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Decision Theatre in Decision Making and Urban Planning

Case: Decision Theatre for Niemi Campus

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ABSTRACT

The aim of this thesis was to study the impact of visualization on the decision making process and establish an immersive information laboratory, named Decision Theatre, to help decision making. The laboratory was built for a project called *Sustainable urban environment laboratory*.

In the first part, the consistent decision making process, effective tools and methods are investigated and presented. Investigation shows that it is possible to develop individual and group decision making skills and techniques.

In the second part, the impact of visualization on decision making is examined and a short empirical survey with a limited number of respondents is presented. These show that there is a strong impact on decision making if complex issues are presented as in visual form to decision makers.

The third part presents the Finnish urban planning process from the national level to detailed plans, as well as regulations on how to draw up the plans.

The thesis then presents the process of establishing an immersive information laboratory on Niemi campus in Lahti. Existing environments were used as a model to plan the laboratory concept. The laboratory was planned to serve research, education and business in their activities. The laboratory was built during summer 2013.

Keywords: decision making, visualization, urban planning, Decision Theatre

CONTENTS

1 INTRODUCTION

1.1 Background

Urban laboratory for sustainable environment is a co-operation project between Lahti University of Applied Sciences, Aalto University and University of Helsinki. One of the project targets was that an environmental information laboratory will be set up on Niemi campus Lahti. The focus in my Master degree thesis was to study the possibilities to implement the information laboratory within the given budget and also to build the laboratory.

For a study case, Decision Theatre was selected in the beginning of the study. Arizona State University (ASU) has created the concept and built up their Decision Theatre (DT) in 2005. Some cases and research materials of Decision Theatre in action were found from sources. The core component in DT (ASU) is visual information around discussion participants, so called “drum”. Participants, who are decision makers or planners, are often organised in a conference layout to refine human commitment among participants and to simplify interaction with the visual information. Visual information helps to understand complex systems. (Arizona State University 2013.)

There was an urban renewal project in Niemi campus during year 2013. The first part of the renewal project finished in summer 2013 and the new environmental information laboratory room found a place in that part of the building. The schedule of the project made it also possible to plan the data and audio visual cabling solution in renewal project.

In the beginning of the study, it became clear that the base of the laboratory must be an up-to-date presentation infrastructure based on a wide screen, Full HD resolution, varied sources and versatile combination of input and output signals. In other words, all data is presented as a Full HD resolution view on the wide screen from a source that can be a computer, a document camera, an AppleTV, a sound system etc. It was important to find Full HD resolution models for all equipment and data transfer cabling.

One purpose of this thesis tries to find out a solution to build up an up-to-date infrastructure and pedagogical model to support planning and decision making.

1.2 Objectives and Research Questions

The main research questions are:

Q1: Can data visualization and immersive environments contribute to decision making?
Q2: What are the most effective tools and techniques to visualize data?
Q3: How can data visualization help urban planners to make better plans?
Q4: What are the possibilities or good practises to implement an immersive environment in decision making, planning and education?

The study objectives

The main objectives of this study were to thesis decision making processes and explore the impacts of visualization and immersive environments on decision making. The thesis also deals with the urban planning process and decision making in that process. The practical aim of the study was to build a technical and pedagogical environment that supports decision making, decisions in urban planning and education in a project called *Kestävän ympäristön kaupunkilaboratorio* (Sustainable urban environment laboratory).

Research strategy and methods

This research has adopted a qualitative approach. Data collection practises are survey, semi-structured interviews and observations. The qualitative survey contains some quantative data-point in multiple-choice questions as likert scale.

The study applies a methodological triangulation. Through triangulation I try to authenticate whether the results of observation, interviews and survey support each other. Triangulation is particularly appropriate when it is a complex problem. (Cohen, Manion & Morrison 2000, 114-115.)

Two project operators, two specialists and one supplier were interviewed as a pre study. That gave a good start to deepen the study. The interviews were documented as memos and emails. One statement from the supplier to plan version 1. was also as in the pre study. That provided a good view of what is possible to build with limited a budget, but to find as new technological solutions as possible. One teacher and two planning specialists were interviewed about decision making and the impact of visualization on the city planning process. Interviews were documented in memos, but they were not transcribed.

Interviews, responses to open-ended questions and observation notes are analyzed using content analysis. The analysis examines the content of the material broken down, the similarities and differences are sought seeking and summarized. Content analysis is intended to form a summary description of the phenomenon, which turns the results of the phenomenon to a broader context, and compares them to the results of other research. (Tuomi & Sarajärvi 2002, 105).

1.3 Key Concepts

Decision Theater

The *Decision Theater (*later also DT*)* is a visualization environment that usually accommodates between 20 - 30 participants. The Decision Theater provides an integrated set of approaches and technological tools to assist human reasoning for group decision-making. (Arizona State University 2013.) DT is presented in more detail in this thesis in Chapter 6.

The Decision Theater concept originated in USA in 2005 and reflects the university leadership's desire to create a new type of visualization room. That vision generated a space where researchers at the universities and communities could explore common issues in a neutral setting. (Rockefeller Foundation 2013.)

In the Arizona State University (ASU), where the room was first built up, seven screens affixed along the wall offered a 260-degree panoramic display of graphics and visualizations. It is called the "drum." Advantage can be taken of a variety of tools to improve decision making including geospatial visualization, simulation

models, system dynamics, and computer-assisted tools for collecting participant input and collaboration. (Arizona State University 2013.)

The approach taken at the Decision Theater is intricate:

- *First*, a group visiting the Decision Theater jointly characterizes the problem, setting its boundaries and modeling how the group works together. The theater technology creates a visual model of what each actor needs to know to make decisions, where that information comes from, and where the connections between different sources of information lie. (Rockefeller Foundation 2013.)
- *The second step* is to model the problem itself, introducing systems thinking to mimic the complex reality that the group has described. The model allows the group to test their assumptions and adapt the model if they had not described it appropriately. (Rockefeller Foundation 2013.)
- *The final stage* is dedicated to getting everyone at the same level of understanding, visualizing the decision making processes of each member of the groups - engineers, lawyers, social scientists, whoever they may be. This process integrates current and emerging understanding of decision sciences, systems thinking and modeling, and visual analytics, to transform the decision making process. (Rockefeller Foundation 2013.)

The innovation in Decision Theater is not just the technology. Rather, it is the use of the technology to transform how groups are able to understand and plan solutions for problems. (Rockefeller Foundation 2013.)

The decision theatre engages participants to involve in the communication process. Communication is uncertain, ambiguous, context-dependent and two or multi directional. One way to manage this is to allow viewers to participate in the communication process, rather than simply subject them to predermined decisions. Communication by participation can also be an effective way of gaining and sustaining viewer's attention. (Poster design 2013, 21)

In communication one should avoid combinations of pictures and words that repeat the message exactly. The nature of research and knowledge means that no

single medium is uniquely effective for transmitting ideas. (Poster design 2013, 27-39.)

Visualization

The term "visualization" may refer to many kinds of visualizations. *Information visualization* is the study of (interactive) visual representations of abstract data to reinforce human cognition. The abstract data include both numerical and non-numerical data, such as text and geographic information. (Lurie & Mason 2007, DeFanti, Brown. and McCormick 1989.)

S*cientific visualization* is to graphically illustrate scientific data to enable scientists to understand, illustrate, and rare insight from their data. The emphasis is on realistic renderings of volumes, surfaces and illumination sources. (DeFanti et. al. 1989.)

In this study the most telling concept would be *interactive visualization,* which involves studying how humans interact with computers, creating graphic illustrations of information, and how this process can be made more efficient. In order to be considered interactive visualization, it must meet two requirements:

1) Human input: control of some aspect of the visual representation of information, or of the information being represented, must be available to a human, and 2) Response time: changes made by the human must be incorporated into the visualization within a certain period of time. (DeFanti et. al. 1989.)

Visual representations can enlarge problem-solving capabilities by enabling the processing of more data without overloading the decision maker. The old saying that "a picture is a worth a thousand words" can be replaced with "a picture is worth a thousand rows [of data]". (Lurie & Mason 2007; DeFanti et. al. 1989.)

Niemi Campus

While this research was being carried out, the Lahti University of Applied Sciences was building a new campus called *Niemi campus* to be located in Niemenkatu in Lahti in the same complex with Lahti Science and Business Park. It is estimated that the new campus will form a learning community for

approximately 5 000 students by academic year 2017–2018. The new campus will also accomodate university partners from University of Helsinki, as well as Lahti Science and Business Park and local companies. (Lahti University of Applied Sciences 2013).

Urban Planning

Urban planning, also known as city and town planning, is a technical and political process concerned with the use of land and design of the urban environment. It is the branch of architecture dealing with the design and organization of urban space and activities. (Kuronen M. 2011, p. 28).

Urban planning covers, both in theory and in practice, various complementary approaches. Planning is always concentrated on the future. The theories and praxis do not go hand-in–hand, but practitioners use complementary theories similarly. Planning in the real world is not done exactly within any one single theory and, even under a single piece of legislation, there can be several approaches to urban planning used in practice at any one time (Kuronen M. 2011, p. 28).

By 2020, approximately 80 % of Europeans will be living in urban areas. As a result, the demand for land in and around cities is becoming acute with conflicting changes in land use, which are shaping landscapes and affecting the environment in and around cities. The growth of cities in Europe has historically been driven by increasing urban populations, while today a variety of other factors are driving urban sprawl (Helsinki University 2013).

One example of the ongoing urban planning projects in Lahti is called KatuMetro and it studies well-being in urban environments: the use of ecosystem services as a tool towards sustainable urban planning. The project focuses on exploring the impact of urban green areas on urban air quality and on urban hydrological cycle (using the quantity and quality of storm water as an indicator). The applicability of the results obtained will be studied in context with urban planning. One aim of the project is giving economic value to some of the ecosystem services. The project is funded by the cities of Helsinki, Lahti, Vantaa and Espoo, the University of Helsinki, Aalto University, and three Ministries of Finland.

(Helsinki University 2013.)

Decision Making

How can *decision making* be defined. Due to the extent of the concept the issue is further discussed in Chapter 2 theoretical part of this thesis.

2 THEORETICAL FRAMEWORK AND PREVIOUS STUDIES

The greatest accomplishment began as a decision once made and often a difficult one (Rawls, M. 2013).

2.1 What is Decision Making?

The ability to make proper decisions is the defining property of a high performance organization. The challenge is to ensure that good decision-making practices are approved in the whole organization. As company grow, staff make decisions in an progressively complex, unclear, and unsure environment. Formal manners enable employees to make decisions that are significant to the stakeholders and guide their behaviours to align with the strategic intent of the company as well as its values and norms. (Michel 2007.)

Decision making is usually the process of selecting a logical choice from the available options. When a person is trying to make a good decision, he or she must weigh the positives and negatives of each option and take into consideration all the alternatives. For efficient decision making a person must be open to forecast the outcome of each option equally and determine which option is the best for that situation. (Harris 2012.)

Vroom, V. & Yetton, P. & Jago, A. (1988) created a decision making model pondering that often the most critical decisions tend to have to be made in the least amount of time. This makes them very challenging.

Decision makers may feel pressured and agitated. The time pressure means taking shortcuts and jumping to conclusions. Fortunately, decision-making is a skill that can be learned and grown into. Somewhere between instinct and over-analysis is a logical and practical approach to decision-making that does not require endless investigation, but helps to estimate the options and impacts (MindTools 2013).

Researchers Charles H. Kepner and Benjamin B. Tregoe created the approach that is well-respected and used by the world's top organizations including NASA and General Motors. Their ideas are presented in the book *The New Rational Manager,* published in 1981.

The Kepner-Tregoe approach is based on the premise that the end goal of any decision is to make the "best possible" choice. This is a critical distinction: the goal is not to make the perfect choice, or a choice that has no defects. So the decision maker must accept some risk. (MindTools 2013.)

2.2 Decision Making Process

> *The real decision taking process involves a lot of people, and the whole structure is redolent with feedback. At every decisive moment, of which there will be great many within the total decision, we range ahead and back and sideways. We gauge the effect of this sub-decision on everything we have tentatively decided already, and on the sub-decisions left to take.* (Stafford Beer, 1975).

2.2.1 Decision Environment

Every decision is made in a decision environment where data collection, choices, values and predispositions are available. In an ideal decision environment all data is correct and all choices are possible. However, in real life data and choices are limited, because it takes too much time to collect all data and analyse all choices. Most decisions must be made within a time limit. That is why resources like manpower, money etc. to prepare data and alternatives are limited. Generally we can say that most decisions are done in an uncertain environment. More important decisions should be made with more detailed preparation. Better preparation guarantees better decisions and reduces risks. (Harris 2012.)

The fact is that decisions must be made within a limited decision environment and that suggests two things. First, data and knowledge has expanded after the decision is made. It is always easy to criticize afterwards the decision that was made at a particular time. Second, decisions are almost always made as late as possible. This way there is as much time as possible to use the available resources in preparation. (Harris 2012.)

Next chapters will present a systematic decision making process.

Step 1. Decide How to Decide

Deciding how to decide is the first step in the decision making process. Sometimes it is better to decide on your own and sometimes it is better to make a decision using group consensus. How to decide which way is better? Making good decisions is one of the most important tasks in leadership. It is not sensible to dictate decisions when group consensus is important and it is not effective to spend resources when you can make the decision on your own. It means that leadership must be adapted to the situation. *Autocratic style* works in some cases and *participatory style* in some cases. Some cases work best using various combinations of styles. (Vroom, V & Yetton, P 1973.)

Three (3) main factors affect decision making are

Decision Quality – How important is it to reach the "right" solution? The higher the quality of the decision needed, the more one should involve other people in the decision. (Vroom et al.1973.)

Subordinate Commitment - How important is it that others accept the decision? When people need to commit to the decision the participation levels need to increase. (Vroom et al.1973.)

Time Constraints – How much time do you have to make the decision? The more time you have, the more you have the luxury of including others. (Vroom et al.1973.)

Step 2. Define the Problem

As a minimum, the process must identify reasons, limiting assumptions, boundaries between organisations and stakeholders' questions. The aim is to express a clear, one-sentence problem that describes the initial conditions and desired outcomes. Sometimes one sentence is not enough if the decision is complex. The sentence has to be accurate and unambiguous written material agreed by all decision makers and stakeholders. Even though this can be a long iterative process, it is a crucial and necessary point before proceeding to the next step. (MindTools 2013.)

Step 3. Determine Requirements

Requirements are conditions that every acceptable solution to solve the problem must meet. Requirements specify what the solution to the problem must do. It is really important that the following steps are stated in exact quantitative form. To prevent ensuing debates, requirements have to be described in writing.

Step 4. Establish Goals

Goals have to go beyond the minimum. Necessities and desires. The goals may be conflicting but this is an inherent aspect in practical decision making. Goals might be short term goals or long term goals. (MindTools 2013.)

2.2.2 Leadership Styles in Decision Making

Vroom-Jago (1988) distinguishes three (3) styles of leadership, and five (5) different processes of decision-making that you can consider using. These are shown in Table 1.

TABLE 1. Three styles of leadership and five different processes of decision making. (Vroom-Jago 1988).

STYLE 1:	Autocratic – decision maker makes the decision and informs others of it. There are two separate processes for decision making in an autocratic style:
PROCESS:	Autocratic 1 (A1) – decision maker uses the information that he/she already has and makes the decision. Autocratic 2 (A2) – decision maker asks team members for specific information and once getting it, he/she makes the decision. Here you do not necessarily tell them what the information is needed for.

STYLE 2:	Consultative – decision maker gathers information from the team and others and then makes the decision.
PROCESS:	Consultative 1 (C1) – decision maker informs team members of what he/she is doing and may individually ask for opinions. However, the group is not brought together for discussion. Decision maker makes the decision.
	Consultative 2 (C2) – decision maker is responsible for making the decision. However, the group gets together to discuss the situation, hear other perspectives, and solicit suggestions.
STYLE 3:	Collaborative – decision maker and team work together to reach a consensus.
PROCESS:	Group (G2) – the team makes a decision together. Decision maker's role is mostly facilitative and helps the team reach a final decision that everyone agrees on.

From Figure 1 it is possible to choose the best decision process for different conditions. In some scenarios, it is not necessary to answer all of the questions.

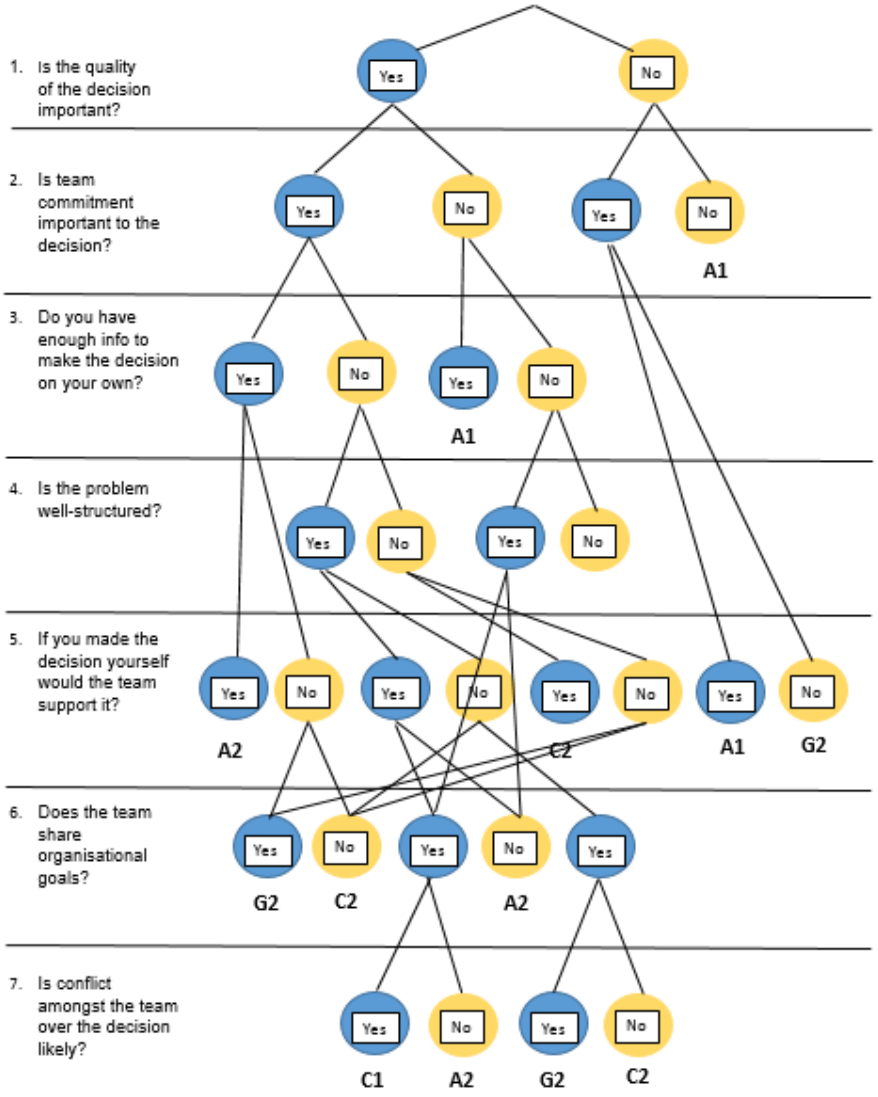

FIGURE 1: The Vroom-Yetton-Jago Decision model (Vroom, Jago 1988).

2.2.3 Decision Making Skills

Simple decisions usually need a simple decision-making process, but difficult decisions typically involve issues like these:

UNCERTAINTY – Many facts may not be known.

COMPLEXITY – Many interrelated factors have to be considered.

HIGH-RISK CONSEQUENCES – The impact of the decision may be significant.

ALTERNATIVES – Each has its own set of uncertainties and consequences.

INTERPERSONAL ISSUES – It can be difficult to predict how other people will react. (MindTools 2013.)

2.2.4 How to Evaluate Decision Making Skills?

It is possible to evaluate decision making skills. There are many tools in internet to do that. Below (Figure 2) is one example from the MindTools page. There it is possible to test one's own decision making skills.

	Not at All	Rarely	Some times	Often	Very often
I evaluate the risks associated with each alternative before making a decision.					
After I make a decision, it's final – because I know my process is strong.					
I try to determine the real issue before starting a decision-making process.					
I rely on my own experience to find potential solutions to a problem.					
I tend to have a strong "gut instinct" about problems, and I rely on it in decision-making.					
I am sometimes surprised by the actual consequences of my decisions.					
I use a well-defined process to structure my decisions.					
I think that involving many stakeholders to generate solutions can make the process more complicated than it needs to be.					
If I have doubts about my decision, I go back and recheck my assumptions and my process.					
I take the time needed to choose the best decision-making tool for each specific decision.					
I consider a variety of potential solutions before I make my decision.					
Before I communicate my decision, I create an implementation plan.					
In a group decision-making process, I tend to support my friends' proposals and try to find ways to make them work.					
When communicating my decision, I include my rationale and justification.					

FIGURE 2. Decision making test. (MindTools 2013.)

This test can be done and the score can be seen at http://www.mindtools.com/pages/article/newTED_79.htm

In the questions some common themes can be seen to develop the decision making process. These are described in the following subchapters.

2.2.5 How to Create a Constructive Environment

Some examples to create a constructive environment for successful decision making:

Defining what the desired outcome is.

Agreeing on the process – Identifying how the final decision will be made, for example will it be based on the decision of an individual or a team. (MindTools 2013.)

Contacting the right people in decision making. The opinion of an interest group should be taken into account when making an effective decision, and people concerned should be involved even if the decision is made individually. A team which consists of five to seven people is an ideal composition to process alternatives. (MindTools 2013.)

Allowing other points of view to be heard – The group should be able to work in a safe environment, so that group members are free to express their unfinished ideas without fear to be rejected. (MindTools 2013.)

The aim is to find the best alternative which is often found when more and more participants are involved in the group discussion and everyone is heard. (MindTools 2013.)

People should be encouraged to avoid groupthink. *The Stepladder Technique* (Rogelberg, S et al. 1992) is known as a method where gradually added persons contribute to the final outcome. However, the objective is to find the best decision among the options: it is not any game in which people are competing with each other about whose alternatives are preferenced. (MindTools 2013.)

Asking the right questions – What is really the true issue? It is essential to find the possible bottlenecks by asking why or what caused this problem. The root cause of the problem should be uncovered. (MindTools 2013.)

Being able to think differently is a basic definition of innovation – yet it also means changing our minds about something and we find that very difficult.

Improvements may happen by taking a look at things from a different perspective. (MindTools 2013.)

2.2.6 Generating Good Alternatives

When generating alternatives, decision makers should be driven to dig deep and look at the problem from different angles. If there are other solutions out there, you are more likely to make the best decision possible. If there are no enough good alternatives, then to make a decision is not possible.

Here is a summary of some of the tools and techniques to help develop good alternatives, through generating ideas:

Brainstorming is probably the most popular method of generating ideas. Brainstorming stimulates people to invent thoughts and ideas that can, at first, look a bit mad. This helps to get people release their normal ways of thinking. (MindTools 2013.)
Reverse Brainstorming works same way but it starts by asking people to brainstorm how to reach the opposite outcome from the one wanted, and then reversing these actions. (MindTools 2013.)
The Charette Procedure is a systematic process for collecting and developing ideas from a large number of attendees. The word "charrette" refers to any collaborative session where a group of designers drafts a solution to a problem. The charette intercepts the ideas generated by a group, and moves them over to the next group, for them to be developed, refined, and finally prioritized. (MindTools 2013.)
The method has been used for example in urban planning. The charrette is a powerful and effective tool for creative and collaborative problem solving in communities. Whether designing a community master plan, designing a park or solving housing challenges in urban neighbourhoods, the charrette provides a physical framework for a community to implement its visions and engage its citizens. (MindTools 2013.)

> *"Charrette process is straightforward and simple. The method can be applied as follows: First, a team is assembled that has the expertise*

> *needed to address the issue at hand. Then, over the course of several days, a series of public input sessions are held to gain an understanding of the issue from the perspective of local citizens. All of these charette sessions are open to the public. Some sessions are targeted to particular groups or constituencies that have a stake in or knowledge of the issue. (The Charette Concept 2013).*
>
> *Next, the charrette design team formulates responses to the issue based on what they have heard and their knowledge and expertise. Finally, at the end of the charrette, the design team makes a public presentation where they may offer solutions to the problems at hand or present different options for the community to consider" (The Charette Concept 2013).*

Crawford Slip Writing Technique is to generate ideas from a large number of people, organizing people into several small groups. This is an extremely effective way to make sure that everyone's ideas are heard and given equal weight, irrespective of the person's position or power within the organization. The method may be used when there is no time or ability to discuss ideas, and just wanting to collect people's thoughts. It is a way to engage an audience, giving them a sense of involvement.

FIGURE 3. Crawford Slip Writing Technique (Create 2013).

Writing rather than speaking during the session can have added advantages: it helps people to think freely without interruption, and it levels the playing field

between quieter people and more outspoken participants. (MindTools 2013, Crawford C.C et al. 1983).

The Concept Fan is a tool for widening the search for solutions. If there are too few options or alternatives which are liked, using the Concept Fan is taking a step back from the problem, and takes a wider perspective. This gives the opportunity to see things in a new light. The Concept Fan technique by Edward de Bono is introduced in his book Serious Creativity in 1992. The method is described below, in Figure 4.

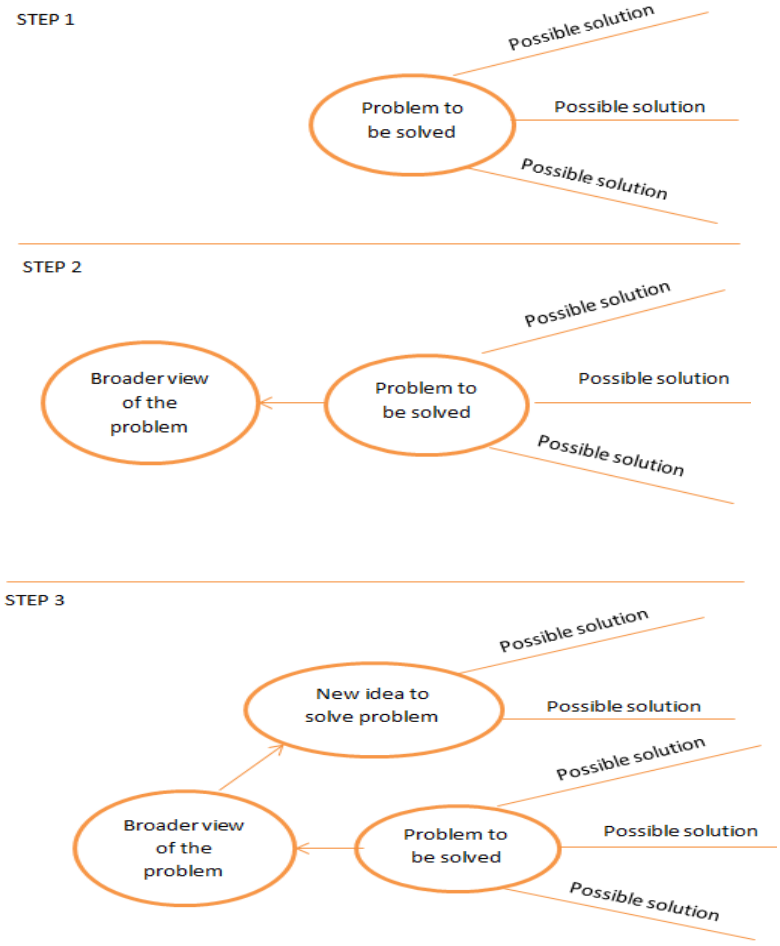

FIGURE 4. Concept Fan Technique (Toolkit For Thinking 2013).

2.2.7 Considering Different Points of View

The issue can be worked out using *The Reframing Matrix of 4 Ps* (Product, Planning, Potential, and People) and that way gathering different perspectives.

Outsiders can be asked to join the discussion, or existing participants can be asked to apply different functional perspectives. A simple four-square grid can be drawn, leaving a space in the middle of the grid in order to define the problem, and after that the problem that you want to explore is entered in this space. The Reframing Matrix tool was created by Michael Morgan, and published in his 1993 book, Creating Workforce Innovation. Figure 5 illustrates the model. (MindTools 2013, Management Class 2013.)

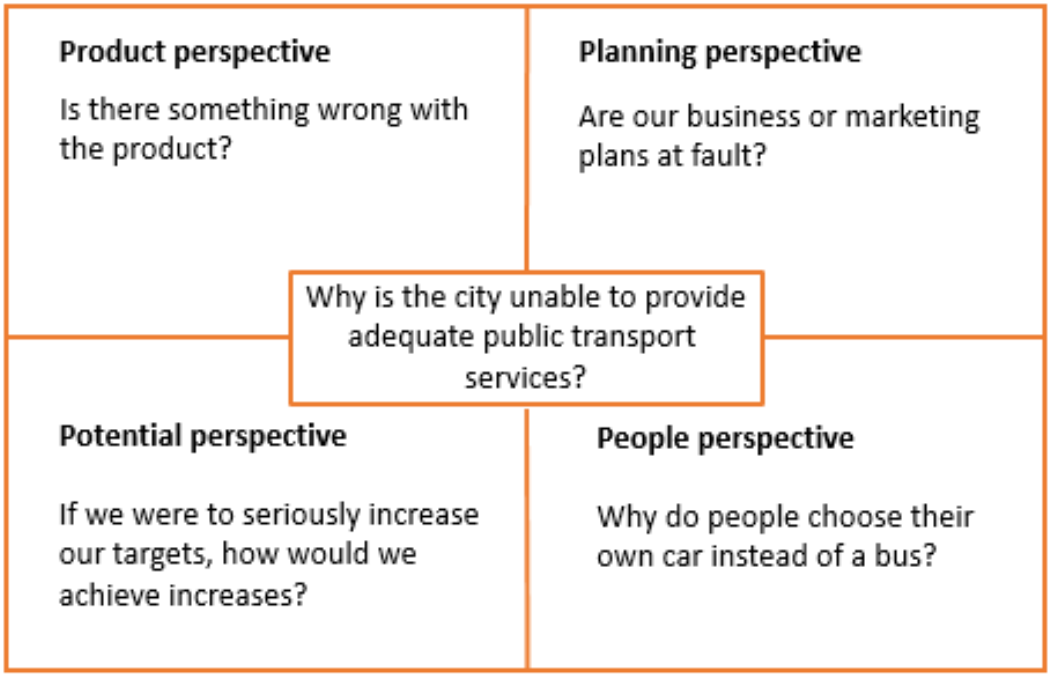

FIGURE 5. Reframing Matrix (MindTool 2013).

2.2.8 Appreciative Inquiry

David Cooperrider introduced the positive method *Appreciative inquiry* in his book in 1986: Toward a methodology for understanding and enhancing organizational innovation. To apply Appreciative Inquiry (The 5D Approach) in order to solve a problem, the point is to focus on strengths. A positive attitude makes it easier to solve problems and positive energy improves the environment. (Cooperrider et al. 2003; MindTools 2013.)

Below is described the 5-step tool using *5 Ds: Define, Discovery, Dream, Design and Deliver*.

Step 1 Problem Definition Phase

The first step is to define what one is looking at and try to find more positive aspects. One method is to change the words or questions, for example instead of asking “Ways to Fix Recruitment Problems” you ask the question “Ways to Accelerate Recruitment”. Even a small change can lead to the fact that things appear in a new light. Many possibilities can be explored and avenues should not be restricted. (MindTools 2013.)

Step 2 Discovery Phase

As many people as possible should be involved and an environment should be created where people are talking and telling stories about what they find is valuable and appreciated. People can be interviewed on experiences which have been successful, to identify the factors that most contributed to the experience. What was most valued? What did people find most fun and motivating. What caused the joy of the success? (MindTools 2013.)

Step 3 Dream Phase

At this stage it is time to dream of “what might be”. It is time to return to the Discovery phase, and reinforce those strengths. A useful approach is to bring together different interest groups and create a brainstorm.. Brainstorming gives tools to check alternatives using relaxed approach.When a dream vision is gained, the Design phase is the next step. (MindTools 2013.)

Step 4 Design Phase

Dreams are to be realized at this phase. In this phase one looks at the practicalities needed to support the vision. (MindTools 2013.)

Step 5 Deliver Phase

This last D is also called the Destiny phase. This implementation phase requires a great deal of planning and preparation. Now the focus is on the implementation of the dream. Many changes may occur simultaneously throughout the organization and that all serves to support and sustain the dream. (MindTools 2013.)

2.2.9 Methods for Organizing Ideas

The following methods are especially helpful when there are a large number of ideas. *Affinity diagram technique* is to organize ideas into common themes and groupings.

The method is applied so that first the issue under discussion is phrased in a full sentence, e.g. 'Why is the city unable to provide adequate public transport services"? Then participants silently record their views on post-in notes. In the ideal case there should be four to seven words on each note. (MindTools 2013.)

The post-ins are randomly displayed. Without discussion, the participants sort the post-ins into 4-10 groupings. The idea is that related notes are gathered together until all cards have been used. Finally the result is reviewed with the team and other key people. (MindTools 2013.)

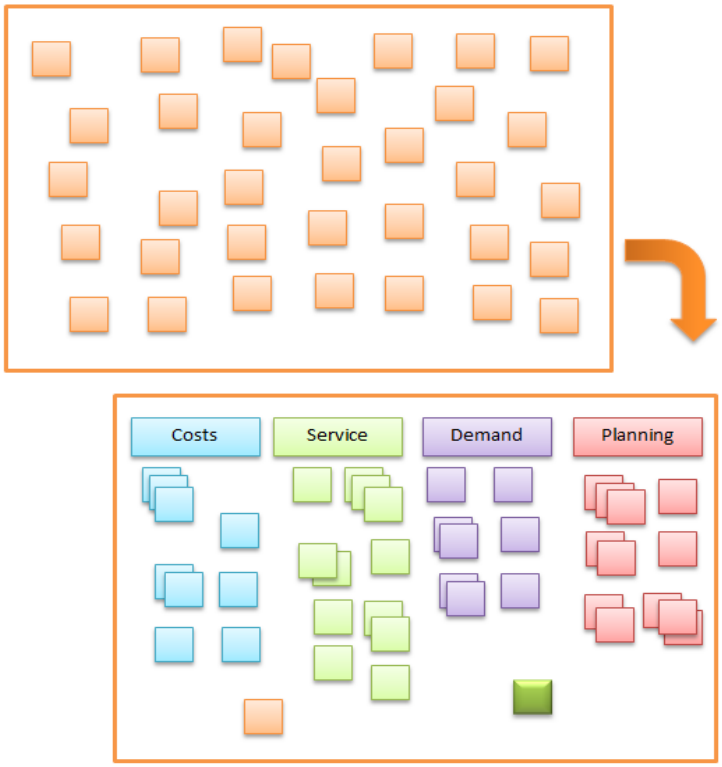

FIGURE 6. Affinity diagram technique. (Six Sigma Material 2013).

When satisfied that you have gathered a good selection of realistic choices, then you need to evaluate each alternative individually like the feasibility and risks. Here, some of the most popular and effective analytical tools are discussed. (MindTools 2013.)

In decision making, there are usually some hesitations, connected to risks. By assessing the risks of alternatives, you can determine whether the risk is manageable. (MindTools 2013.)

Risk Analysis helps to look at risks objectively. There are many tools to manage risks. For example *SWOT analysis* described below in Figure 7 helps to manage risks. (MindTools 2013.)

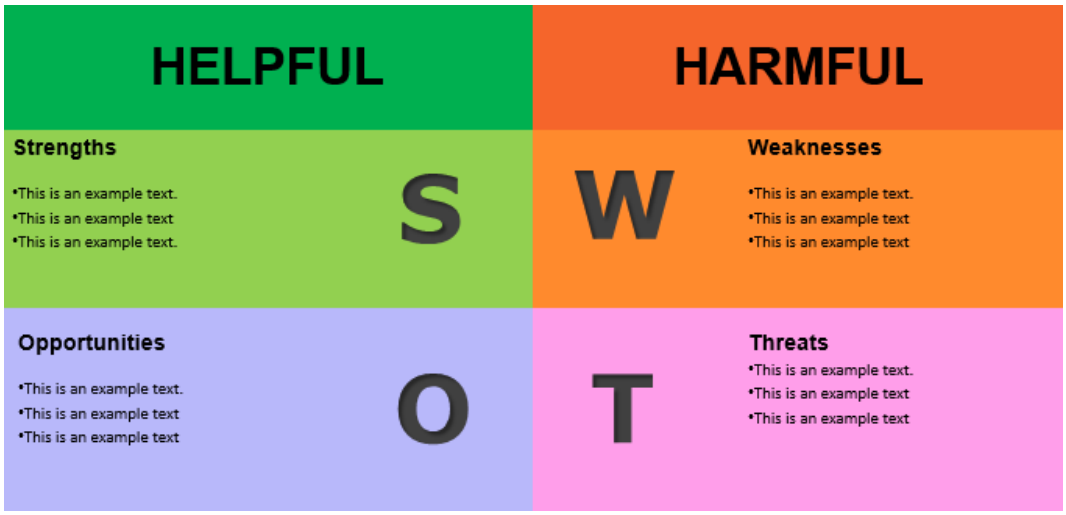

FIGURE 7. Swot-form example.

Another way to look at choices is by considering the potential effects of each.

Six Thinking Hats Method was developed by Edward De Bono in 1989 and presented in his book Educational Psychology in Practice. The method helps to assess the consequences of a decision by looking at options using six different points of view. What happens when people with different thinking styles discuss the same problem?

The main point is that a hat directs to new ways of thinking rather than giving a label for pondering. The technique is based on the premise that the human brain thinks and processes information in six distinct ways: via questions, emotions, judgement of bad and good points, creativity, and thinking (or to be accurate, meta-thinking). (Labelle 2005, MindTools 2013.)

White Hat: With this thinking Hat the focus is on the available data and what can be learned from it. This is done by analysing past trends, and trying to gather historical data.

Red Hat: Wearing the Red Hat, is to look at problems using intuition and emotional response, also trying to think how other people will react emotionally. (Labelle 2005.)

Black Hat: Black Hat thinking is to look at all the bad points of the decision, trying to see why it might not work. This is important because it highlights the

weak points in a plan. It allows to eliminate them, alter them, or prepare back-up plans. (Labelle 2005.)

Yellow Hat: The Yellow Hat means to think positively. It is the optimistic viewpoint. Yellow Hat thinking helps to keep going when everything looks dark and difficult. (Labelle 2005.)

Green Hat: The Green Hat stands for creativity. It is a freewheeling way of thinking, in which there is little criticism of ideas. Creativity Tools like brainstorming, brain writing etc. can help to develop solutions. (Labelle 2005.)

Blue Hat: The Blue Hat means process control. This Hat is worn by the host of the meeting host. If ideas are running dry, they may direct activity into Green Hat thinking. When back-up plans are needed, they will ask for Black Hat thinking, etc. (Labelle 2005.)

2.2.10 Choosing the Best Option

The next step after evaluating the options is to choose between them. Even if the choice is obvious, below in Figure 8 is shown one useful method, *Grid Analysis.* Each option can be scored by how well it satisfies each factor.

Factors:	Cost	Quality	Location	Reliability	Payment Options	Total
Weights:						
Supplier 1	1	0	0	1	3	
Supplier 2	0	3	2	2	1	
Supplier 3	2	2	1	3	0	
Supplier 4	2	3	3	3	0	

.

FIGURE 8. Grid Analysis (MindTools 2013).

As quoted earlier in this thesis, according to The Kepner & Tregoe Approach (1981), it must be remembered that the goal is not to make the perfect choice and the decision must accept some risk. The idea is not to find a perfect solution but

rather the best possible choice, based on actually achieving the outcome with minimal negative consequences.

2.2.11 Evaluating the Decision Made

At this stage it is time to check the level of satisfaction with the choices. There may be doubts whether decisions are based on right arguments. A common decision-making problem is over-confidence. If a decision is made against one's own experience, one must have time to review the case thoroughly and explore any doubts one may have. (MindTools 2013.)

Our beliefs have a big effect on how we see the reality, and sometimes this can lead us to ignore the facts. Anyhow, if the decision is made based on consistent arguments, the decision-making process has reached its goal. (MindTools 2013.)

2.2.12 Sharing and Starting the Process

Once the decision is made, it is time to explain it to those involved, giving reasons why the alternative was chosen. The more background information is provided about the pros and cons, the more easier it is to support the decision. (MindTools 2013.)

2.2.13 Summary of Decision Making Methods and Tools

All of us are making decisions of some scale and content. All people who make decisions that impact other people's lives should understand and be able to use tools that support better decisions. It is not efficient to provide too much resources for decision making but to get enough resources to the process. Systematic decision making can be learned and effective techniques can be used easily. It is always not possible to make a perfect decision but with right tools and techniques it is possible to make the best possible decision in the circumstances. Research shows that Decision Theatre infrastructure and pedagogy supports Decision Making. (MindTools 2013.)

2.3 Visual Analytics

> *If you asked me what a data scientist was, I would say someone who can bridge the raw data and the analysis - and make it accessible. It's a democratising role; by bringing the data to the people, you make the world just a little bit better* (Rogers 2012).

Decision makers have more information than they know what to do with. High speed networks, scanning and tracking technology, and large data warehouses offer increasing opportunities for decision makers to monitor and respond dynamically to changing of the world. (Alba et al. 1997.)

Visual analytics is the science of analytical speculation exploiting interactive visual interfaces. "*Visual representations and interaction technologies give users a gateway into their data, letting them see and understand large volumes of information at once. To facilitate analytical reasoning, visual analytics builds on the human mind's ability to understand complex information visually*." (Thomas & Cook 2006.)

Figure 9 illustrates the detailed scope of visual analytics. With respect to the field of visualization, visual analytics integrates methodology from information analytics, geospatial analytics, and scientific analytics. Human factors (e.g., interaction, cognition, perception, collaboration, presentation, and dissemination) play a key role in the communication between human and computer, as well as in the decision making process. (Keim et al., 2006.)

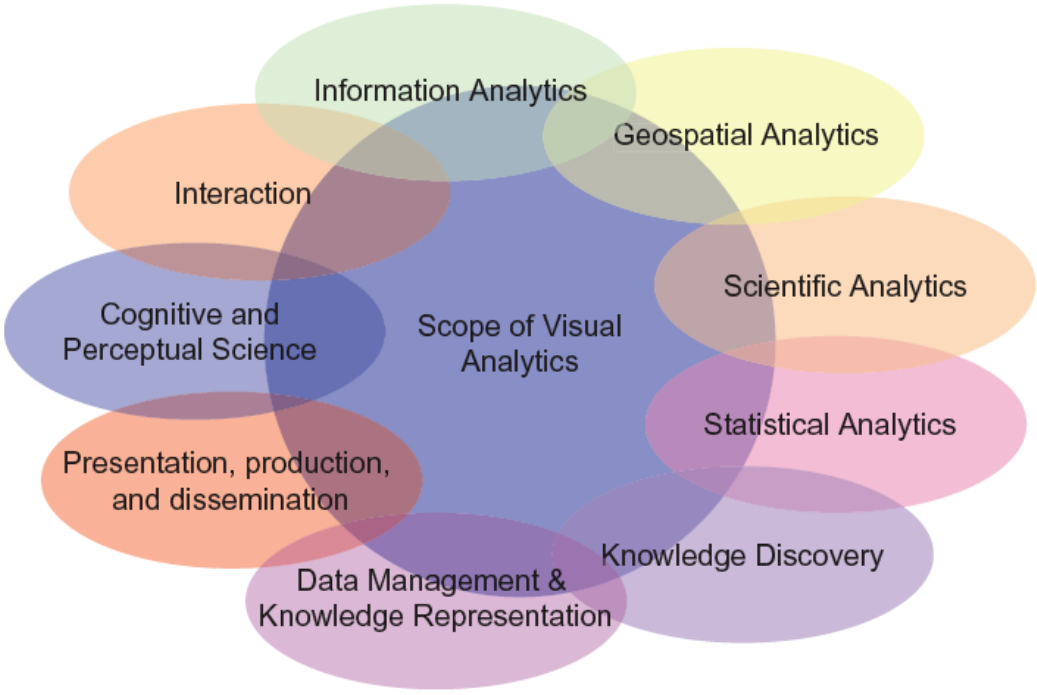

FIGURE 9. Visual analytics as a highly multidisciplinary field of research (Keim et al., 2006).

2.4 Visual Representation

The terms “information visualization” (Card, Mackinlay & Shneiderman 1999), “data visualization” (Green 1998), and “scientific visualization” (DeFanti, Brown, & McCormick 1989) are used to refer to the presentation of information in visual form. These terms are not mutually exclusive and are not always used consistently. Distinctions among these terms are often based on whether the underlying data are numerical or non-numerical, whether the data are tied to physical or abstract attributes, whether absolute or relative values of data are represented, and the number of variables that are simultaneously represented. (Nicholas et al. 2007.)

Another form of visualization is virtual reality, in which a computer display simulates a three-dimensional, interactive visual environment. The term “visual representation” encompasses these various forms of visualization. Specifically, visual representation involves the selection, transformation, and presentation of data (including spatial, abstract, physical, or textual) in a visual form that

facilitates exploration and understanding. The term “visualization tool” refers to a specific implementation, including software applications, of visual representation. (Nicholas et al. 2007.)

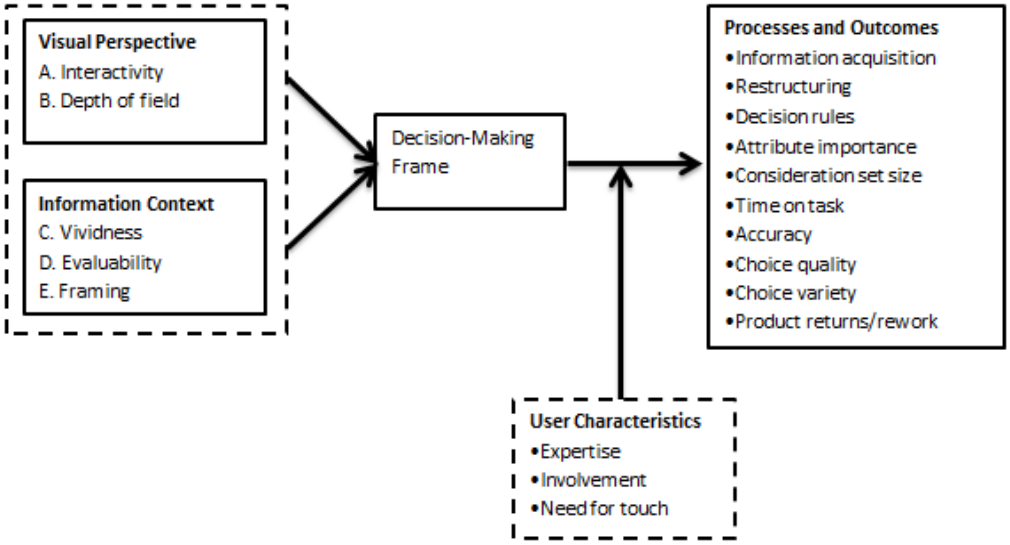

FIGURE 10. Characteristics of Visual Representations and Implications for Decision Making. (Nicholas et al. 2007.)

Visual analytics tools and techniques are used to combine information and it gives possibility to take advantage of massive and often conflicting data; perceive the unexpected and sort out the expected. (Nicholas et al. 2007.)

3 DECISION MAKING AND THE IMPACTS OF VISUALIZATION ON CITY PLANNING

The City of Lahti, for example, states on their website that best way to move things forward is then when issues are under processing. To influence over matters already completed is very difficult. Participation in city development requires interest from the city residents. (City of Lahti 2013.)

According to the Local Government Act, the City Council must ensure that local people and service-users are given the opportunity to influence on municipal operations (City of Lahti 2013).

The system of planning land use is built from the top downwards so, that at the top, at the national level, there are lower-level design guided by the national land use objectives. National level land use objectives are ruled by the Finnish Government. With nation-wide objectives, the preparation must be based on stakeholder interaction. The objectives of the preparation are issued by government decree. (Ekroos, Kumpula, Kuusiniemi & Vihervuori 2010.)

Land use planning is regulated by the national land use objectives, as well as by the Land Use and Building Act (*Maankäyttö- ja rakennuslaki*). Finnish abbreviation of the Act is MRL and further in this thesis the acronym used of the Land Use and Building Act is LUBA. (Ekroos et al. 2010, 135.)

The next level of the planning is regional. At this level, the land-use planning tool is a regional land use plan, which aims to control the approximate location of the land use in the province. (Ekroos et al. 2010, 135.)

Land use planning at the municipal level has two forms, master plan and detail plan. The master plan is a general scheme of land use whereas the city plan is a tool for planning the land use in more detail. Regional land use plan is driven by Regional Council, where municipalities are members. The regional plan is presented on a map. "*The plan includes a key to the symbols used and written regulations"*. (Ekroos et al. 2010, 135.)

The planning system proceeds according to the Land Use and Building Act (Maankäyttö- ja rakennuslaki, MRL) so that a lower-level planning is driven and

controlled by the plans developed in higher, general level. In the system level, this control from the top downwards is inevitable. In practice, the control, however, is not always able to operate fully, although the national objectives are emphasizing the control of higher level authorities in broader regional planning issues. Lower level authorities will, however, continue to decide a lot of important questions. (Ekroos et al. 2010, 135-136.)

The land use planning system proceeds so that a more detailed plan displaces a more general plan when coming into force. (Ekroos et al. 2010, 136; Finlex 1999).

3.1 Land Use Planning

Land use planning is the planning for what purpose and how the land is used in cities.

There are three levels of planning: provincial plan, master plan and city plan. A plan at the general level is a guideline for more detailed plans. Planning aims to organize land use and construction so as to create the conditions for a good living environment developing it ecologically, socially and culturally. (Finlex 1999).

This study describes master and city plans briefly.

Figure 11 shows an example of the development areas of the region.

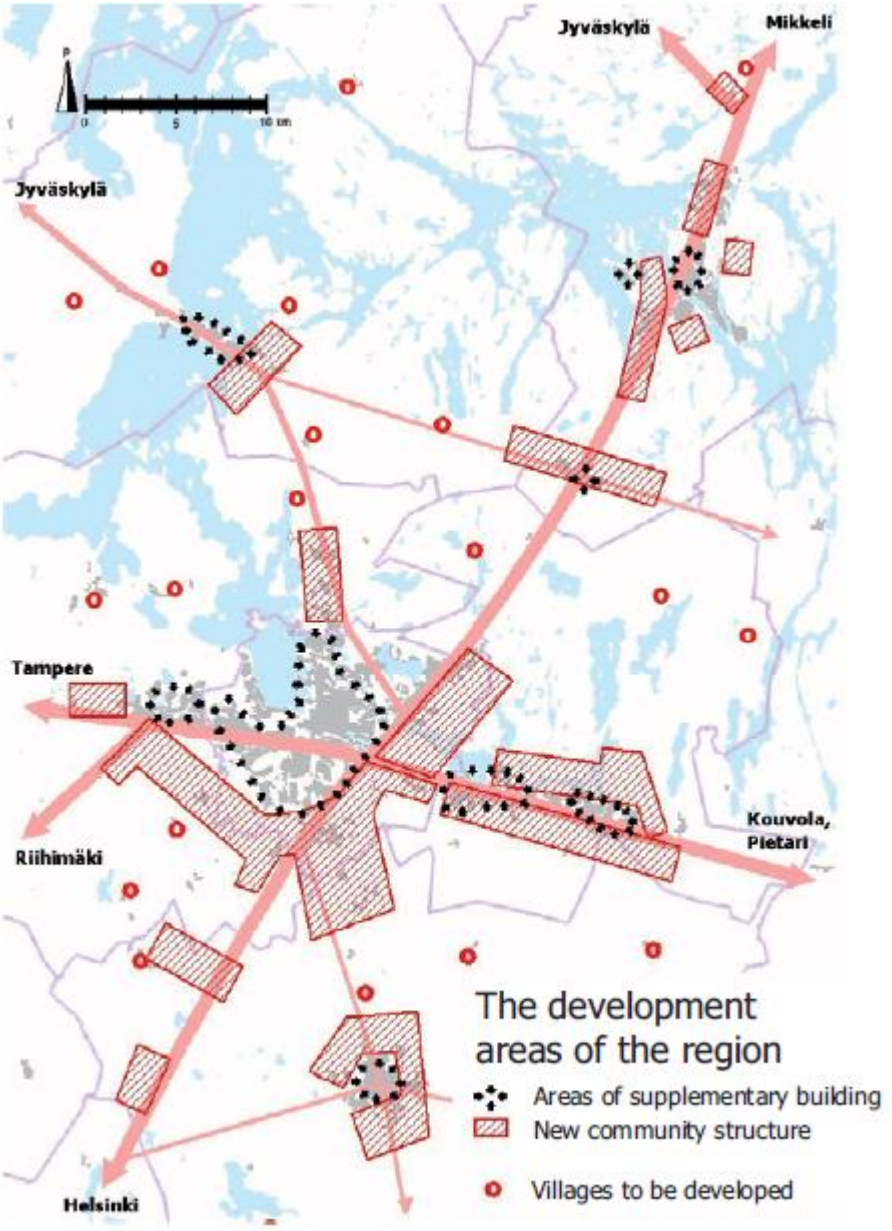

FIGURE 11. The development areas of the region. (Lahti city 2013).

Number of residents is an important driver for land use planning. Figure 12 illustrates the number of recidents of the region.

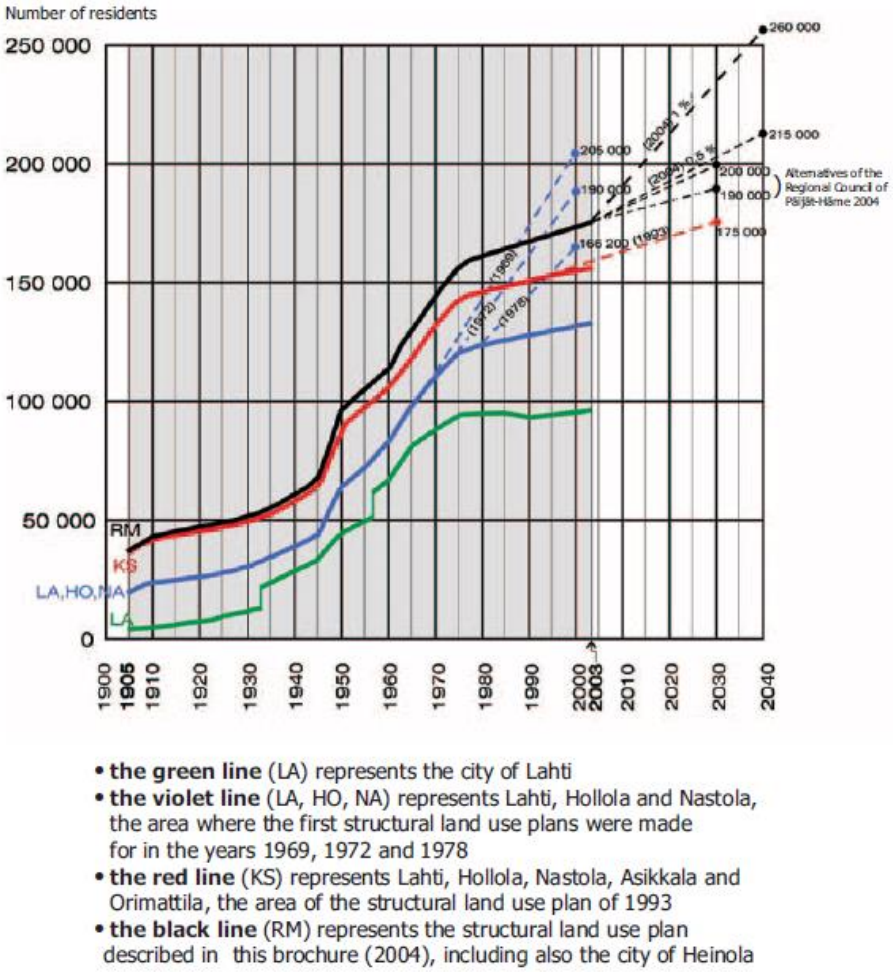

FIGURE 12. The development of the number of residents during the years 1905-2003 and forecasts according to different structural plans. (Lahti city 2013).

Figure 13 shows changes of land use in region by the year 2040.

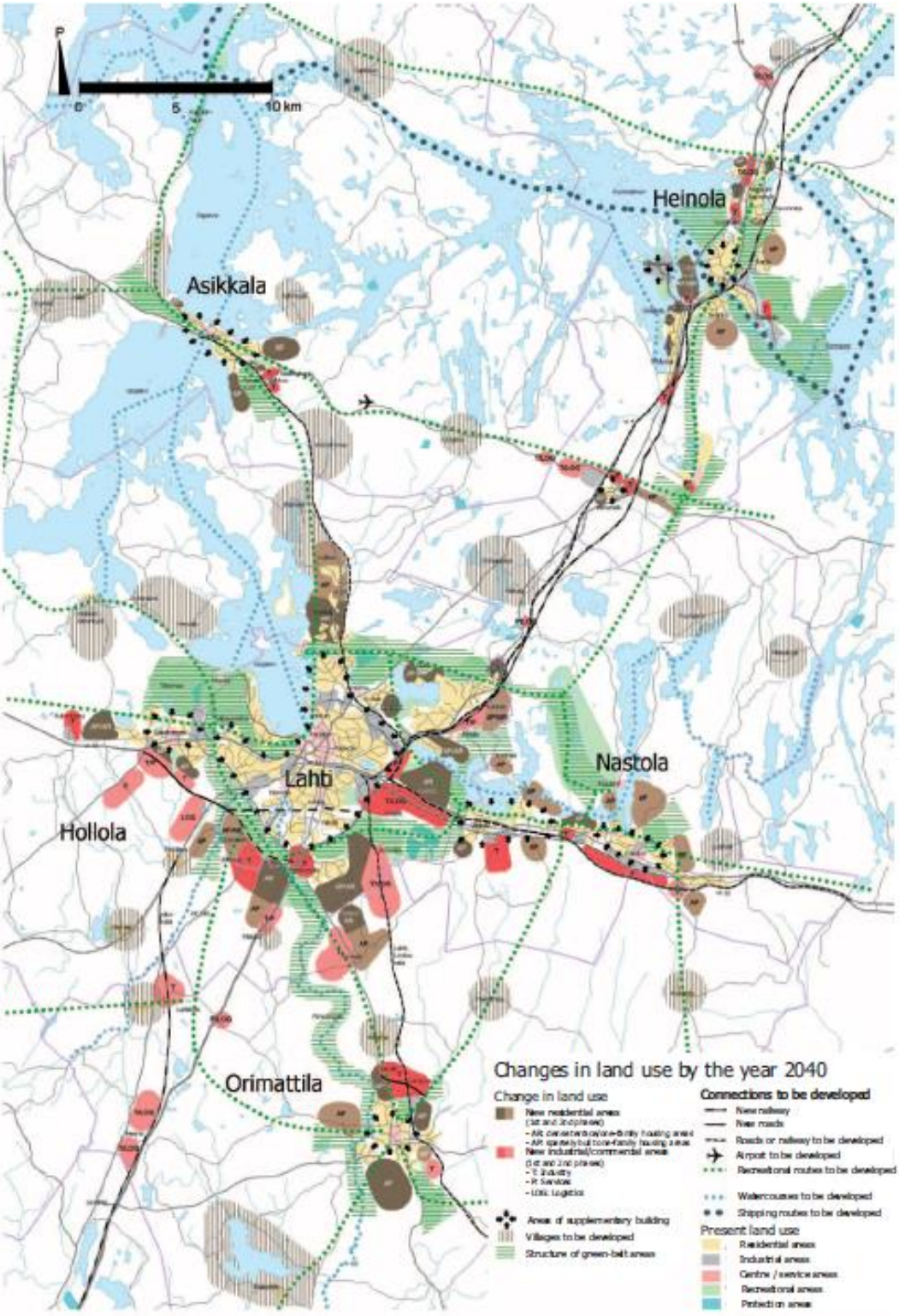

FIGURE 13. *C*hanges of land use in region by the year 2040. (Lahti city 2013).

Master Plan

A master plan (*yleiskaava*) is a general land use plan of a city, covering the entire city or parts of it. A master plan can also be drawn for an area belonging to two or more municipalities. It is a general plan to guide a city's urban structure, land use and transport network. It reserves areas for needs of housing, jobs, transport, nature conservation and recreation. A master plan may also concern a certain theme, such as green areas. The master plan is shown on the map, and it also includes plan notations, regulations and a report. In Lahti city masterplan is revised by the season of city board. This responds to current challenges in the long-term goals without forgetting. (City of Lahti 2013.)

Master plans are used to control for the future changes in the environment and preserve the valuable features of an environment. The aim is to create the conditions for development. The master plan controls city planning. The master plan is published on a communal notice board by the city board and driven by the city council. (Finlex 1999).

Figure 14 shows an example of master plan from Lahti city.

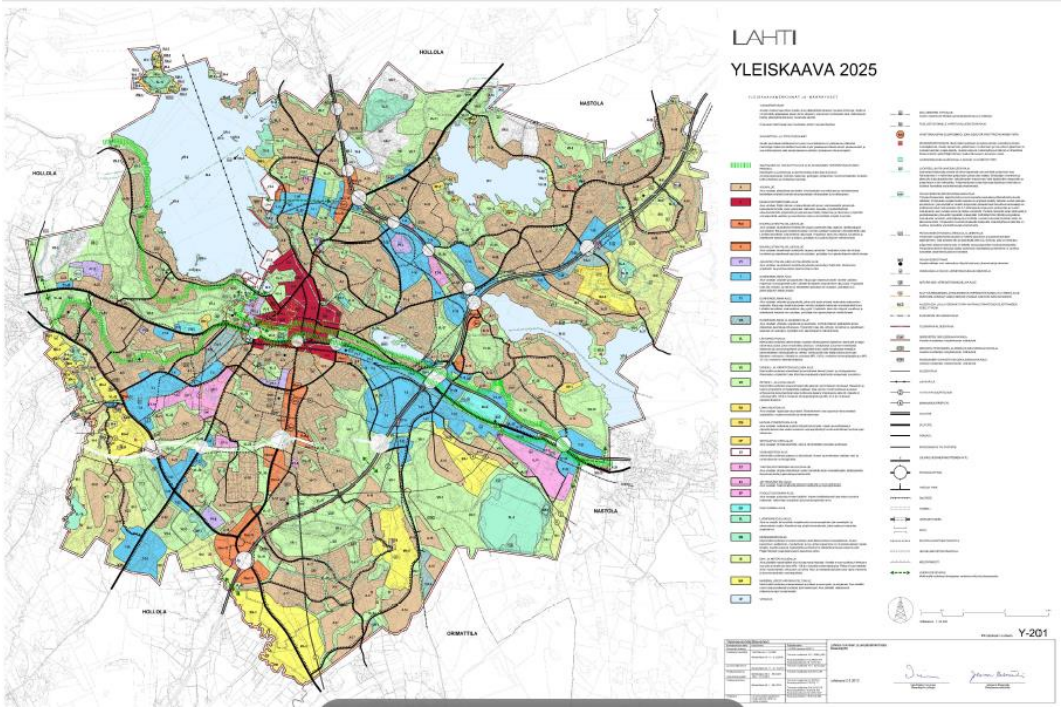

FIGURE 14. Master plan of Lahti 2025. (Lahti city 2013).

City Plan

The city planning aims to prepare the use and construction of areas so that the preconditions are created for a good environment and also develop it ecologically, economically, socially and culturally sustainable. (Lahti city 2013).

The city plan defines for example

- the purpose for which the area can be used
- how much can be built on a plot
- the heights of buildings, roof angles and materials
- street widths
- the conservation values of buildings and nature

The city plan is approved by the city council.

Figure 15 as an example of city plan.

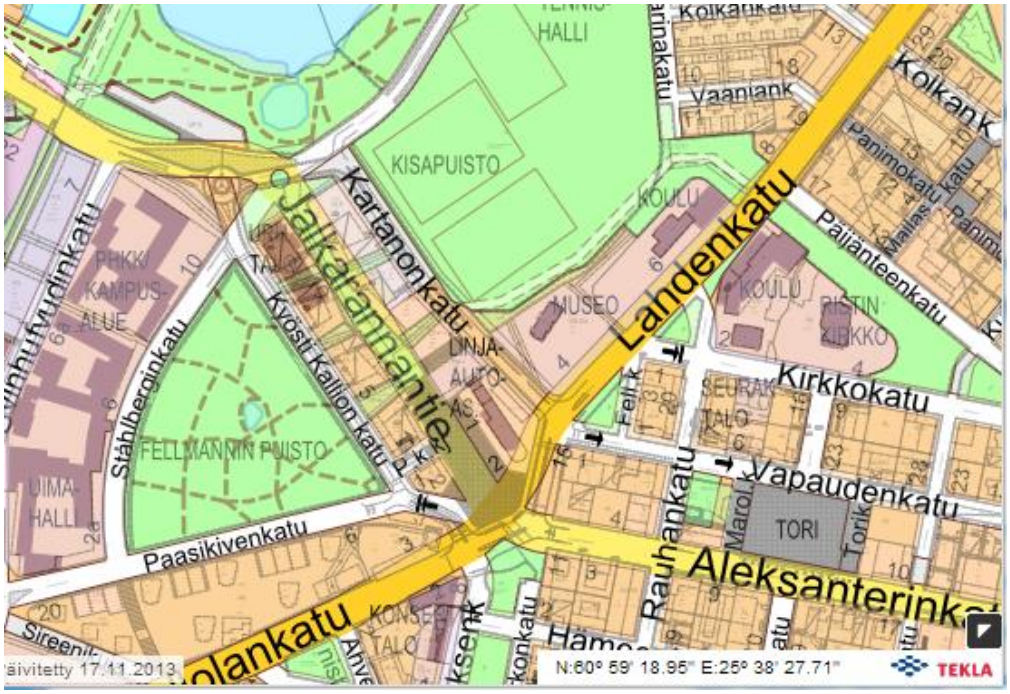

FIGURE 15. Real time city map 2013. (Lahti City 2013).

Below in Figure 16 Ranta-Kartano area as visualized 3-dimensional mass model to help perceiving of the area.

FIGURE 16. Ranta-Kartano area as 3-dimensional visualized (Etelä-Suomen Sanomat 9 Sep 2013).

Shore Plan

Buildings can not be built in shore zones in the shore area of the lake or near waterways without a local detailed plan or "*a legally binding local master plan which contains special provisions concerning use of the local master plan or a part thereof as the basis for granting a building permit".* (Finlex 1999.)

Shore area building has to be realized according to a valid local master plan, i.e. the purpose is determined by the master plan. When a local master plan or a local detailed plan (detailed shore plan) is made for the principal purpose of organizing for holiday homes in a shore area, no permanent housing is allowed without permission. (Ekroos et al. 2010.)

3.2 Planning Procedures and Interactive Design

Ekroos et. al. (2010, 243-267) present planning procedures and interactive design in their book Ympäristöoikeuden Pääpiirteet (The Main Features of Environmental Law).

The Procedural Provisions

The planning procedures are collected in Land and Building Law (Maa- ja rakennuslaki MRL) in their own chapter (Land Use and Building Act, LUBA).

Basic provisions dealing with the planning procedure are gathered in Land Use and Building Act in a specific chapter and they are applied to all procedures relating to the plans.

> *The Act also aims to ensure that everyone has the right to participate in the preparation process, and that planning is high quality and interactive, that expertise is comprehensive and that there is open provision of information on matters being processed* (Land Use and Building Act, Chapter 1 §).

Interactive design culture is playing a key role in the planning procedure. The spirit of Chapter 20.2 of the Finnish Constitution is manifesting itself also in the Land Use and Building Act. The Constitution determines the right for general freedom to associate with groups according to the choice of the individual, and for the groups to take action to promote their interests. Also the introductory enacting clause in Chapter 5.1 in LUBA (Objectives in land use planning) takes a stand on interactive design.

> *The objective in land use planning is to promote the following through interactive planning and sufficient assessment of impact: 1) a safe, healthy, pleasant, socially functional living and working environment which provides for the needs of various population groups, such as children, the elderly and the handicapped (*Land Use and Building Act 5.1 §).

According to general provision in LUBA 62 § the start of the planning process should be notified so that interested parties have the opportunity to get information on the principles of the planning and of the participation and assessment procedure.

The concept of *interested party* represents in LUBA the parties with an interest in land use planning matters. The concept of an interested party is not entirely

equivalent to the traditional concept of the concerned or interested, but it is wider. Involved are not only those having direct advantage of the subject matter but also those whose sphere of action the planning process touches upon. Involved are both public authorities and civil organizations.

First, according to LUBA 62 § interested parties include landowners, whose land is located in a planned area. There is no distinguishing between landowners, but involved are both private landowners and communities, including public corporations. Second, involved are also those on whose living, working or other conditions the plan may have a essential effect. The third group comprises authorities and communities whose field of operation is in question. Communities can roughly be divided into two groups: 1) general governments; e.g. municipality, municipal federation, parish and 2) private communities that are also juridical persons; e.g. company, cooperative, association. Communities are not required to be registered. (Ekroos et al. 2010, 243-245).

The chart below in Figure 17 illustrates in simplified form the various stages of drawing up a plan, in other words how planning takes place in practice (City of Jyväskylä 2013.)

FIGURE 17. Drawing up a plan in Jyväskylä (City of Jyväskylä 2013).

When plans are approved by the Technical Committee, the City of Lahti gives a public notice on their website (Kuulutukset ja ilmoitukset). When plans are important, an announcement is also made in the Lahti official bulletin Uusi-Lahti in connection with planning reports to be published or in the newspaper Etelä-Suomen Sanomat. Some of the issues will also be informed by personal letter. During the period of display for public inspection plans are on display also in the lobby of the City Library. The webpage allows the inhabitants of the city follow the progress of the planning work. (Lahti City 2013.)

Appeal Procedure

A plan is published by the City of Lahti once the Technical Committee has accepted it. The plan is available for public viewing for a period of 30 days, and if nobody appeals against it, the City Council will approve it. (Lahti City 2013.)

4 SURVEY ON THE IMPACTS OF VISUALIZATION ON DECISION MAKING

Visualization seems to have an impact of decision making. That is why a survey was organized as part of this thesis to find necessary and important features to develop and build an inspirational environment to help decision making.

4.1 Survey Basics

The survey about the impacts of visualization on decision making was made with Google Form Application for a limited group of people. Respondents were from Lahti University of Applied Sciences, Faculty of Technology. Most respondents were teachers. Teachers are educating future decision makers and many of them are decision makers themselves too. Invitation to answer was sent to 70 faculty members by an email distribution list. Seventeen (17) told their opinion to 29 propositions that were asked in the survey.

Survey propositions (P) were divided into two (2) main fields: A) Visual Perspective and B) Information Context. Visual Perspective (P1-P2) was divided to two subtasks: Interactivity (P3-P11) and Depth of Field (P12-P13). Information Context had three (3) subtasks: C) Vividness (P14-P22), D) Evaluability (P23-P26) and E) Framing (P27-P29).

In statistics, the *standard deviation* (represented by the Greek letter sigma, σ) shows how much variation or dispersion from the average there is. A low standard deviation indicates that the data points tend to be very close to the mean (also called expected value); a high standard deviation indicates that the data points are spread out over a large range of values.

Here is some background information of the respondents of the survey:

Population, N = 70.
Number of cases, n = 17.
Sex: Female (F) = 7 (41%), Male (M) = 10 (59%).

Respondents rated the statements on a scale of one to five likert. One is “disagree” and five is “fully agree”.

TABLE 2. Respondent’s age and sex.

Age	**Female Number of cases**	**Male Number of cases**	**Number of cases**
20 - 30 years	0	0	0
30 - 40 years	0	0	0
40 - 50 years 56%	4	6	10
50 - 65 years 44%	3	4	7

Survey respondents’ age and sex follows decision makers’ age and sex in Finland. In October 2013 48 % of the Members of Parliament are female, and 52 % are male. (Finnish Parliament 2013.) All propositions and detailed answers are as appendices in the end of the thesis. The following chapter summarize the answers to the propositions.

4.2 Visual Perspective Proposition

The term “visual perspective” refers to how a given visual representation changes the relationship between visual information and the decision maker (Lurie & Mason 2007).

Compared with non-interactive displays, interactive visualization tools lead to:

1. More information restructuring. Responds Average (AVG): 3.94 and Standard Deviation (STD DEV): 1.03.

2. Information acquisition that more closely reflects the decision maker's pre-existing preferences or knowledge structures. AVG: 3.35; STD DEV: 0.86.

Propositions pattern visual perspective (P1-P2) AVG: 3.65, STD DEV AVG: 0.95.

Both propositions were mostly accepted by respondents. In proposition 1, one respondent evaluated 1 (disagree), other respondents evaluated from 3 to 5.

4.3 Interactivity Propositions Analysis

Interactivity is included many current visualization tools. Such tools enable the user to restructure the representation of information (Coupey 1994, 83–99) by interactively changing which variables are shown, cut points for displaying variables, and whether particular variables are shown by colours or shapes. Other tools allow the user to group objects and move selected objects into focus or to prune information from display. (Chuah et al. 1995 61-70; Hasha, Plaisant, and Scheiderman 1997 103-124).

Compared with noninteractive displays, interactive visualization tools lead to:

3. Enhanced use of pre-existing decision rules. AVG: 3.82; STD DEV: 0.81.
4. More compensatory decision processes. AVG: 3.88; STD DEV: 1.02.
5. More accurate decisions. AVG: 3.88; STD DEV: 0.99.

These three propositions were accepted by respondents. With proposition 4 and 5 standard deviation was a little wider than in proposition 3. So there was more dispersion in that proposition.

The use of interactive virtual reality visualization tools leads to:

6. Higher prepurchase confidence. AVG: 3.59; STD DEV: 1.00
7. Greater product trial and adoption. AVG: 4.12; STD DEV: 0.70.
8. Higher levels of postpurchase satisfaction. AVG: 3.82; STD DEV: 0.81.
9. More incoherent choices. AVG: 2.88; STD DEV: 1.17.

10. Less post purchase product reworking (returns and exchanges). AVG: 3.71 STD DEV: 0.99.
11. Smaller differences between actual and expected product performance. AVG: 3.88; STD DEV: 1.11.

Interactivity propositions pattern (P3-P11): AVG: 3.73, STD DEV AVG: 0.96.

These six propositions were also accepted by respondents. Proposition number 7 got the second high score in the whole survey.

4.3.1 Depth of Field

Visual representations vary in depth of field , i.e., the extent to which they provide contextual overview versus detailed information or enable decision makers to attend to both levels in focus at the same time (Lurie & Mason 2007, 165).

Decision makers using visual representations that provide more context than detail or present more alternatives within a given visual field:

12. Consider more alternatives. AVG: 3.65; STD DEV: 0.70.
13. Have a better understanding of the range of attribute values. AVG: 3.82; STD DEV: 0.64.

Depth of field propositions pattern (P12-P13): AVG: 3.73, STD DEV AVG: 0.96.

Respondents accepted depth of field, and contextual overview more than detailed information.

4.4 Information Context

Changes in the particular data values, colours, and shapes used in a given visual representation affect how information is accessed and compared (Lurie & Mason 2007, 166).

4.4.1 Vividness

Vividness refers to the availability of specific information. More vivid visual information is likely to be acquired and processed before less vivid visual information (Lurie & Mason 2007, 167).

Decision makers using graphic versus text-based presentations of the same information:

14. Place greater weight on this information when it is presented graphically. AVG: 4.24; STD DEV: 0.44.

15. Are more likely to change their choices in response to changes in attributes. AVG: 3.65; STD DEV: 0.70.

16. Are more likely to overestimate this information when making judgments. AVG: 3.29; STD DEV: 0.77.

Graphically presented information impact, proposition number 14 got the highest score and the narrowest standard deviation given by respondents. It seems that respondents prefer graphical data to numerical data to support decision making.

Decision makers using visual representations that include graphic as well as text-based information.

17. Place greater weight on the graphic information. AVG: 3.82; STD DEV: 0.88.

18. Are more likely to change their choices in response to changes in attribute values that are shown graphically. AVG: 3.65; STD DEV: 0.70.

19. Overestimate the graphic information and underestimate the textual information. AVG: 3.29; STD DEV: 0.85.

Decision makers using visual representations for which some information shows greater variance in shape, size, or colour:

20. Place greater weight on information that shows more variance. AVG: 3.82; STD DEV: 0.73

21. Overestimate high variance information and underestimate low variance information. AVG: 3.65; STD DEV: 0.70.

Decision makers using visual representations that vary in their presentation of features that are salient in human perception:

22. Overestimate information shown by salient features and underestimate information shown by nonsalient features. AVG: 3.29; STD DEV: 0.69.

Vividness propositions pattern (P14-P22): AVG: 3.63, STD DEV AVG: 0.71.

4.4.2 Evaluability

Evaluability refers to the ease with which information can be assessed and compared. By making it easier to compare information, visualization tools enable decision makers to notice changes, recognize outlines, and see patterns more quickly. Making information easier to compare is likely to lead to increased acquisition, weighting, and processing of this information. (Ariely 2000.)

Decision makers using graphic versus text-based (tabular) presentations of the same information

23. More quickly identify outlines, trends, and patterns of covariation between variables. AVG: 4.06; STD DEV: 1.09.
24. Make less accurate assessments of differences between values. AVG: 3.06 STD DEV: 0.97.
25. Decision makers using visual representations that allow attributes (versus alternatives) to be more easily compared show greater processing by attributes than by alternatives. AVG: 3.29; STD DEV: 0.47.
26. Decision makers using visual representations that highlight the similarity among alternatives on a given attribute weigh other attributes more heavily in their decision making. AVG: 3.53; STD DEV: 0.72.

Vividness propositions pattern (P23-P26): AVG: 3.49, STD DEV AVG: 0.81.

Propositions on Evaluability field were accepted by respondents. Proposition number 23 got high score, so it seems that according to respondents graphics help to make decisions more quicly.

4.4.3 Framing

By changing the presentation of a given problem, visual representations may accentuate biases and heuristics in decision making. This could occur by changing the reference point against which data are compared, thus framing data alternatively as a loss or a gain. Because daily losses are more frequent and dramatic than losses over longer periods, a daily presentation is more likely to

show losses than a longer-term presentation. Because decision makers are often risk seeking for losses but risk averse for gains, a visualization with a more recent reference point may lead investors to riskier behaviour. (Lurie & Mason 2007, 170.)

27. Decision makers using visual representations that present changes in percentage terms (e.g., pie charts) are more likely to segregate gains and losses (mixed gains) than those using visual representations that make it easier to see absolute changes (e.g., line graphs). AVG: 3.35; STD DEV: 0.70.

28. Decision makers using visual representations that sort information from highest to lowest make higher estimates than those using visual representations that sort information from lowest to highest. AVG: 3.35; STD DEV: 0.70.

29. Decision makers using visual representations that make information easier to compare on an attribute for which one alternative is dominant are more likely to make decisions that are consistent with the attraction effect than those using visual representations that make comparisons on that attribute more difficult. AVG: 3.29; STD DEV: 0.47.

Framing propositions pattern (P27-P29): AVG: 3.33, STD DEV AVG: 0.62.

4.5 Summary of Survey Analysis

All counted averages on different propositions were between 3 and 4.3 and standard deviations between 0.5 and 1.2. Causes for that narrow result might be respondents' homogeneity of education and social status. Only in some propositions one (1) respondent had a completely different point of view that average or the proposition was understood wrong.

Proposition 14 got the highest grade: Decision makers using graphic versus text-based presentations of the same information place greater weight on this information when it is presented graphically. AVG: 4.24; STD DEV: 0.44.

Proposition 9 got the lowest grade: The use of interactive virtual reality visualization tools leads to: More incoherent choices. AVG: 2.88; STD DEV: 1.17.

Result shows that all the introduced propositions in the survey support decision making process to make better decisions (28/29 counted averages are more than 3). All tools or applications to visualize data will help people to understand complex things better. It might be possible to manipulate decision makers to focus on visualization and some important things (text) might be hidder behind visualization.

> *Although decisions based on interactive visual representations may be somewhat different to those made without them, responsible decision-makers are not likely to be misled by the new way of having information presented to them, and rather they should find it simply easier to make informed decisions.* (Open response in survey Visualization impacts for decision making)

5 RELIABILITY AND VALIDITY

Reliability is the extent to which an experiment, test, or any measuring procedure yields the same result on repeated trials. Without the agreement of independent observers able to replicate research procedures, or the ability to use research tools and procedures that yield consistent measurements, researchers would be unable to satisfactorily draw conclusions, formulate theories, or make claims about the generalizability of their research. (Colorado State University 2013).

In this thesis decision making and visualization was investigated from previous research. Designing and building the Decision Theatre Niemi campus Lahti were based on these results.

In the survey of Visual Representation: Implications for Decision making, 17 respondents gave similar answers as previous research.

6 STUDY CASE: DECISION THEATRE

6.1 Turning Knowledge into Action

The Decision Theatre (DT) concept, a world-class research facility, has been developed in Arizona State University (ASU), USA, for exploring and understanding decision making in uncertain times. By using the latest visualization, simulation and solution tools, decision-makers can respond to today's challenges and answer tomorrow's emerging issues. (Arizona State University 2013).

Enabling action through knowledge-based decision processes, Decision Theatre currently specializes in the following:

- Simulation and modelling of complex systems
- Data analysis and information visualization
- Group (collaborative) decision-making
- Policy analysis and evaluation

(Arizona State University 2013).

6.1.1 The infrastructure of Arizona State University Decision Theatre

The Decision Theatre at Arizona State University is a 740 m^2 visualization environment that accommodates up to 30 participants (Arizona State University 2013).

The core component of the Decision Theatre is the 'drum' comprising a 260-degree faceted screen, seven rear-projection passive stereo sources, tracking devices and surround sound. This enables data to be displayed and interacted with in a panoramic setting using 2D or 3D stereoscopic video (Arizona State University 2013).

Unlike some visualization labs and flat-wall display facilities, the Decision Theatre is an immersive environment designed for collaboration. Participants are often arranged in a conference configuration to improve human engagement with each other and to interact with the visual information around them. They can take

advantage of a variety of tools to improve decision making, including 3D and geospatial visualization, simulation models, system dynamics, and computer assisted tools for collecting participant input and collaboration. They also have access to the university's ongoing research in policy informatics, design, geography, computational science, business, psychology and mathematics. (Arizona State University 2013).

In Figure 18 is a typical situation (people and visualized data) in the Decision Theatre.

FIGURE 18. Decision Theatre (Arizona State University 2013).

6.1.2 Examples of Decision Theatre in Action

In February 2013 Arizona State University held a *Waste Management Forum*. The focus was in three questions:
Q1: "What implications does Sustainability have in the business world?"
Q2: "Why is Sustainability important in a business environment?"
Q3: "How can Sustainability become better incorporated into everyday business?"

"The Decision Theater's role in the forum was focused on successfully executing numerous breakout discussion groups led by Waste Management sustainability

experts that took place after the morning's keynote addresses. The participants in the discussion groups were divided by industry which allowed attendees to discuss the benefits and challenges of sustainability as it related to their individual sectors and industries. The overarching goal of these discussion groups was to motivate and inspire industry leaders to make changes. The success of the forum is a hopeful indicator of future collaborations between Waste Management and the Decision Theater." (Arizona State University 2013).

Scenario Analysis for Arizona's Water Resources

In Figure 19 is an example pictures from Arizona's Water Recources scenario.

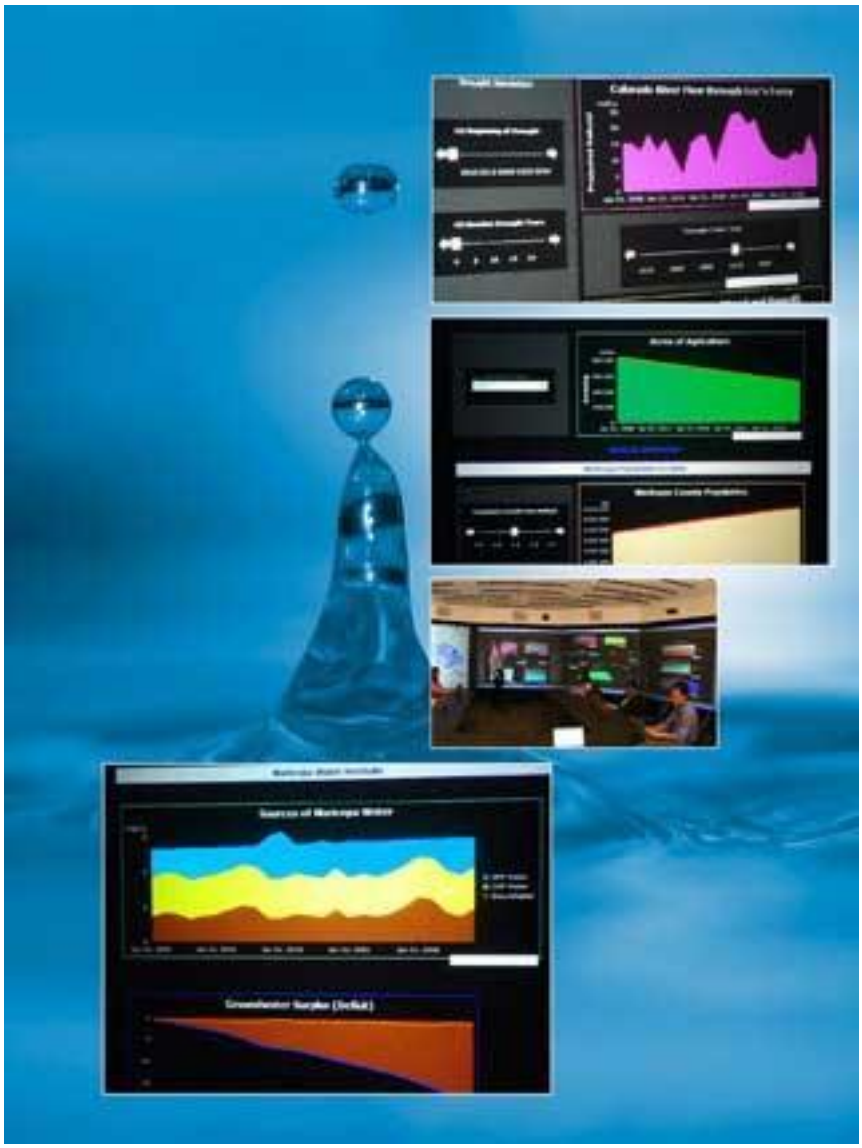

FIGURE 19. Decision Theatre in action at Arizona State University (Arizona State University 2013).

Challenge

"The Decision Centre for a Desert City (DCDC) is a "boundary organization" that bridges the divide between academic research and policy making. They wanted to show the relationships between climate change, water supplies and urbanization in Phoenix." (Arizona State University 2013).

Solution

"DCDC created a system dynamics model with a graphical "dashboard" that allows water professionals in the state to explore alternative scenarios for growth, water supply and water demand. Called WaterSim, the model incorporates growing water demand on the Salt-Verde watershed and the Colorado River in the face of climatic variability and growth." (Arizona State University 2013).

Results

"DCDC WaterSim has the ability to predict the impact of droughts on Arizona's watersheds, their impact on regional growth, and assist policy makers to explore sustainable water conservation and use policies." (Arizona State University 2013).

6.2 Project Urban Laboratory for Sustainable Environment

Aalto University, the University of Helsinki and Lahti University of Applied Sciences has a project Urban laboratory for sustainable envinronment during 2012 and 2014. The aim of the reseach project is to get an Urban laboratory for sustainable environment studies the functioning of urban ecosystems, impacts of building on the environment and the associated knowledge infrastructure (Aalto University 2013).

As a result of the project a research infrastructure of urban environment, civil engineering and environmental informatics will emerge in Lahti to complement the existing environmental sector research infrastructure in this area. (Aalto University 2013.)

Environmental information management brought to a new level: an entire urban area as a test laboratory. The project will facilitate research cooperation between

research teams in Lahti area and elsewhere associated with urban environments. In the initial stage, a test area network and an environmental information laboraratory will be set up in Lahti (Aalto University 2013).

6.3 Basics of Study Case Decision Theatre in Lahti Niemi Campus

One part of the Urban laboratory for sustainable environment project is to develop and implement and immersive environmental information laboratory for researchers and to present the results of the project. The model for the theatre comes from Arizona State University Decision Theatre. The infrastructure should be carried out with new technologies, such as High Density projectors and touch screen displays. Professor Ari Jolma from Aalto University gave some keywords and study problems to start the study:

• What concepts or notions do planners use in their work and how are the concepts connected with each other – especially from the environmental point of view?

• What tools are used and how?

• What is the spatial treatment level of planning? If we want to divide the town to polygons, what are the polygons?

Keywords:

- Demo infrastructure (”Temple of Challenge” or ”Decision Theatre”).
- Planning tools and concepts.

After some search Arizona State University was found from internet. It was possible to find some documentation from their achievement. That was a good model to make the 1st plan to the local solution which can be seen in figure 20.

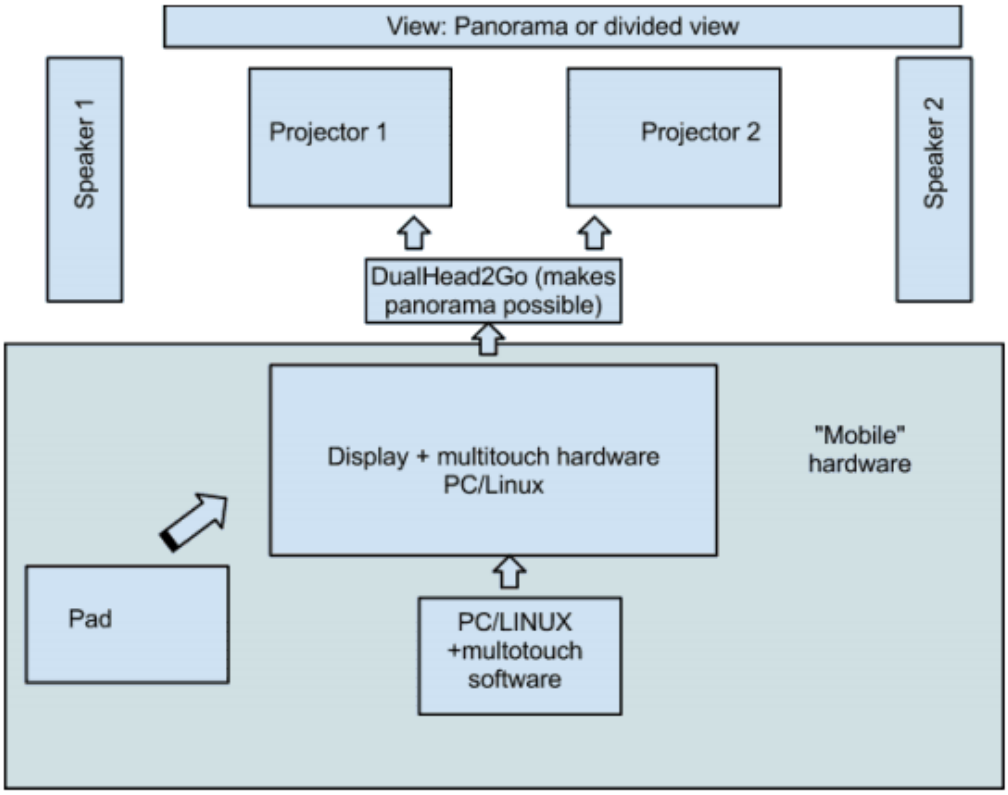

FIGURE 20. Version 1 draft for Decision Theatre, Niemi campus.

This version 1 or idea 1 was sent to a couple of Audio-Visual suppliers. An estimated budget and feedback on problems was received from suppliers. The plan was presented to the project steering group and further developing suggestions were received from the group.

During spring 2013 new technology projectors were launched out to the market. New technology was hybrid LED and Laser projectors with edge blending option. Edge blending makes it possible to extend two projectors to make one wide one, for example 32:9 aspect ratio panorama view in Full HD mode. The 32:9 aspect ratio is generated by a special graphics card in computer. Hybrid, LED and Laser diode system uses a combination of Light Emitting Diodes and 445 nm laser diodes as the light source, while the image is processed with Digital Light Processing (DLP) chip. Hybrid projectors also give ten (10) times longer lamp life compared to traditional LCD projectors, which use LCD light gates.

6.3.1 Plan Version 2 Decision Theatre Niemi Campus

Some replanning was done after the feedback and new technology release. Projectors were turned to the other wall to get maximum size of view. See figure 21.

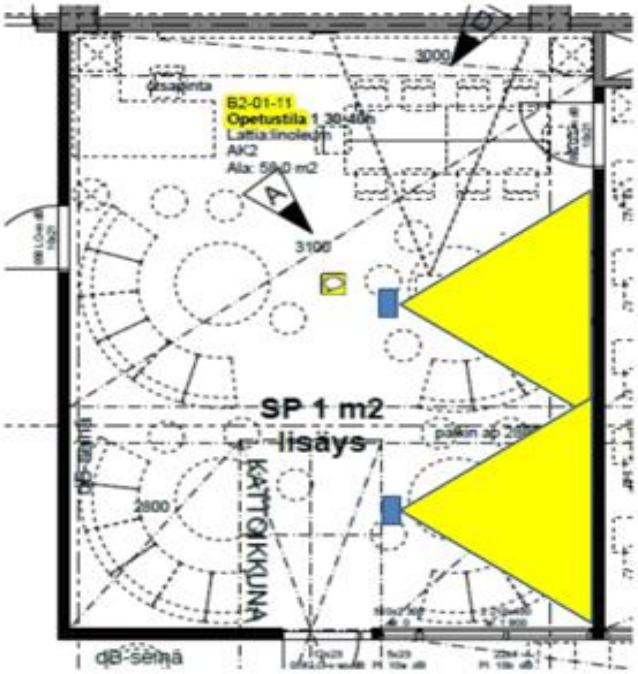

FIGURE 21. Physical room layout of DT.

Below is a picture (Figure 22) that was sent to suppliers to get equipment and installation offers. From the picture it is possible to see main the components and wireless requirements.

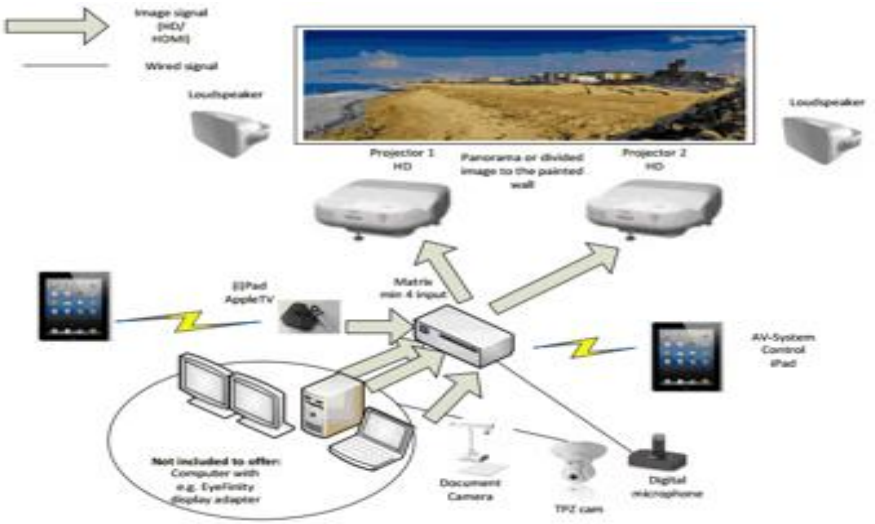

FIGURE 22. Plan 2 of Decision Theatre hardware in Niemi campus, Lahti.

6.3.2 Examples from Decision Theatre Niemi Campus Lahti

Below in Figure 23 can be seen an example layout from the room. Participants can sit as small groups and discuss. The Furniture is light and easy to reorganize get the best layout.

FIGURE 23. Decision Theatre room layout. (Photo: Ari Vesikko.)

Some seminars have arranged in DT Niemi campus. Below Figure 24 is an example of divided view: left side is a computer view and right side is document camera view.

FIGURE 24. Rescue Project having a seminar in Decision Theatre. (Photo: Ari Vesikko.)

Figure 25 shows an example oPanorama view. Aspect ratio 32:9. The Physical width of the view is five (5) meters. In this image it is also possible to see the color difference between projector pictures.

FIGURE 25. Colour problem with two projectors. (Photo: Ari Vesikko.)

In Figure 26, the left side of the view is a picture from a computer and right side of the view is a picture from AppleTV.

FIGURE 26. Integrated sources in one view. (Photo: Ari Vesikko.)

In figure 27 is a view to one water measurement station data. Web application is developed by Aalto University.

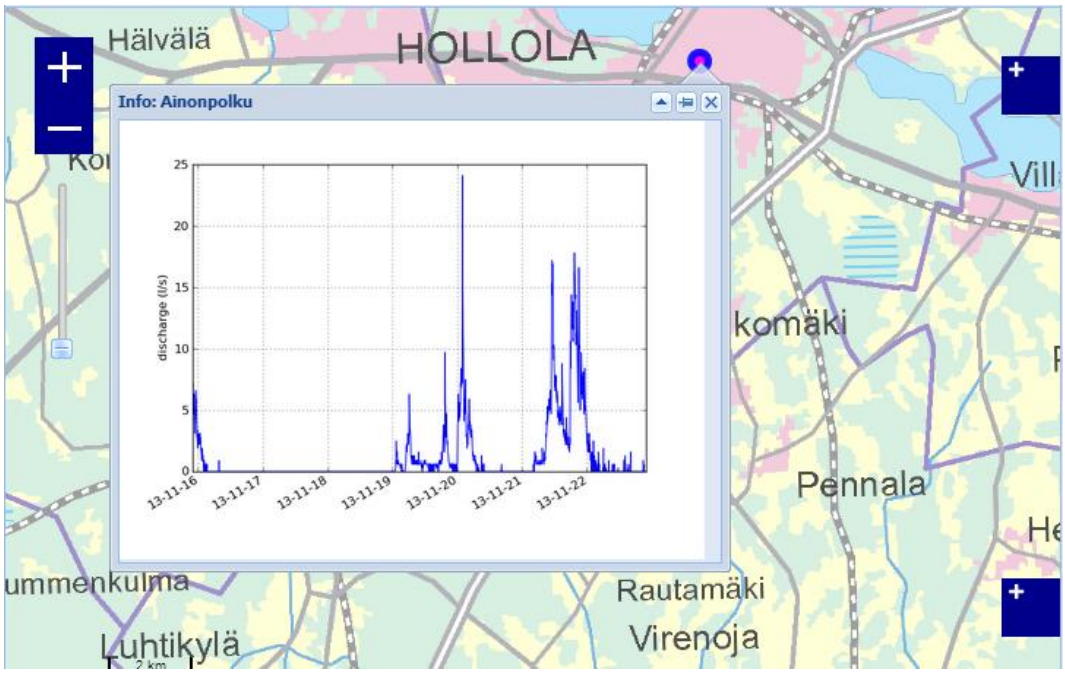

FIGURE 27. Runoff water measurement data from station Ainonpolku. (Aalto University 2013.)

6.3.3 Technology and Pedagogy in Decision Theatre Niemi Campus

The Decision Theatre at Niemi campus is a 60 m^2 visualization environment that accommodates up to 25 participants.

The core component of the Decision Theatre is the screen and sound. Image to the screen is produced from two led and laser hybrid projectors with edge blending option. This enables data to be displayed and interacted with in a panoramic setting or split from two different sources. The Decision Theatre is an immersive setting designed for cooperation. Participants are often arranged in a small group structure to improve human commitment with each other and to interact with the visualised data on the wall.

7 CONCLUSION

Decision making belongs to every person's life. Some decisions are bigger than others. If decision is based on complex data, visualization and an environment, where it is possible to show visual data to participants to help them to do better decisions are easy to implement with up-to-date technology. Data harvest, Wireless networks and High Density (HD) images give more possibilities to visualize. Risk of over visualization or misleading with visualization must be kept in mind when making big decisions. The Law defines some presentation formats. For example land use process outcomes are defined in the Land Use and Building Act.

7.1 Analysis of Research Questions

In the beginning of my thesis the main research questions were determined:

Q1: Can data visualization and immersive environments contribute to decision making?
Conclusion to Q1: According to the results of previous research, interviews and my survey, data visualization and immersive environments can contribute to decision making. In some cases over visualization can, however, even lead to a bad decision. Experienced decision makers can observe the facts in the right perspective.

Q2: What are the most effective tools and techniques to visualize data?
Conclusion to Q2: Literature and my survey on data visualization and immersive environments show that decision makers using graphic versus text-based presentations of the same information: place greater weight on this information when it is presented graphically.

Q3: How can data visualization help urban planners to make better plans?
Conclusion to Q3: Official planning documents must be presented as a map. The plan includes a key to the symbols used and written regulations. Two specialists were interviewed about this focus. Their opinion was, that in the planning process the best time to visualize is when the plans are tested during planning. 3D models

may not be too exact. Usually mass/volume models are enough. More detailed models might give a wrong signal about plans.

Q4: What are the possibilities or good practises to implement an immersive environment in decision making, planning and education?
Conclusion to Q4: New campus centres are integrating education, research and enterprise activities. An up-to-date environment supports all operators on the campus. Each operator can use the environment for their own special activities, if the environment is not too fixed to one operator's needs. Diverse environments are expensive to build and maintain, several operators pay as smaller shore each if consensus is found.

7.2 Further Studies

Decision Theatre Niemi campus Lahti was built during this study. There were limited resources (money and time) to use in the project. If more resources are gained in the future, many things can be developed to help the functions in DT.

Almost everything can nowadays be visualized by computer applications. Computer applications or web applications can be evaluated as much as there are resources for that. Spatial data solutions are used in many fields from traditional city planning to developing a new commercial centre developing. Effective solutions to visualize data are always welcome to the many sectors to help decision makers to make better decisions. Here are two examples 1) Wireless connection from laptops or pads to projectors and 2) Effective programs or applications to visualize big data or complex data.

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Figure 2. Decision making test. (MindTools 2013.) Available on

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Figure 3. Crawford Slip Writing Technique (Create 2013). Available on http://www.icreate-project.eu/index.php?t=336

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Figure 7. Swot-form example.

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Figure 9. Visual analytics as a highly interdisciplinary field of research. (Keim et al., 2006). Available on http://www.infovis-wiki.net/index.php/Visual_Analytics

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Figure 11. The development areas of the region. (Lahti city 2013). Available on http://www.lahti.fi/www/cms.nsf/pages/96A90325A73A7DBBC22570FA0046839B

Figure 12. The development of the number of residents during the years 1905-2003 and forecasts according to different structural plans. (Lahti city 2013). Available on

Tables

9 APPENDICES

Appendix 1. Survey about Visualization impacts for decision making

The impacts of visualization and immersive environments for decision making

Wanna help me with my thesis?
Below are some pretensions. Apprise pretension to Your own experience by value 1 to 5.
5 = Fully agree 1 = Disagree.
Any personal information is not recorded. Further information: Ari.Vesikko[at]lamk.fi. Thanks for Your time.
*Pakollinen

The defendant's background information. *
Sex:

- ☐ Female
- ☐ Male

The defendant's background information. *
Age:

Visual Perspective

The term "visual perspective" refer to how a given visual representation changes the relationship between visual information and the decision maker.

1. Compared with noninteractive displays, interactive visualization tools lead to *
More information restructuring.

1	2	3	4	5
○	○	○	○	○

2. Compared with noninteractive displays, interactive visualization tools lead to *
Information acquisition that more closely reflects the decision maker's preexisting preferences or knowledge structures.

1	2	3	4	5
○	○	○	○	○

Interactivity

Interactivity separates many current visualization tools. Such tools enable the user to restructure the representation of information by interactively changing which variables are shown, cut points for displaying variables, and whether particular variables are shown by colors or shapes.

3. Compared with noninteractive displays, interactive visualization tools lead to *

Enhanced use of preexisting decision rules.

1	2	3	4	5
○	○	○	○	○

4. Compared with noninteractive displays, interactive visualization tools lead to

More compensatory decision processes.

1	2	3	4	5
○	○	○	○	○

5. Compared with noninteractive displays, interactive visualization tools lead to *

More accurate decisions.

1	2	3	4	5
○	○	○	○	○

6. The use of interactive virtual reality visualization tools leads to *

Higher prepurchase confidence.

1	2	3	4	5
○	○	○	○	○

7. The use of interactive virtual reality visualization tools leads to *

Greater product trial and adoption.

1	2	3	4	5
○	○	○	○	○

8. The use of interactive virtual reality visualization tools leads to *
Higher levels of postpurchase satisfaction.

1	2	3	4	5
○	○	○	○	○

9. The use of interactive virtual reality visualization tools leads to *
More incoherent choices.

1	2	3	4	5
○	○	○	○	○

10. The use of interactive virtual reality visualization tools leads to *
Less postpurchase product reworking (returns and exchanges).

1	2	3	4	5
○	○	○	○	○

11. The use of interactive virtual reality visualization tools leads to *
Smaller differences between actual and expected product performance.

1	2	3	4	5
○	○	○	○	○

Depth of field

Visual representations vary in depth of field—that is, the extent to which they provide contextual overview versus detail information or enable decision makers to attend to both levels in focus at the same time.

12. Decision makers using visual representations that provide more context than detail or present more alternatives within a given visual field *
Consider more alternatives.

1	2	3	4	5
○	○	○	○	○

13. Decision makers using visual representations that provide more context than detail or present more alternatives within a given visual field *
Have a better understanding of the range of attribute values.

1	2	3	4	5
○	○	○	○	○

Information Context

Vividness

Vividness refers to the availability of specific information. More vivid visual information is likely to be acquired and processed before less vivid visual information.

14. Decision makers using graphic versus text-based presentations of the same information *

Place greater weight on this information when it is presented graphically.

1 2 3 4 5

○ ○ ○ ○ ○

15. Decision makers using graphic versus text-based presentations of the same information *

Are more likely to change their choices in response to changes in attributes.

1 2 3 4 5

○ ○ ○ ○ ○

16. Decision makers using graphic versus text-based presentations of the same information *

Are more likely to over estimate this information when making judgments.

1 2 3 4 5

○ ○ ○ ○ ○

17. Decision makers using visual representations that include graphic as well as text-based information *

Place greater weight on the graphic information.

1 2 3 4 5

○ ○ ○ ○ ○

18. Decision makers using visual representations that include graphic as well as text-based information *

Are more likely to change their choices in response to changes in attribute values that are shown graphically.

1 2 3 4 5

19. Decision makers using visual representations that include graphic as well as text-based information *

Overestimate the graphic information and underestimate the textual information.

1 2 3 4 5

○ ○ ○ ○ ○

20. Decision makers using visual representations for which some information shows greater variance in shape, size, or color *

Place greater weight on information that shows more variance.

1 2 3 4 5

○ ○ ○ ○ ○

21. Decision makers using visual representations for which some information shows greater variance in shape, size, or color *

Overestimate high variance information and underestimate low variance information.

1 2 3 4 5

○ ○ ○ ○ ○

22. Decision makers using visual representations that vary in their presentation of features that are salient in human perception *

Overestimate information shown by salient features and underestimate information shown by nonsalient features.

1 2 3 4 5

○ ○ ○ ○ ○

Evaluability

Evaluability refers to the ease with which information can be assessed and compared. By making it easier to compare information, visualization tools enable decision makers to notice changes, recognize outliers, and see patterns more quickly. Making information easier to compare is likely to lead to increased acquisition, weighting, and processing of this information.

23. Decision makers using graphic versus text-based (tabular) presentations of the same information *

More quickly identify outliers, trends, and patterns of covariation between variables.

1	2	3	4	5
○	○	○	○	○

24. Decision makers using graphic versus text-based (tabular) presentations of the same information *

Make less accurate assessments of differences between values.

1	2	3	4	5
○	○	○	○	○

25. Decision makers using visual representations that allow attributes (versus alternatives) to be more easily compared show greater processing by attributes than by alternatives. *

1	2	3	4	5
○	○	○	○	○

26. Decision makers using visual representations that highlight the similarity among alternatives on a given attribute weigh other attributes more heavily in their decision making. *

1	2	3	4	5
○	○	○	○	○

27. Decision makers using visual representations that present changes in percentage terms (e.g., pie charts) are more likely to segregate gains and losses (mixed gains) than those using visual representations that make it easier to see absolute changes (e.g., line graphs). *

1	2	3	4	5
○	○	○	○	○

28. Decision makers using visual representations that sort information from highest to lowest make higher estimates than those using visual representations that sort information from lowest to highest. *

1 2 3 4 5

29. Decision makers using visual representations that make information easier to compare on an attribute for which one alternative is dominant are more likely to make decisions that are consistent with the attraction effect than those using visual representations that make comparisons on that attribute more difficult. *

1 2 3 4 5

30. Your ideas about the impacts of data visualization and immersive environments for decision making.

Type free text and give Your ideas.

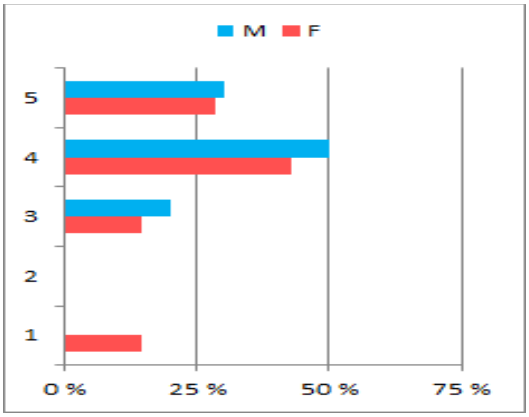
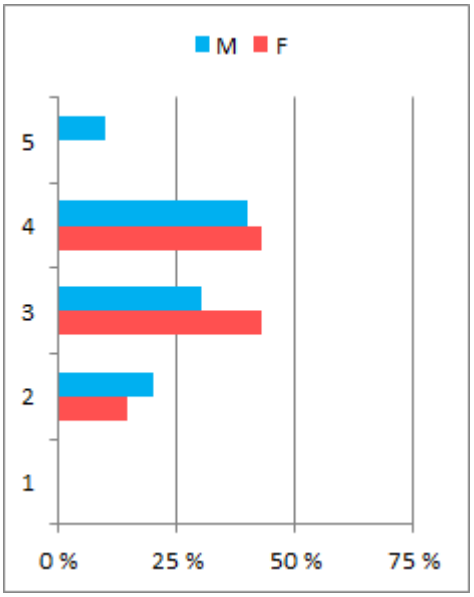
Lähetä

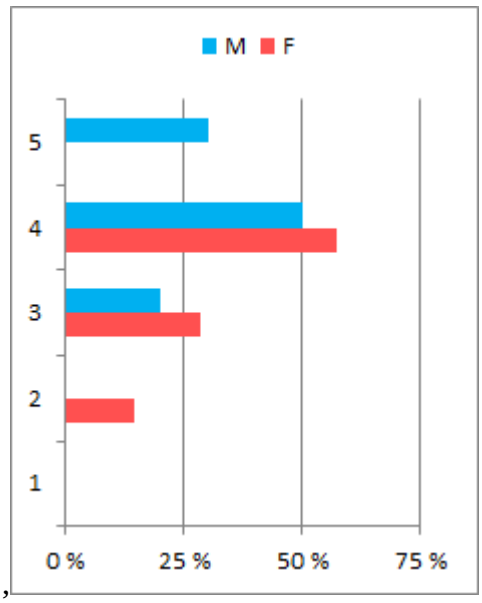
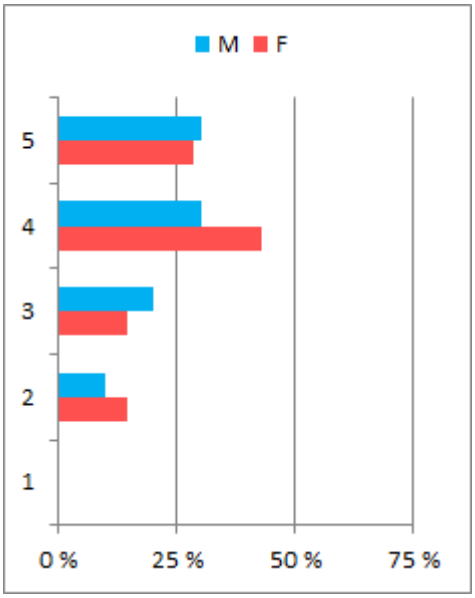
Älä koskaan lähetä salasanaa Google-lomakkeiden kautta.

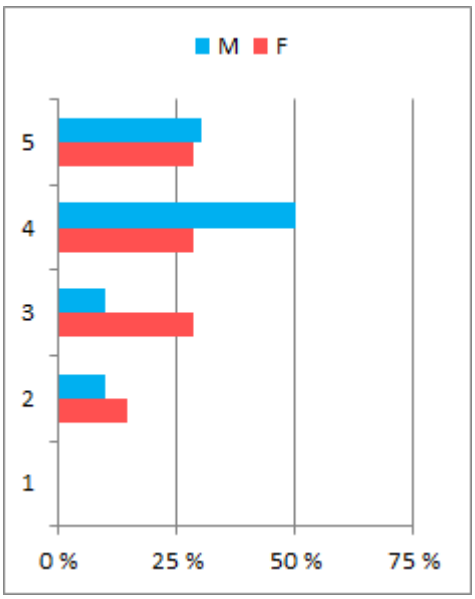
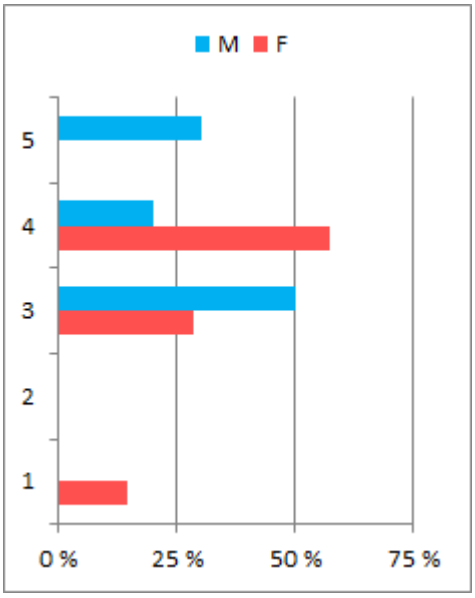
100 %. Sait sen valmiiksi.

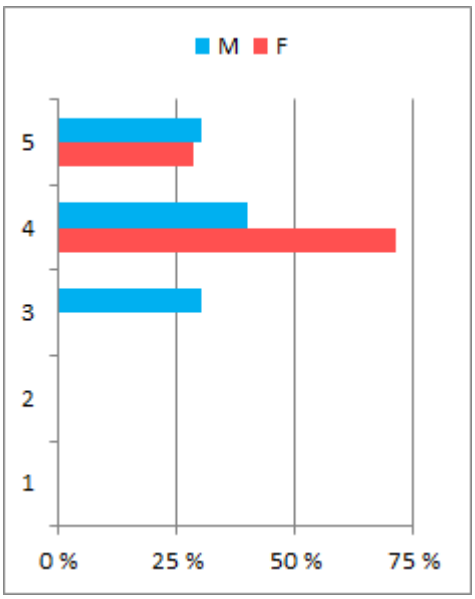
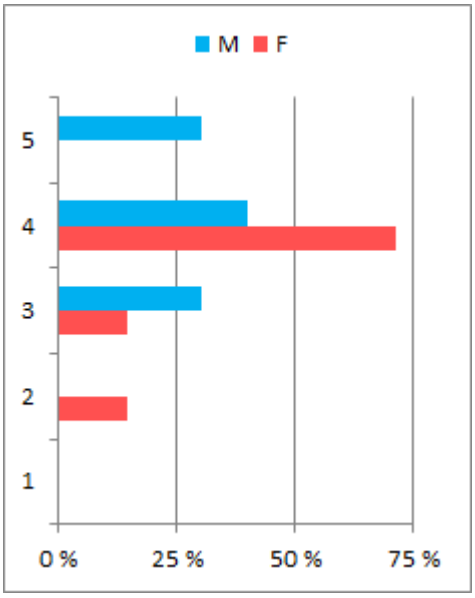
Appendix 2. Survey results and analysis about Visualization impacts for decision making.

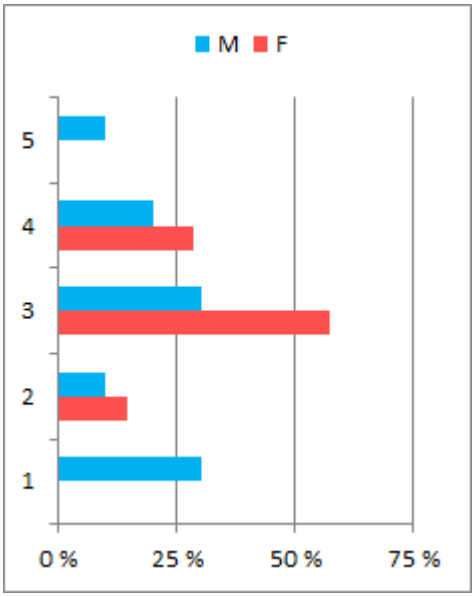
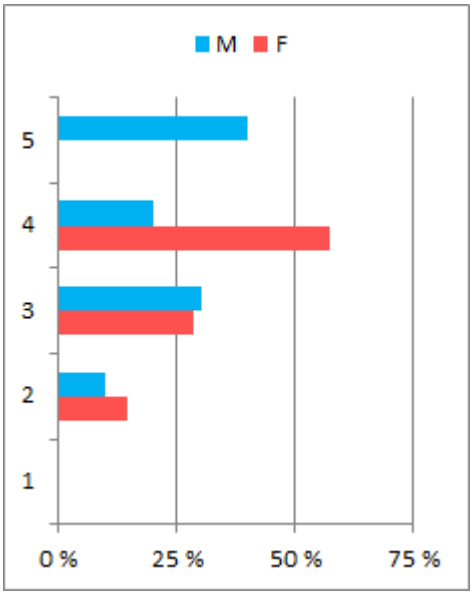
M= Male, F= Female

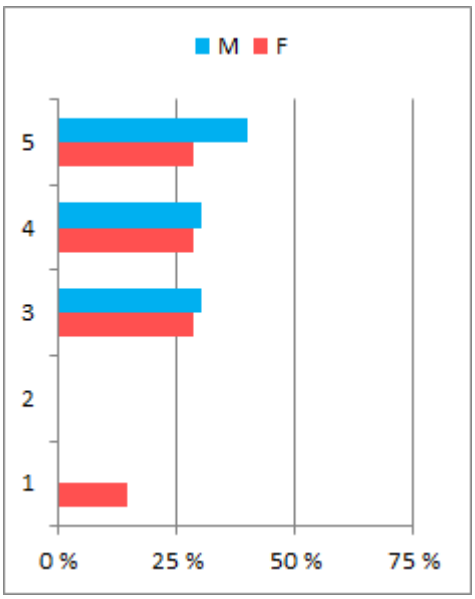
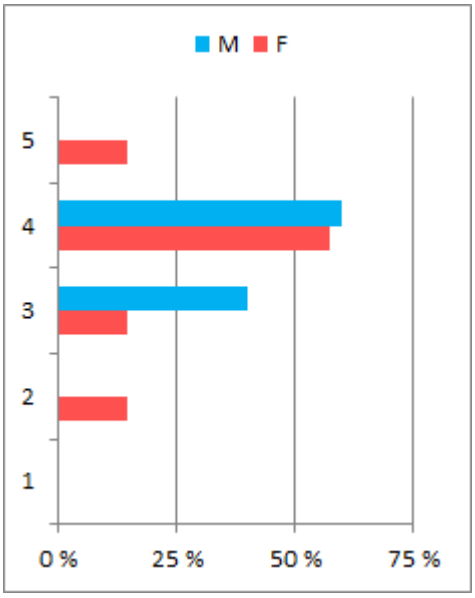
	1. Compared with non-interactive displays, interactive visualization tools lead to : More information restructuring. AVG: 3.94 STD DEV: 1.03
	2. Compared with no interactive displays, interactive visualization tools lead to : Information acquisition that more closely reflects the decision maker's pre-existing preferences or knowledge structures. AVG: 3.35 STD DEV: 0.86

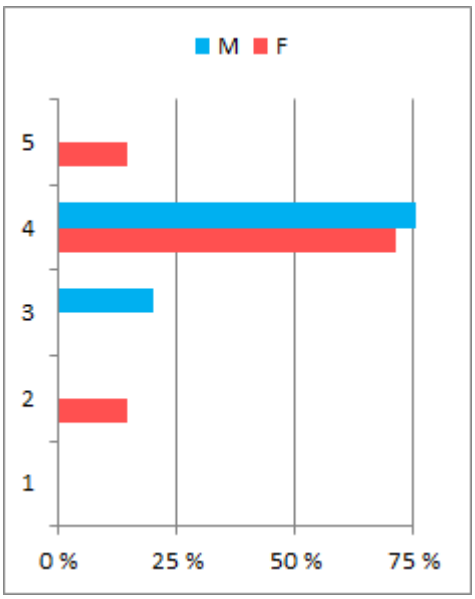
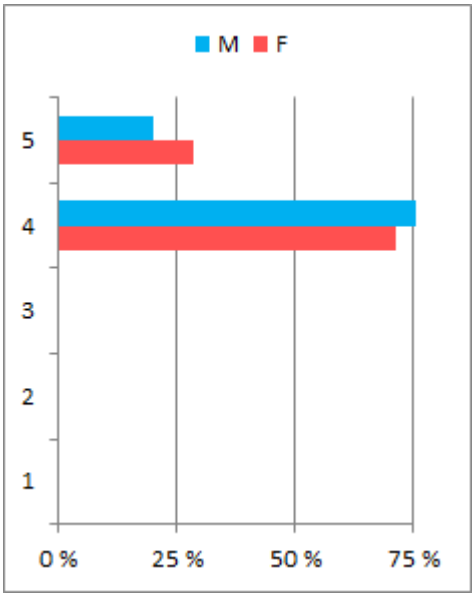
 ,	3. Compared with non-interactive displays, interactive visualization tools lead to : Enhanced use of pre-existing decision rules. AVG: 3.82 STD DEV: 0.81
	4. Compared with non-interactive displays, interactive visualization tools lead to : More compensatory decision processes. AVG: 3.88 STD DEV: 1.02

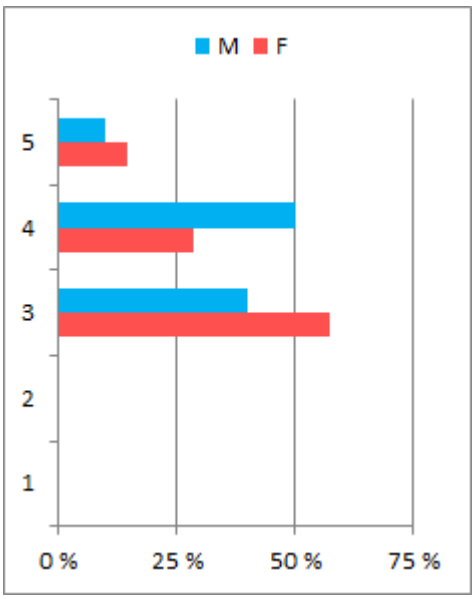
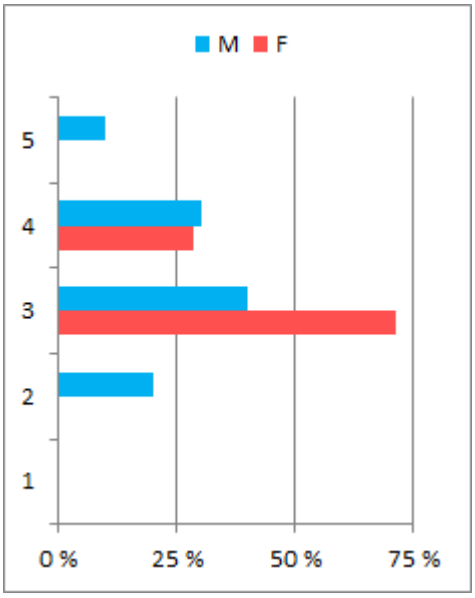
	5. Compared with non-interactive displays, interactive visualization tools lead to : More accurate decisions. AVG: 3.88 STD DEV: 0.99
	6. The use of interactive virtual reality visualization tools leads to : Higher repurchase confidence. AVG: 3.59 STD DEV: 1.00

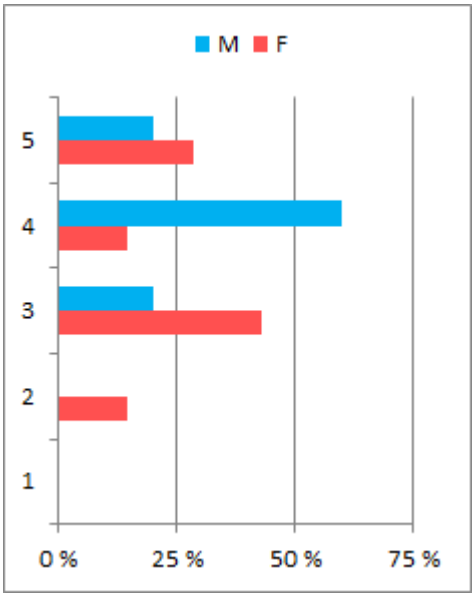
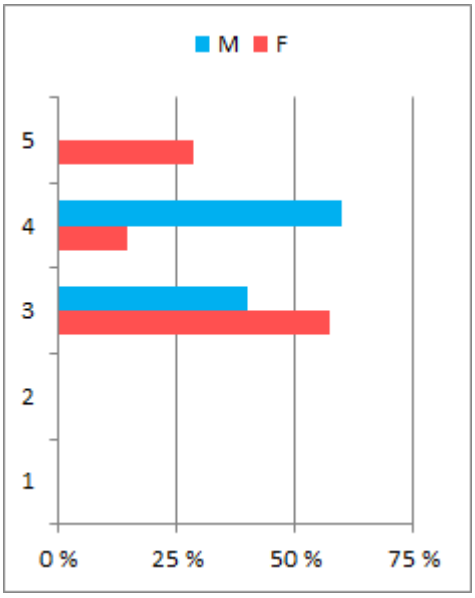
	7. The use of interactive virtual reality visualization tools leads to : Greater product trial and adoption. AVG: 4.12 STD DEV: 0.70
	8. The use of interactive virtual reality visualization tools leads to : Higher levels of post purchase satisfaction. AVG: 3.82 STD DEV: 0.81

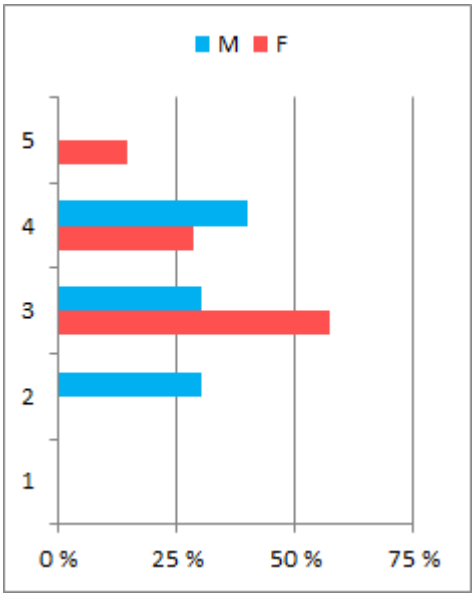
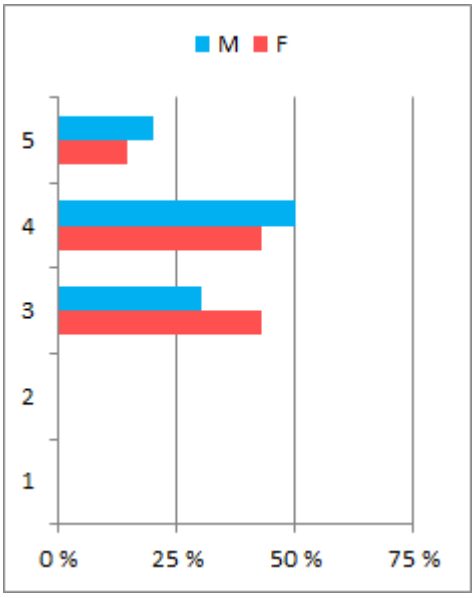
	9. The use of interactive virtual reality visualization tools leads to : More incoherent choices. AVG: 2.88 STD DEV: 1.17
	10. The use of interactive virtual reality visualization tools leads to : Less post purchase product reworking (returns and exchanges). AVG: 3.71 STD DEV: 0.99

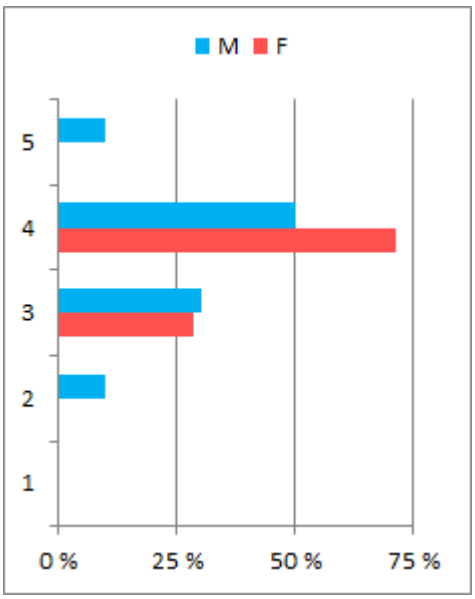
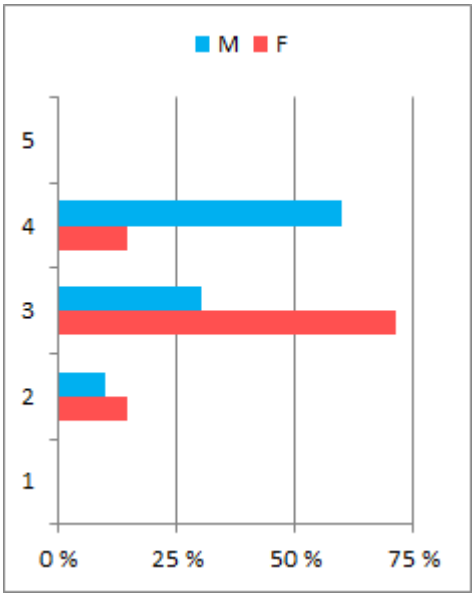
	11. The use of interactive virtual reality visualization tools leads to : Smaller differences between actual and expected product performance. AVG: 3.88 STD DEV: 1.11
	12. Decision makers using visual representations that provide more context than detail or present more alternatives within a given visual field : Consider more alternatives. AVG: 3.65 STD DEV: 0.70

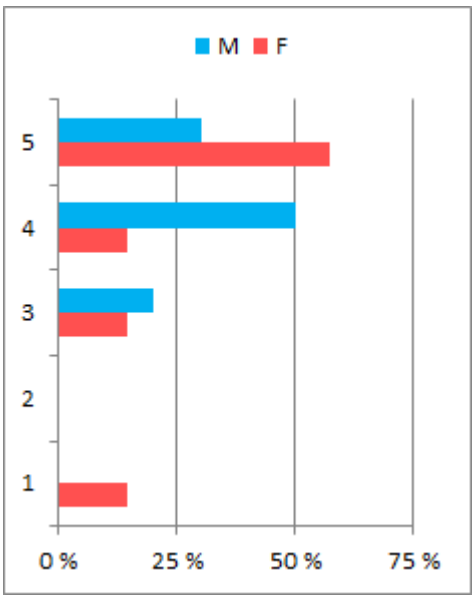
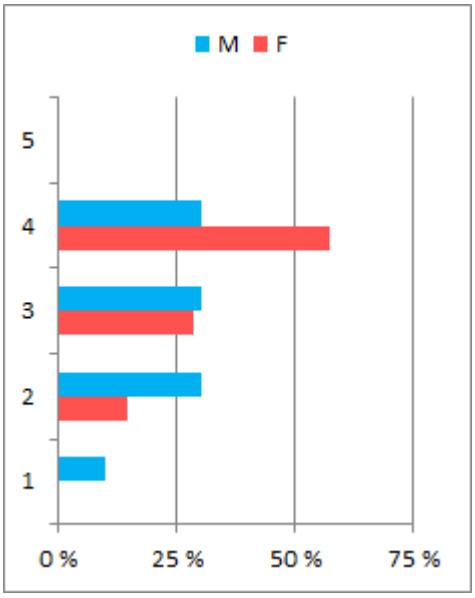
	13. Decision makers using visual representations that provide more context than detail or present more alternatives within a given visual field : Have a better understanding of the range of attribute values. AVG: 3.82 STD DEV: 0.64
	14. Decision makers using graphic versus text-based presentations of the same information : Place greater weight on this information when it is presented graphically. AVG: 4.24 STD DEV: 0.44

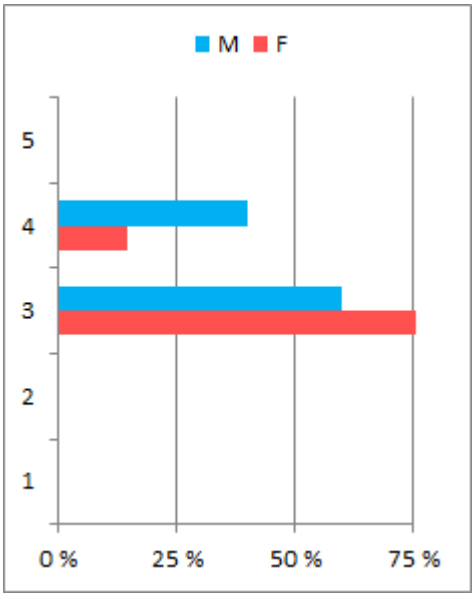
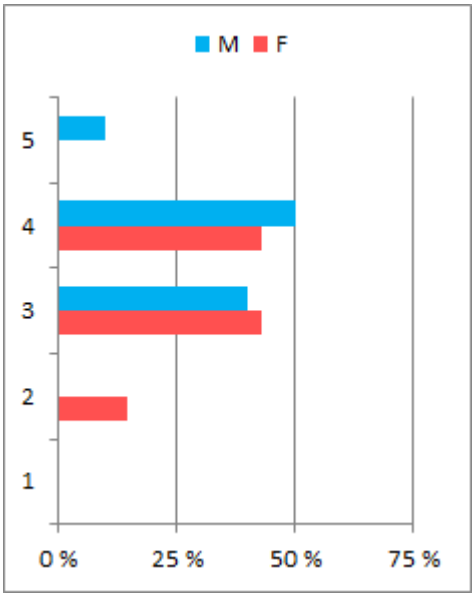
	15. Decision makers using graphic versus text-based presentations of the same information : Are more likely to change their choices in response to changes in attributes. AVG: 3.65 STD DEV: 0.70
	16. Decision makers using graphic versus text-based presentations of the same information : Are more likely to overestimate this information when making judgments. AVG: 3.29 STD DEV: 0.77

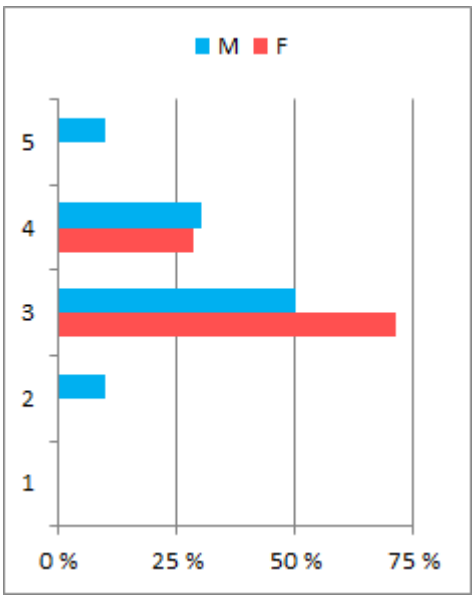
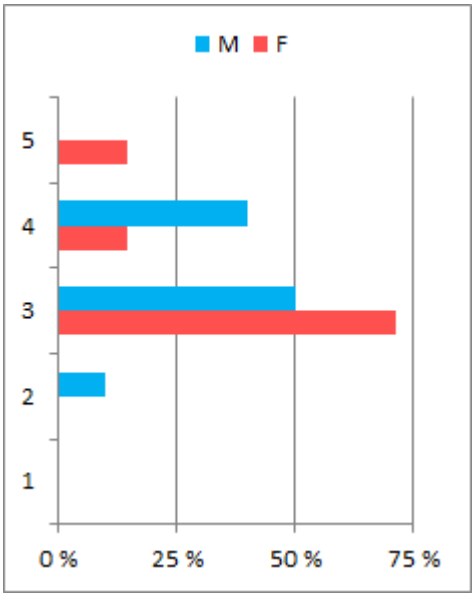
	17. Decision makers using visual representations that include graphic as well as text-based information : Place greater weight on the graphic information. AVG: 3.82 STD DEV: 0.88
	18. Decision makers using visual representations that include graphic as well as text-based information : Are more likely to change their choices in response to changes in attribute values that are shown graphically. AVG: 3.65 STD DEV: 0.70

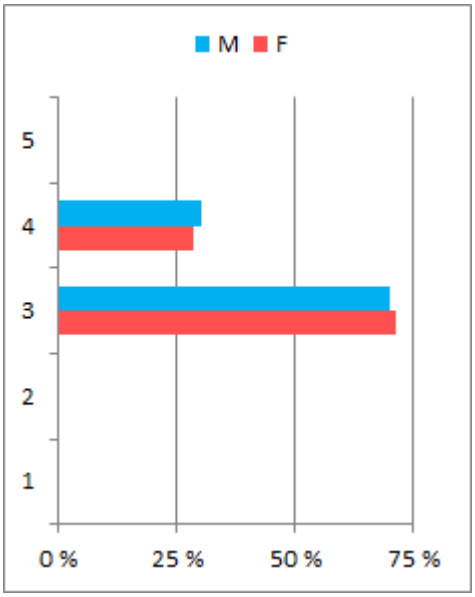
	19. Decision makers using visual representations that include graphic as well as text-based information : Overestimate the graphic information and underestimate the textual information. AVG: 3.29 STD DEV: 0.85
	20. Decision makers using visual representations for which some information shows greater variance in shape, size, or colour : Place greater weight on information that shows more variance. AVG: 3.82 STD DEV: 0.73

	21. Decision makers using visual representations for which some information shows greater variance in shape, size, or colour : Overestimate high variance information and underestimate low variance information. AVG: 3.65 STD DEV: 0.70
	22. Decision makers using visual representations that vary in their presentation of features that are salient in human perception : Overestimate information shown by salient features and underestimate information shown by nonsalient features. AVG: 3.29 STD DEV: 0.69

	23. Decision makers using graphic versus text-based (tabular) presentations of the same information : More quickly identify outliers, trends, and patterns of covariation between variables. AVG: 4.06 STD DEV: 1.09
	24. Decision makers using graphic versus text-based (tabular) presentations of the same information : Make less accurate assessments of differences between values. AVG: 3.06 STD DEV: 0.97

	25. Decision makers using visual representations that allow attributes (versus alternatives) to be more easily compared show greater processing by attributes than by alternatives. AVG: 3.29 STD DEV: 0.47
	26. Decision makers using visual representations that highlight the similarity among alternatives on a given attribute weigh other attributes more heavily in their decision making. AVG: 3.53 STD DEV: 0.72

	27. Decision makers using visual representations that present changes in percentage terms (e.g., pie charts) are more likely to segregate gains and losses (mixed gains) than those using visual representations that make it easier to see absolute changes (e.g., line graphs). AVG: 3.35 STD DEV: 0.70
	28. Decision makers using visual representations that sort information from highest to lowest make higher estimates than those using visual representations that sort information from lowest to highest. AVG: 3.35 STD DEV: 0.70

	29. Decision makers using visual representations that make information easier to compare on an attribute for which one alternative is dominant are more likely to make decisions that are consistent with the attraction effect than those using visual representations that make comparisons on that attribute more difficult. AVG: 3.29 STD DEV: 0.47