** by Frank Gehry helps to show relationships among parts. [5]

3 Translated by the author.
4 Retrieved August 4, 2003, http://www.designboom.com/eng/funclub/dillerscofidio.html
5 Retrieved August 4, 2003, http://www.thecityreview.com/gehry.html

3.5 Interactive Visualization

Interactive visualizations are computer-based visualizations that allow users to control, combine and manipulate different types of information or media. Figure 5 illustrates an interactive three dimensional interface that visualizes the data of the New York Stock Exchange. For the transfer of knowledge, interactive visualizations help to fascinate recipients, enable interactive collaboration, present and explore complex data.

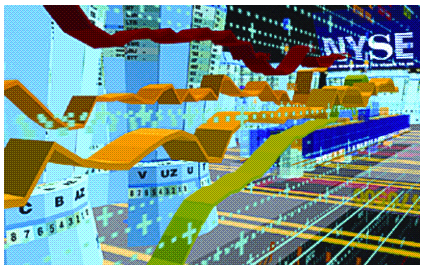

Figure 5. An **Interactive Visualization** helps to supervise the New York Stock Exchange. [6]

This section presented the five main visualization types planners use. We found that planners barely use the visualization types of decision makers.

4. VISUALIZATION OF DECISION MAKERS

This section presents visualizations of decision makers. To understand how they use visualizations one needs to know their tasks and targets.

4.1 Tasks and Targets of Decision Makers

In corporations it is the imperative to increase financial returns. The tables 1-4 present an overview on tasks and targets of decision makers.

6 Retrieved August 4, 2003, http://www.asymptote.net

Table 1. Strategy

Task	Target
Strategic Planning	Formalized strategic planning processes and scenario planning.
PEST Analysis	Political, Economic, Social and Technological factors to be considered when analyzing the external macro-environment.
SWOT Analysis	Strengths, Weaknesses, Opportunities and Threats in situation analysis.
Competitor Analysis	Determination of the competitor's objectives, assumptions, strategy and capabilities.
Value chain	Primary and support activities and their role in developing a competitive advantage.
Growth Share Matrix	*"Dogs, Question Marks, Stars, Cash Cows"* of the BCG Diagram.

Table 2. Economics

Task	Target
Demand/Supply Curve	Factors that may cause a shift in demand/supply. Price level determination. Effects of a shift in supply or demand to the equilibrium of price and quantity.
Opportunity Costs	The concept of opportunity costs and relative price.

Table 3. Operations

Task	Target
Process Analysis	Analysis of business processes. Flow diagrams, performance measures, bottlenecks.
Work Breakdown Structure	Breaking down a complex project into individual tasks, facilitating Resource allocation, assignment of responsibilities and measurement.
Gantt Charts	Visualizing the progression of a project in a chart.
Critical Path Method	A network model for project management.
PERT	Program Evaluation and Review Technique is a network model that allows for randomness in activity completion times.
Time-Cost Trade-offs	Types of project costs and trade-offs between project cost and project completion time.

Table 4. Marketing

Task	Target
Marketing Concept	Production concept, sales concept, advertising concept, PR concept.
Situation Analysis	Analysis of the internal and external marketing situation. Five “C”s: Company, Collaborators, Customers, Competitors, and Climate.
Market Definition	Progressively narrowing scope of potential market, available market, target market, and penetrated market. Market segmentation.
Market Analysis	Market size, growth rate, profitability, cost structure, distribution channels, trends, key success factors.
Product Life Cycle	Different strategies and marketing mix decisions in different life cycle stages.
Marketing Mix	Marketing mix elements of the four “P”s: Product, Price, Place, and Promotion.
Pricing Strategy	Pricing a product or service, including pricing objectives and methods of achieving them.

4.2 Business Diagrams

In each of the above disciplines there are conventions on the use of business diagrams. *Figure 6* presents an overview on the most commonly used business diagrams, which are discussed by others.

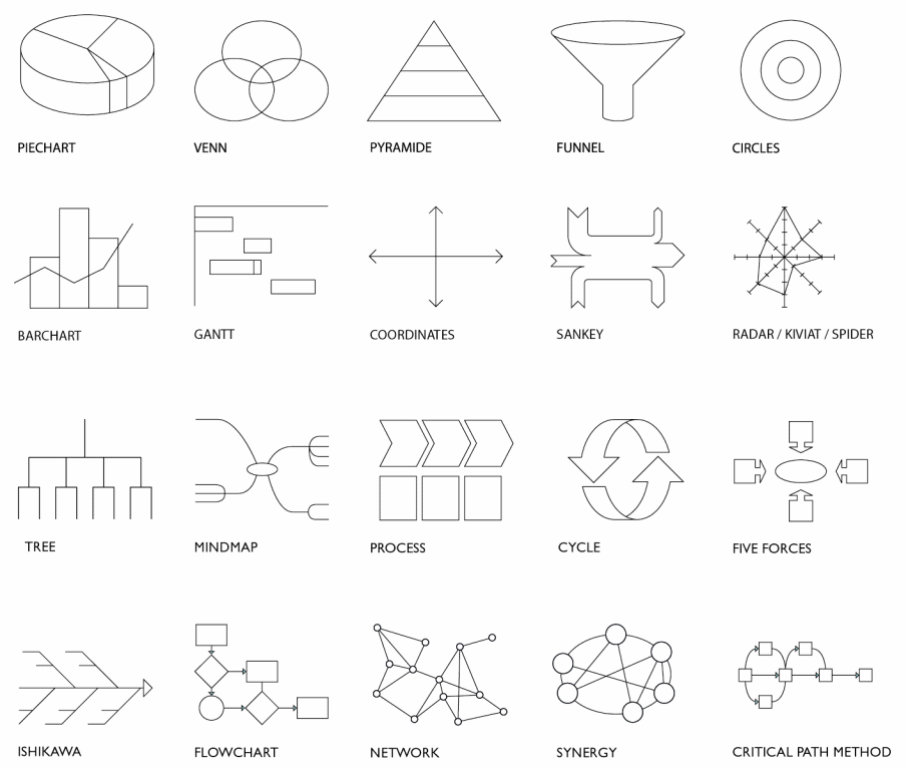

Figure 6. Overview on the diagrams business decision makers use.

Apart from business diagrams business decision makers use visual metaphors and clip arts.

This section presented the tasks and targets of business decision makers and the diagrams they use. Planners rarely use the business diagrams shown above. One reason for this is the missing know-how about the use of these diagrams. Another reason is that planners are not familiar with the tasks and targets as listed above. A third reason is that planners are not educated to present business relevant information of a project. The juxtaposition of the

visualizations that planners and decision makers use reveals a major gap: Both groups use different visualization types and both groups are not familiar with the visualization types of each other. Both groups could benefit from each other, but what is necessary is a general framework for visualization research. The next section introduces the missing framework.

5. THE KNOWLEDGE VISUALIZATION FRAMEWORK

This section introduces the knowledge visualization framework, which helps (1) to systemize visualization methods, (2) to identify missing research areas and (3) to mediate between different research areas.

5.1 Classifications of Visual Representations

Bertin (1974) created a semiology of graphic representation methods. Lohse et al. (1994) report a structural classification of visual representations. It focuses on the classification of visual representations into hierarchically structured categories. Six groups were introduced: graphs, tables, maps, diagrams, networks and icons. Shneiderman (1996) proposes a type by task taxonomy of information visualization where he sorts out the design prototypes to guide researchers to new visualization approaches.

Several researchers offer design guidance by discussing examples: (Bowman, 1968, Keller, 1993, Tufte, 1990, Tufte, 1997).

5.2 The Need for a Knowledge Visualization Framework

First, visualization research is not integrated into the context of communication science (Fiske, 1982). The role of the recipient is not studied enough. However in the transfer of knowledge, the recipient plays the major role and needs therefore major attention. Successful visualizations need to be customized to the cognitive background of the recipient so that the recipient can reconstruct own knowledge as intended by the sender.

Second, visualization research is not integrated into knowledge management research (Alavi and Leidner, 2001). Knowledge management research distinguishes different knowledge types. Today's visualization research focuses primarily on one knowledge type (information, facts). For the difference between information and knowledge we refer to Schreyoegg (2003) and cite Eppler (2004) who discusses this point: "*Apart from facts (to answer questions as what? who? when? how many?) knowledge communication needs to further transfer insights (to answer questions as*

why? and how?), experiences, attitudes, values, premonitions, perspectives, opinions and predictions, in a way that the recipient can re-construct similar knowledge, as the sender intended" [7].

Third, visualization research needs a general framework to mediate between the different isolated research areas in the field of knowledge visualization. These are information visualization (Bertin, 1974, Card, et al., 1999, Chen, 1999, Spence, 2000, Tufte, 1990, Tufte, 1997, Ware, 2000), cognitive art (Horn, 1998), knowledge management (Alavi and Leidner, 2001), communication science (Fiske, 1982), information architecture (Wurman, 1996), learning psychology (Mandl and Levin, 1989, Weidenmann, 1989), cognitive psychology (Farah, 2000) or cognitive art (Horn, 1998).

5.3 The Knowledge Visualization Framework

For an effective transfer of knowledge three perspectives are important: (1) a Knowledge Type, (2) a Recipient Type and a (3) Visualization Type perspective. The three perspectives are summarized in Table 5:

Table 5. Three different perspectives of the knowledge visualization framework

Knowledge Type (what?)	Recipient Type (whom?)	Visualization Type (how?)
Know-what	Individual	Sketch
Know-how	Team	Diagram
Know-why	Organization	Image
Know-where		Object
Know-who		Interactive Visualization

The **Knowledge Type Perspective** aims to identify the type of knowledge that needs to be transferred. Different types of knowledge are described in knowledge management literature. For our framework we distinguished five types of knowledge: Declarative knowledge (Know-what), procedural knowledge (Know-how), experimental knowledge (Know-why), orientational knowledge (Know-where), individual knowledge (Know-who). Today no classification exist, that links visualization types and knowledge types.

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 or a network of persons. Knowing the context and the cognitive background of the recipient is essential for finding the right visualization method for the transfer of knowledge. Today graphic design

7 Translated by the author

and information visualization (Bertin, 1974, Tufte, 1990, Tufte, 1997) do not focus on this perpective.

The **Visualization Type Perspective** aims to establish a simple taxonomy that is able to structure the existing visualization methods. Today a simple taxonomy that can mediate between different areas (as between planners and decision makers) is missing.

The **Knowledge Visualization Framework** combines the three perspectives to a three dimensional matrix as seen in Figure 7. As a conceptual framework it helps to structure thinking. In our interactive Knowledge Visualization Cube each visualization method can be linked to one or more suitable coordinates in this framework. Practitioners can use the cube to structure and find the most promising visualization methods by clicking on the slices and individual cubes. Each Knowledge Visualization Cube is context specific and can be filled with different visualizations.

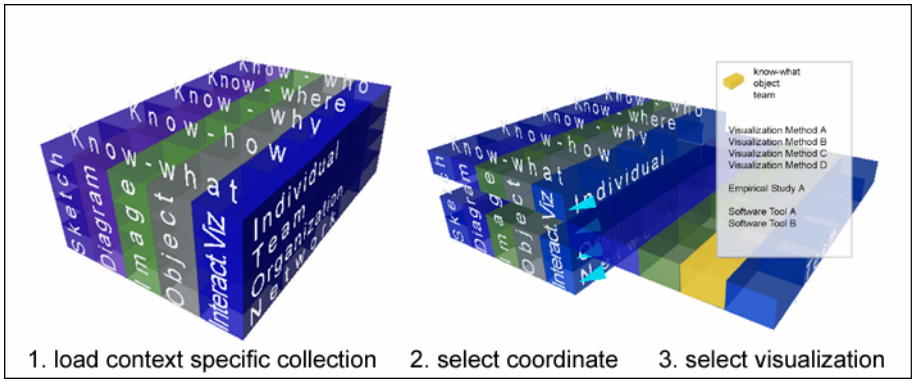

Figure 7. The **Knowledge Visualization Cube** integrates the three important perspectives to be considered when choosing a visualization method. Slices can be selected which then allow a single cube to be selected. Selecting a link in the appearing view loads detailed information in an additional window.

This section presented the Knowledge Visualization Framework. The next section describes examples how the conceptual framework was used.

6. SCENARIO: PRESENTING A COMPLEX URBAN PLANNING PROJECT TO DECISION MAKERS

This section presents new approaches that an urban planning office[8] we analyzed used to communicate complex urban planning projects to decision makers. The office has two business segments: knowledge visualization and urban planning. In presentations it combined traditional project visualizations with business knowledge visualizations to get the **attention**, the **interest** and the **desire** of the decision makers to finally initiate **actions**.

6.1 Attention: Visualizing the Situation

To illustrate a situation analysis an interactive visualization (Brodbeck and Girardin, 2003) as seen in Figure 8 was used. It allowed different attributes of the cities in Switzerland to be explored. The visualization fascinated the recipients and revealed important relationships. The understanding of these relationships and seeing the "big picture" was important for the argumentation and to present different options.

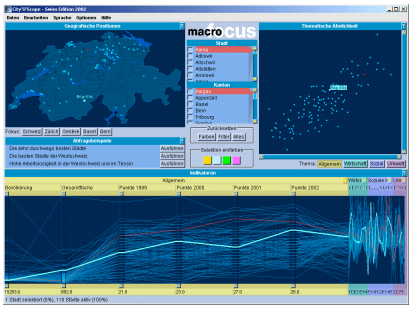

Figure 8. **Attention**: An interactive visualization helped to present an overview on the situation of the city and influencing factors.

Figure 9. **Interest**: To illustrate potential scenarios on the use of a public space narrative texts were used to foster creativity without determining one function.

6.2 Interest: Visualizing Options

The visualization as seen in Figure 9 adapts the insight that storytelling is effective for the transfer of knowledge (Loebbert, 2003). Narrative keywords were integrated in the plans to present potential functions and social

[8] www.vasp.ch

scenarios. In that way different scenarios and functions could be transferred. In contrast to the conventional denoting of a function (i.e. restaurant), the narrative keywords (i.e. red wine and BMW) address the emotions, foster creativity and imaginations and increase remembrance.

6.3 Desire: Visualizing Potential Earnings

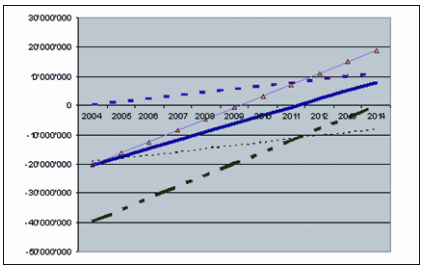

Figure 10. **Desire**: A line chart with the revenues of five scenarios was the breakthrough visualization to reach the business decision makers.

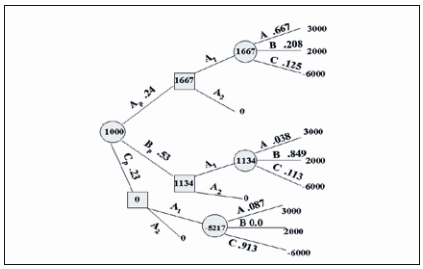

Figure 11. **Action**: In a decision tree different options and scenarios were presented. In that way decision making could be influenced.

Potential earnings of different scenarios were approximately calculated and illustrated with a line chart (Figure 10). This chart had a tremendous effect: The decision makers were motivated to see that the office cares about their tasks and the discussion quality became considerably more constructive. The decision makers felt that the office cares about their finances.

6.4 Action: Visualizing Options to Decide

A decision tree as seen in Figure 11 structured the decision that needed to be made. This chart is simple but effective. The decision trees helped to get the overview on the different decision-scenarios and supported structured decisions.

This section presented how decision making was improved by combining traditional project visualizations with business knowledge visualizations.

7. CONCLUSION

Planners who combine traditional visualizations with business knowledge visualizations can improve the transfer of knowledge with decision makers. If planners illustrate business relevant issues, the information quality and decision quality can be improved. Further it reduces the information overload, prevents misinterpretation, increases the information quality, improves communication and as a consequence, improves decision making.

This paper introduced a **Knowledge Visualization Framework**. The three perspectives (a knowledge type, a recipient type and a visualization type perspective) help to systemize visualization methods, to identify missing research areas and to mediate between different research areas. Feedback from a company we analyzed stated that the framework helped them to more systematically develop new visualization methods.

The gap we described is a potential for planners: Business decision makers need new and better visualization methods to present complex projects to their stakeholders. Developing such visualizations to illustrate business related issues of complex urban planning projects is a new field of research. The office we analyzed confirms the need. Thus the approach has implications for the education of future planners.

In our future work we will investigate how to integrate imaginary visualizations (i.e. dream, story, mental image) in our framework. Further we will compare two domain specific collections to isolate generic types.

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