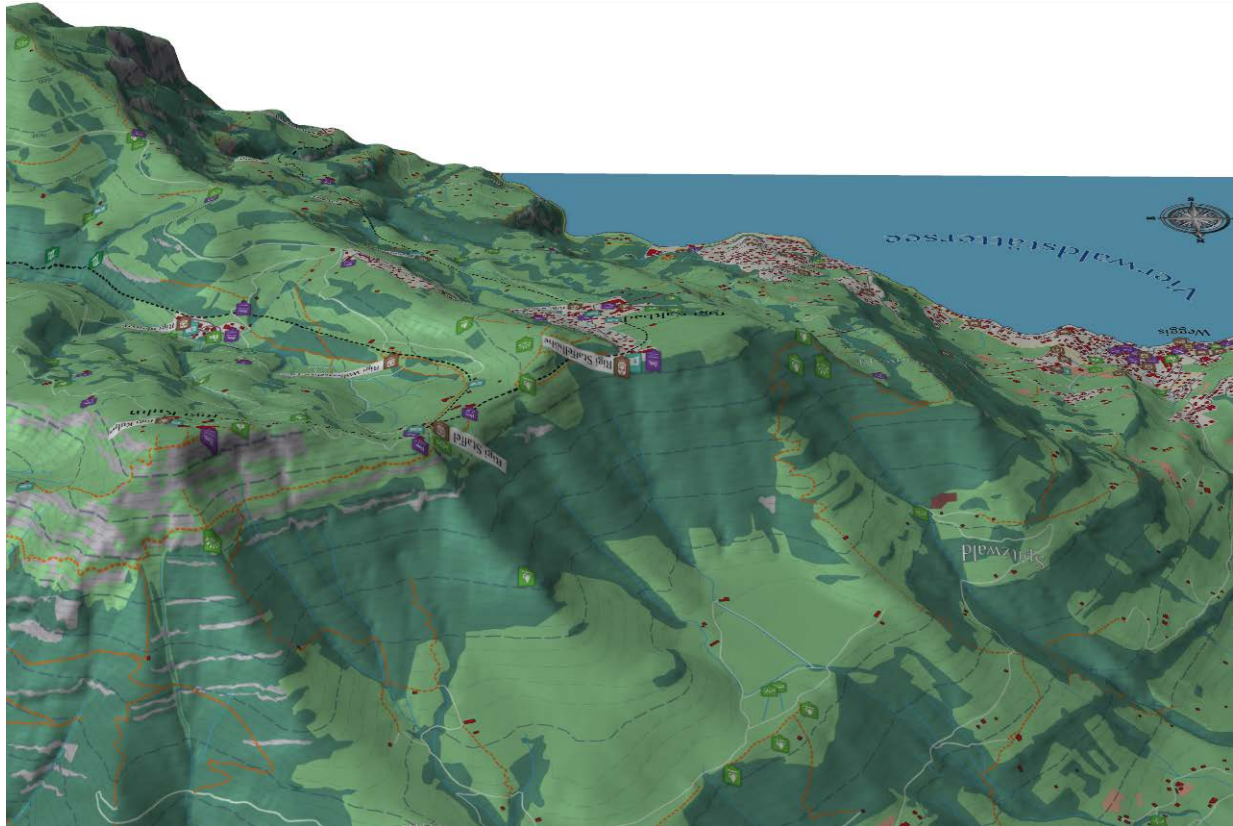


A useful workflow to compare different 2D and 3D visualizations of an alpine region



MASTER PROJECT

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Abstract

This master project deals with the development of a new workflow for the comparative evaluation of two different visualizations, especially of a 2D map and a 3D perspective view of an alpine region. The literature review shows that nowadays the map-designers have no evidence on which method of comparing cartographic visualizations can be easily implemented and give better results. The need of new easy and useful methods to compare different cartographic visualizations is identified.

In the present master project, a new easy-to-handle and useful workflow is proposed. The design of a 2D visualization of an alpine region, the creation of the 3D visualization of the same alpine region and the creation of polls with new formulated questions for an effective comparison between the two different visualizations are implemented. The integration of the new created modules on a website is realized for user testing each one of the two visualizations by test-users. For the conduction of map-user-tests, the created website is consisted of a map-user-test on the 2D visualization, a map-user-test on the 3D visualization and an introduction page offering the possibility to the test-user to select which visualization wants to evaluate first. The map-user-tests are conducted in the sense of a pilot study. The analysis of the map-user-tests' results draw general and important conclusions concerning to the two different visualizations, but also important conclusions are derived about the workflow. Possible improvements or adjustments of the workflow are discussed and suggested for future works or tasks.

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1. Introduction

1.1 Situation and Problem statement

Nowadays, the discipline of cartography is an ongoing progress and the production of cartographic visualizations, either 2D or 3D map visualizations, has significantly been improved. New techniques are used for the map design and new technologies help to make the cartographic practice work better. In addition to that, the way of presenting a map is also a matter of importance. Different presentation techniques are followed for their display, from the traditional paper maps to the interactive maps on screen allowing the interaction with further information.

Although the methods that are used for the production and presentation of maps are abundant, their evaluation is often neglected. During the last years, only a few efforts are made to evaluate map visualizations. Tests containing questions or tasks concerning to the expressiveness and the effectivity of a map, as well as tests to compare different cartographic visualizations have been conducted. However, little research, which will be analysed in the next chapter, presently exists on such tests.

The shortness of tests on cartographic visualizations, conducted by test-(map-)users, has an impact on map designing. While new techniques for designing and presenting cartographic visualizations are developed and used, these ones are not evaluated regarding their implementing and handling. The map-designers have no evidence on which method could be easily implemented and give better results. The need to find simple and useful methods to compare map visualizations is identified and attempts should be made. Accordingly, the current project is an effort to approach this problem.

1.2 Goals

1.2.1 Motivation and Main Goal

The main goal of this master project work is to develop and provide an easy-to-handle and useful workflow for a comparative user evaluation of two different visualizations, especially of a 2D map and a 3D perspective view of an alpine region. The motivation for this master project has been identified due to the shortness of user testing for cartographic visualizations (map-user-tests), either on 2D or 3D visualizations, and the need to find new easy methods to handle them. The workflow should contain a proposed method for designing a 2D visualisation of an alpine region and for creating a 3D perspective view of the same alpine region. Furthermore, a method for creating a poll for the conduction of the map-user-tests and a way for analyzing the given responses from the test-users should be presented in this workflow. The interpretation and discussion of the results of the single processes will bring into light advantages and also limitations when following the proposed workflow as well as recommendations to map-designers on specific process steps.

1.2.2 Sub-goals

In order to achieve the main goal of the master project work, sub-goals, closely related to single process steps of the workflow, are defined for a better approach to the problem. The first sub-goal is to design the 2D visualization of a selected alpine region. The second sub-goal is the creation of a 3D visualization of the same alpine region. For the implementation of the 3D visualization, the 2D visualization is used as texture which should be nicely adjusted on the block diagram¹ of this specific region.

The third sub-goal is the comparison between the derived 2D and 3D visualizations of the same depicted area of an alpine region. The two visualizations are presented on a website enriched with a poll with questions and tasks. The processes of gathering, evaluation and interpretation of the answers will give conclusions concerning to which map type is more accurate and which one test-users prefer for the implementation of the specific questions and tasks of the poll.

The fourth and last sub-goal is the procedure and evaluation of the pilot study. The pilot study constitutes the conduction of some map-user-tests which should be implemented for the evaluation of

¹ block diagram: is the display of a landscape block.

the functionality and effectiveness of the created poll, but also for the evaluation of the whole designed workflow.

1.3 Limitations

The attempt of implementing a simple workflow may produce useful inference, but also there are some limitations which cannot be overcome. The fact that this workflow should be easy-to-handle leads to a possibility of deriving only general conclusions. Because the single process steps of the proposed workflow should be simple too, important inferences may not be provided respecting these steps, but only some conclusions that may have been already known.

Furthermore, the workflow is a row of recommended steps to map-designers. It is possible that specific process step(s) may not be considered simple by the map-designers and only a part of the workflow could be easily implemented by them. For instance, the map-designers may only be experts on designing the maps and have no knowledge or experience on creating websites and polls for creating map-user-tests.

What is more, it is important to say that the selected region is an alpine region, a suitable landscape to create a 3D visualization with unambiguous three-dimensionality. The selection of the area to create a 3D visualization should be done carefully. The 3D perspective view of a flat area may be similar to its 2D visualization, therefore the comparison between 2D and 3D visualizations may be fruitless for the specific flat area.

Additionally, the optimal comparative evaluation between the two visualizations would be implemented with their parallel presentation on a website for screen display. However, this option could not be realized because of the lack of space. The available space for the presentation of the visualizations is a computer screen, where additionally a poll should be presented. This limitation leads to the solution of evaluating each of the visualizations separately and, after this, the comparison of the answers of the two evaluations for a final comparative evaluation between the two different visualizations.

1.4 Description of the content

The presented master project work is structured in 6 chapters, including the introduction.

In **Chapter 1**, the introduction, contains the situation and the problem overview and describes the main goal, the sub-goals as well as the limitations of following the proposed workflow. Finally, the structure of this master project work is listed.

In **Chapter 2**, the state-of-the-art of user testing and user questioning is described, as well as a review of related works. Further on, an evaluation of the former map-user-tests is carried out.

Chapter 3 presents the proposed new schematic workflow and the structure of the planned process steps is explained. Additionally, the used data and infrastructure are presented.

Chapter 4 describes the actual process steps of the workflow which were followed for the achievement of the goals. In the subchapters of Chapter 4, the design of the 2D visualization, the creation of the 3D visualization, the formulation of the questionnaire for the map-user-tests, the designing of the website for the accomplishment of the map-user-tests and the procedure of the map-user-tests are analysed.

In **Chapter 5**, the analysis of the results of the map-user-tests is implemented and conclusions concerning to the comparison of the two visualizations are drawn.

In **Chapter 6**, a final evaluation of the workflow is carried out and conclusions are derived. Possible future tasks and works are discussed.

2. Literature review

First, an analysis is conducted based on existing literature and previous works in the subject of map-user-tests to assess the present situation in the area of user testing and user questioning on cartographic visualizations.

2.1 State-of-the-art of user testing and user questioning

2.1.1 User testing

User testing offers benefits to the product designers or service providers. First of all, the user testing gives confidence, by verifying that real users can use it successfully, or identifying what prevents them from doing so. It helps designers to understand users and see things from their perspective, so that they are more likely to design something that works for users first time. Furthermore, the expense of user testing is generally far less than the cost of getting it wrong. Even if a product or the service seems to be completed, or is theoretically implemented, if it is not tested with real, there is a risk that it may not be ready in practice. [UniversalDesign_UserTesting, 2014]

The actual testing is just one part of the methodical procedure of a user test that involves the following stages:

- Planning the test
- Recruiting users
- Running and observing user sessions
- Collecting data
- Analysing the observations and data
- Reporting issues and recommendations [UniversalDesign_UserTesting, 2014]

The stage of the data collection is the important aspect which defines the whole planning of the user-test. The data collection techniques that can be used are:

- Document analysis
- Surveys (participant questionnaires, surveys, and checklists)
- Interviews (documented questions and answers with participants)
- Observations
- Focus groups (documented questions and answers with multiple participants interviewed as a group)
- Case studies (in-depth interviews) [Toolkit_DataCollectionMethods, 2014]

But whichever method is selected for the data gathering, it should be done carefully, because inaccurate data collection can impact the results of a user-test and ultimately lead to invalid results.

Another important aspect for the creation of a user test is its type of evaluation. The evaluation can be characterised as being either formative or summative. There are also other various types of evaluation but these are the two main philosophical approaches. Formative evaluation is an ongoing process that allows for feedback to be implemented during the product's design. However, summative evaluation occurs after the product implementation and provides an overall description of product's (or service's) effectiveness. [Cyfernetsearch_Evaluation, 2014]

2.1.2 User questioning

The questionnaire is the tool of user questioning. Normally, it is consisted of a series of questions for the purpose of collecting answers from respondents. Questionnaire is a type of survey that has advantages comparing to the other types in that they are cheap and often have standardized answers that make it simple to analyze the answers. Questionnaires do not require much effort from the responder as verbal or telephone surveys. However, such standardized answers may frustrate users. Questionnaires are also sharply limited by the fact that respondents must be able to read the questions and respond to them. Thus, for some demographic groups conducting a survey by questionnaire may not be practical. [Wikipedia_Questionnaire, 2014]

There are two types of questionnaires; questionnaires with questions that measure separate variables and questionnaires with questions that are aggregated into either a scale or index. Questionnaires with questions that measure separate variables, could for instance include questions on preferences (e.g. political party), behaviors (e.g. food consumption) either on facts (e.g. gender). Questionnaires with questions that are aggregated into either a scale or index, include for instance questions that measure latent traits (e.g. personality traits such as extroversion), attitudes (e.g. towards immigration) or an index (e.g. Social Economic Status). [Wikipedia_Questionnaire, 2014]

Main modes of questionnaire administration are: 1. Face-to-face questionnaire administration, where an interviewer presents the items orally, 2. Paper-and-pencil questionnaire administration, where the items are presented on paper, 3. Computerized questionnaire administration, where the items are presented on the computer, 4. Adaptive computerized questionnaire administration, where a selection of items is presented on the computer, and based on the answers on those items, the computer selects following items optimized for the tester's estimated ability or trait. [Wikipedia_Questionnaire, 2014]

A new and inevitably growing method of user questioning is the use of Internet based questionnaire. This would mean receiving an e-mail on which you would click on an address that would take you to a secure web-site to fill in a questionnaire. This type of research is often quicker and less detailed. Some disadvantages of this method include the exclusion of people who do not have a computer or are unable to access a computer. Also the validity of such surveys is under question as people might be in a hurry to complete it and so might not give accurate responses. [SurveyDesign_Questionnaire, 2014]

2.2 Overview of former map-user-tests

Map-user-test is the user-test measuring the extent to which a cartographic visualization fulfils the claims made by the map-designer. Through the conduction of this kind of user-test, aspects, that produce difficulties, confusions or misunderstandings to map-users when reading the provided map, are identified. The feedback information that is gathered from the completed map-user-tests enables the map-designers to improve specific characteristics in the next design iteration, so that it better fits map-users' requirements and preferences. [UniversalDesign_UserTesting, 2014]

Until now, different kinds of map-user-tests have been conducted for the evaluation of cartographic visualizations. Different data collection techniques were used. Questionnaires, interviews and observing are the techniques that are mainly used for the evaluation of cartographic visualizations. Among them, questionnaire is the most preferred technique and it is met also in the mode of an internet based questionnaire, which is quicker and the participation of more respondents is possible. However, the creation of an internet based questionnaire requires some knowledge on creating web pages. The questionnaires are proved to be less time consuming in comparison to the conduction of interviews. Although the internet based questionnaires are easier to handle and quicker for the participants to answer, the responses might be inaccurate because the responders may be in hurry to complete the map-user-test.

Additionally, another aspect is the selection of the participants, the test-users, of the map-user-test. It is observed that in specific map-user-tests the selection of the test-users is limited to expert users or students in the field of cartography or a related field. Taking into consideration that nowadays the majority of the people know and use maps in their everyday lives, this makes them capable to evaluate cartographic visualizations and probably their responses provide insight into real users' preferences.

The norm environment for the conduction of former map-user-tests is the indoor settings, but the approach of carrying out map-user-tests outdoors was also realized. The concept of putting test-users to

evaluate cartographic visualizations while being at the depicted area is pioneering. However, such a map-user-test is time-consuming and difficult to be achieved.

Last but not least, combination of techniques has also been observed for the evaluation of cartographic visualizations. Such an approach could give more accurate results. For instance, the implementation of a questionnaire supported by interviewing could not leave any gap for inaccurate responses. On the other hand, the combination of techniques is more difficult to be realized and more time consuming than a single technique.

2.3 Evaluation of former map-user-tests

In order to propose and develop a new workflow for a comparative evaluation of two different cartographic visualizations, previous relevant works were analyzed and compared. The majority of the existing map-user-tests (user testing on maps), that were examined, were created for the evaluation of the effectiveness of 3D visualizations. Moreover, there are map-user-tests evaluating 2D and 3D evaluations separately, but also comparing the effectiveness of the two visualizations. The characteristics of the past map-user-tests are examined and may be considered useful for the design of a new easy-to-handle workflow.

The main aim in the work “Topographische 3D-Karten” of Christian Häberling was the derivation of cartographic design principles for 3D visualizations by evaluating settings and options for specific graphic variables. Based on an inventory of design aspects and graphic variables for 3D visualizations, selected cues for two major design aspects (degree of abstraction and size of map objects) and five different graphic variables (viewing inclination, zoom factor, light direction, haze density, and sky structure) on 3D visualizations were evaluated through interviews to experts [Häberling, 2005]. Although the sample was not big, but it was only consisted of experts, i.e. 27 interviewees, the procedure of the map-user-tests was very time consuming. Each interview lasted approximately two to three hours and was conducted in controlled indoor settings. During the conduction of an interview, the responses of the interviewees, their rankings and comments were recorded in writing by the interviewer. From the careful interpretation of the answers, 19 cartographic design principles for 3D visualizations were derived and proposed as the beginning of a framework to extend cartographic theory and assist map-designers in the iterative design process. Therefore, the informative value of this effort is high, but the conduction of such map-user-test cannot be considered easy-to-handle. It needs a lot of time and effort, the interviews should be carried out very carefully and the participants should be only experts. [Häberling, 2003]

Another effort on user testing to evaluate 3D visualizations was done through internet questionnaires in the work “Analysis of user’s response on 3D cartographic presentations” of Petrovič and Mašera. The example 3D visualizations used for the conduction of these map-user-tests were: a topographic map draped over a DTM², an orthophoto image draped on a DTM and a 3D symbolic presentation. The sample of the test-users was selected with the criterion that they often use maps and they are not necessarily experts in cartography. The sample was mainly constituted by surveyors, spatial planners, mountaineers, scouts and orienteering runners. The test-users were asked by mail to complete a questionnaire for evaluating the available 3D visualizations. An introduction was available for basic explanation of DTM and a 2D topographic map of the same depicted area at a scale 1:50’000 was presented for easier comparison of different map use task between the 2D and 3D visualizations. In twenty days 420 visits of the web-page were recorded, but only 119 test-users completed the questionnaire. The average time for completing the questionnaire was 6 minutes. The answers were automatically written in txt file and the analysis was done automatically too. The methodology followed in this effort could be characterized as an easy way to gather results. The consumed time of the responders was trivial and the researchers spent time mainly for the interpretation of the results. [Petrovič and Mašera, 2007]

It is worthwhile to mention the map user study of Schobesberger and Patterson that was conducted at Zion National Park, United States. This map user study was conducted for evaluating and comparing the communication efficiency between 2D and 3D trailhead maps. Aspects such as which kind of map is more attractive were examined and the park visitors were motivated to go hiking. The study was

² DTM (Digital Terrain Model): is a digital model or 3D representation of a terrain's surface created from terrain elevation data [Wikipedia_DTM, 2014].

conducted outdoors, at the Zion National Park. The methods that were used during this study were two: trailhead monitoring and implementation of a questionnaire. The behaviour and interaction of the park visitors with the map (2D or 3D map at trailhead exhibit on alternating days) was monitored and the time of the map reading of each participant was counted. The study period was from 4th to 21st September 2006 and the number of the study population that completed the questionnaire was 185. The results concerning the map preference, cartographic communication, positioning accuracy and map attraction of both map types were interesting. The conclusions of this map user study were significant. However, the preparation and conduction of this study were time consuming and the recruitment of study population was not a trivial matter. The study population was consisted of experts and also park visitors. [Schobesberger and Patterson, 2007]

Another effort evaluating 3D visualizations, specifically panoramic maps, also in comparison with 2D topographic maps was made by Spengler and Räber (2012). The method used for this map-user-test was the creation of a questionnaire. The test-users were asked by email to participate to the map-user-test. The study population was consisted of experts and non-experts. The gathered completed questionnaires were 100. Conclusions how panoramic maps are perceived and interpreted by various test-users, also in comparison with 2D topographic maps, were derived. This map-user-test used an easy methodology and was not time consuming. [Spengler and Räber, 2012]

3. Design of a new proposed workflow

3.1 Design process of the new proposed workflow

The analysis, based on the existing literature and previous works in the area of map user testing, lead to some inference on the characteristics of the past map-user-tests to be considered for the suggestion of a new workflow.

3.1.1 The new schematic workflow

The new designed workflow consists of four different phases. Each phase consists of successive process steps that should be followed for the achievement of the initial set goal. The structure of the schematic proposed workflow by process steps is depicted in the figure 1.

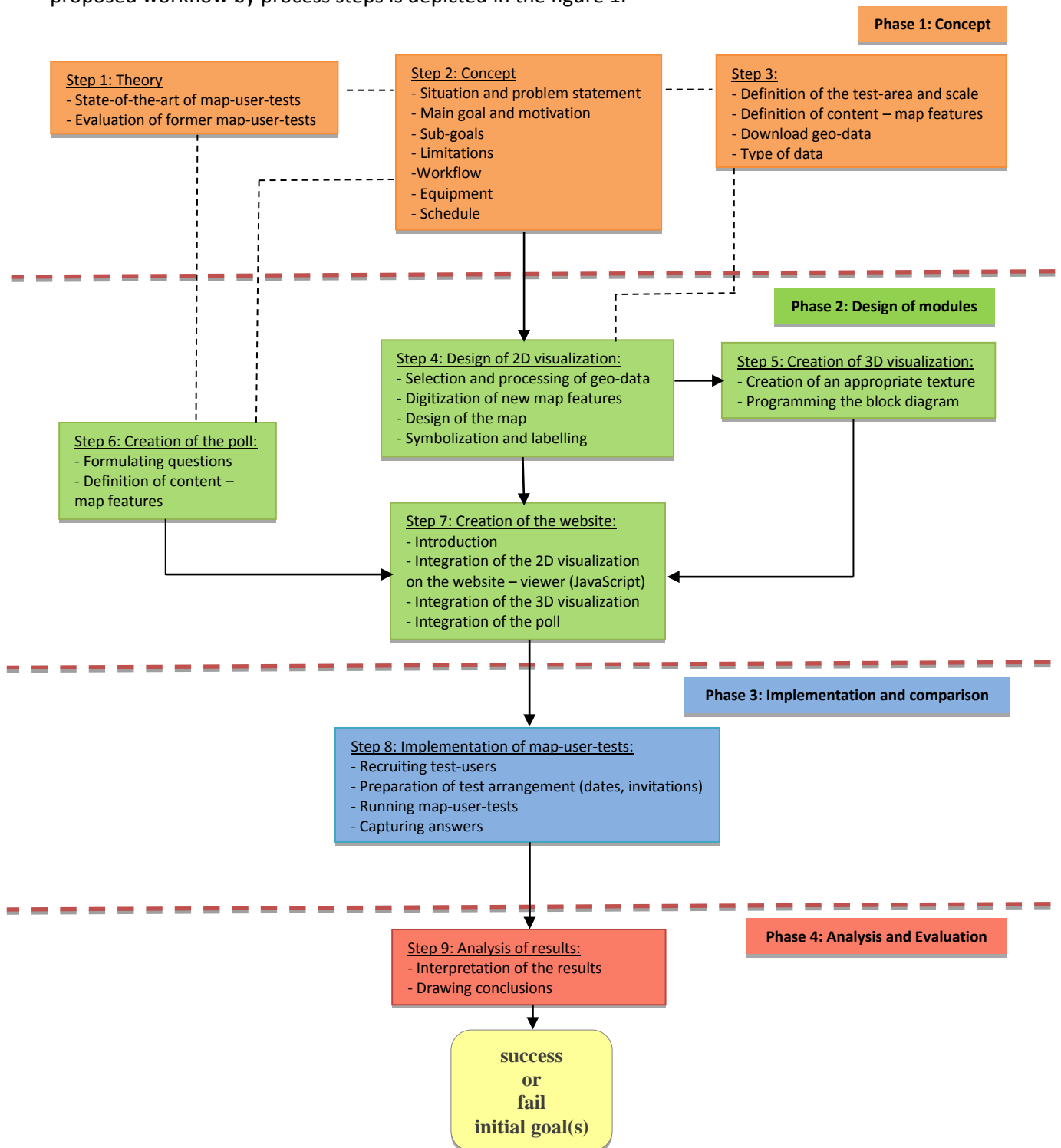


Figure 1: The new proposed schematic workflow

3.1.2 Overview of the process steps of the workflow

The main process steps of the design and implementation of the intended workflow are:

PHASE 1: CONCEPT

The phase 1 is the theoretical background of the whole project. It does not contain any actual step for the progress of the workflow, but it is the most basic and preparatory step for the completion of the project.

Step 1: Theory

On this step, the very initial theory is considered. The state-of-the-art of user testing and user-questioning is analysed. The definition of the map-user-tests is examined and former map-user-tests are presented and evaluated.

Step 2: Concept

On this step, aspects, such as the present situation, the problem, the motivation, the main goal and the sub-goals, the limitations, the design of the workflow, the equipment that may be needed and the organization of the schedule of the master project work are considered and defined.

Step 3: Collecting data

The test-area and the scale are defined for the design of the 2D visualization. The map-content is considered and some map-features are defined. The type of geo-data (vector or raster) that are going to be used for the design of the 2D visualization is discussed and the first geo-data are downloaded from the platform GeoVITe³. Also, the need of a DHM⁴ matrix with the terrain elevations is considered that will be used for the creation of the 3D visualization.

PHASE 2: DESIGN OF MODULES

The phase 2 is the practical part of the project. It contains the design of the different three modules, the 2D visualization, the 3D visualization and the poll, and the creation of the fourth module, the website, where the three first modules are integrated.

Step 4: Design of 2D visualization

On this step, the 2D visualization (map, in the classical sense) of the defined test-area is designed. The geo-data that will be used for the new 2D visualization are selected and their processing begins. If the downloaded data do not satisfy the map-content's needs, new map features are digitized. Corrections and adjustments of the 2D visualization are implemented where it is needed. The symbolization of the map features and the labelling follows. The 2D visualization is exported at a raster format.

Step 5: Creation of 3D visualization

For the creation of the 3D visualization, an appropriate texture, the 2D visualization with high resolution, is created to be adjusted on the supplied block-diagram from the Institute of Cartography. Possible further programming block-diagram will be implemented.

Step 6: Creation of the poll

The selected method for collecting data, after the state-of-the-art of user testing, is the questionnaire. The questionnaire should probe the major differences between two different visualizations, especially a 2D and a 3D visualization, from the test-user's point of view. A poll will be created for the integration of the questions.

³ GeoVITe: ETH Geodata Portal (beta): is a platform that offers an easy-to-use online access to the most important Swisstopo geodatasets. This service is provided by the Institute of Cartography and Geoinformation in cooperation with the ETH Library. [GeoVITe, 2014]

⁴ DHM (Digital Height Model): is a set of data representing the 3D form of the earth's surface without vegetation and buildings. [swisstopo_DHM25, 2014]

Step 7: Creation of the website

On this step, a website is designed for the integration of the 2D visualization, the 3D visualization and the poll. An introduction page or an introduction paragraph is considered that should be also designed.

PHASE 3: IMPLEMENTATION AND COMPARISON

On the phase 3, the map-user-tests are conducted for the collection of the test-users' answers.

Step 8: Implementation of the map-user-tests

On this step, the recruiting of test-users and the preparation of the test-arrangements (invitations, dates etc.) take place. The map-user-tests are carried out by the recruited test-users and their responses are collected.

PHASE 4: ANALYSIS AND EVALUATION

On the phase 4, responses of the test-users are analysed and conclusions are derived.

Step 5: Analysis of the results

The results are interpreted and the conclusions are derived. Conclusions concerning to the success or failure of the initial goals are drawn. Possibly, a new workflow is designed and proposed.

3.2 Data

For the design of the 2D visualization, geo-data, in vector and raster format that belong to swisstopo, were downloaded from the GeoVITe platform. Furthermore, the DHM, which is required to build the block diagram, belongs also to swisstopo and was recovered through GeoVITe. A block diagram of the Swiss World Atlas interactive was supplied from the Institute of Cartography, ETH Zurich, for the creation of the 3D visualization. These data will be used exclusively for the purpose of this master project. Also, Google Drive⁵ Forms were used for the conduction of the map-user-tests.

3.3 Infrastructure

The master project work and the report have been realized on the computers in the StudiLab of the Institute of Cartography and Geoinformation, ETH Zürich, and on my personal computer.

On the step of designing the 2D visualization, the processing of the geo-data was done with the software ArcGIS Desktop 10.1 and Quantum GIS (QGIS) 1.8.0. After these, the Adobe Illustrator CS5 and Adobe Photoshop CS5 were used. On the step of creating the 3D visualization and the webpage, the Notepad++ was used. Last but not least, the report was written with Microsoft Word 2010.

⁵ Google Drive: a file storage and synchronization service provided by Google, released on April 24, 2012, which enables user cloud storage, file sharing and collaborative editing. Files shared publicly on Google Drive can be searched with web search engines. Google Drive is the home of Google Docs, an office suite of productivity applications that offer collaborative editing on documents, spreadsheets, presentations, and more. [Wikipedia_Google_Drive, 2014]

4. Implementation of the workflow

The main axis to follow in this master project work is the proposed workflow as it is presented in the previous chapter. Although the workflow suggests the steps for completion of the project, in practice some specific single steps may be different. Therefore, in this chapter, the actual steps that are realized during this master project work are analysed.

4.1 Design of the 2D visualization

On this step, the 2D visualization (i.e. map in the classical sense) of a selected area is designed. The goal of this step is that the final product, i.e. the 2D visualization, allows a good recognition of the real landscape and also allows a satisfying map interpretation by the test-users.

4.1.1 Definition of the test area

The selection of the test-area is a crucial subject in this master project work. The test-area should be a suitable one also for the creation of the 3D visualization, therefore the three-dimensionality of the selected area should be unambiguous (Figure 2).



*Figure 2: Summer 3D visualization of Rigi, Switzerland
[Mappuls, 2014]*

For this purpose, an alpine region, Rigi in Switzerland, was considered to be defined as the test-area of the two visualizations. Rigi is a massif in central Switzerland, and it is also known as the “Queen of the mountains” (Figure 2). The highest peak 1’797.5 meters is the Rigi Kulm, easily accessible by public transport, such as cable cars, railway and bus transportation. The presence of the height difference between the Rigi Kulm and the lake level (height of 434 meters) is optimal for the 3D visualization.

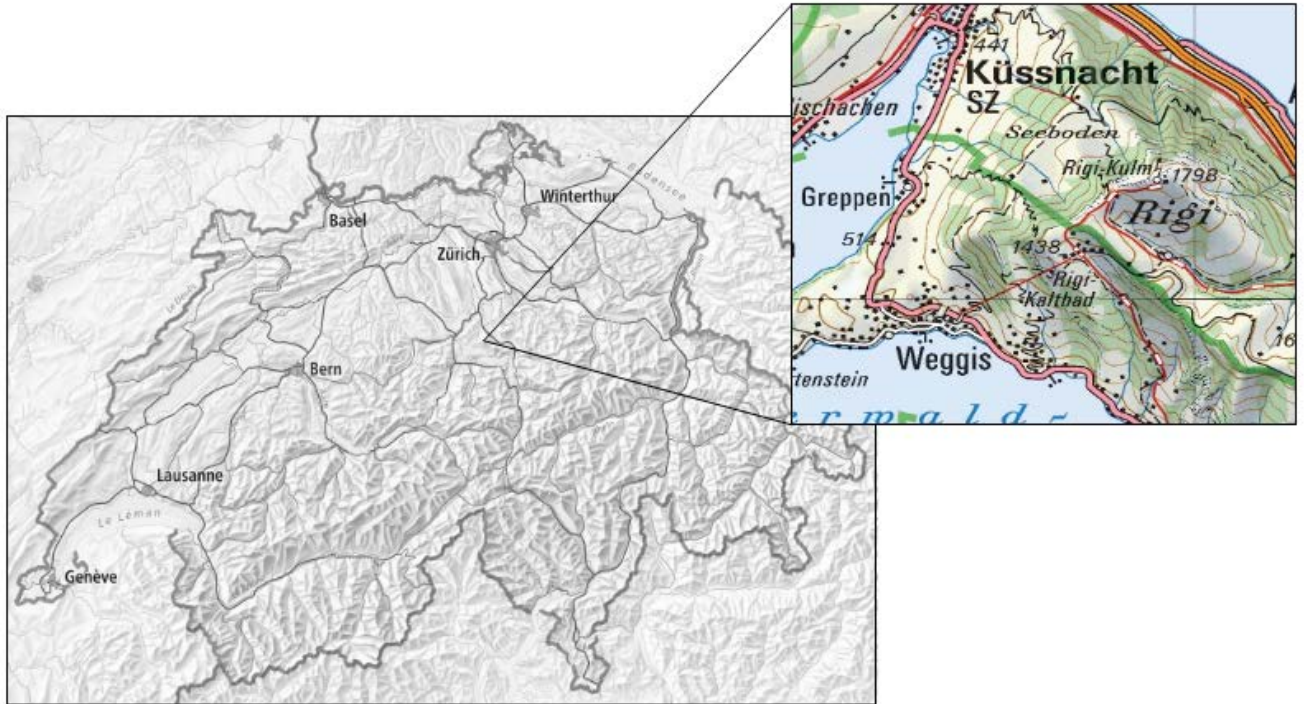


Figure 3: Location of Rigi in Switzerland

[Geo.admin.ch, 2014]

The existence of buildings, water bodies (rivers and lakes) and transportation network (roads, trails, paths, railway, bus lines, cable cars) give the potential for the creation of an attractive map of Rigi. Furthermore, it offers many activities such as skiing or sledging in the winter, and hiking in the summer, which makes Rigi an advantageous region to be depicted on a map.

The map extent of the selected area is given by the coordinates W-E 675'000m to 681'000m and S-N 208'000m to 214'000m, and the area is equal to $6\text{km} \times 6\text{km} = 36\text{ km}^2$.

4.1.2 Definition of the map-content

The visualizations were decided to be summer-time hiking-tourist maps with main element the hiking paths. Therefore, the map will be drawn in spring-summer colours (greenish-coloured landscapes). The purpose of the creation of the visualizations is the hikers' navigation and to get to know what facilities there are.

Additionally, other map features, which would be useful information for hikers or tourists, were thought to be added. Hotels, restaurants and tourist highlights were some of the map features that should be depicted on a hiker-tourist map. The public transportation, road networks, access points (railway stations, bus stops, cable-cars), ticket offices and boat connections were considered to be important information for hikers and tourists. But the final selection of the map-content was also dependent on the availability of the geo-data for the specific test-area.

4.1.3 Data collection and preparation

Initially, a research of the available geo-data for the specific map-extent of the test-area was carried out at the platform of GeoVITE (Figure 4). The login to GeoVITE platform was possible with the n.ethz-ID.

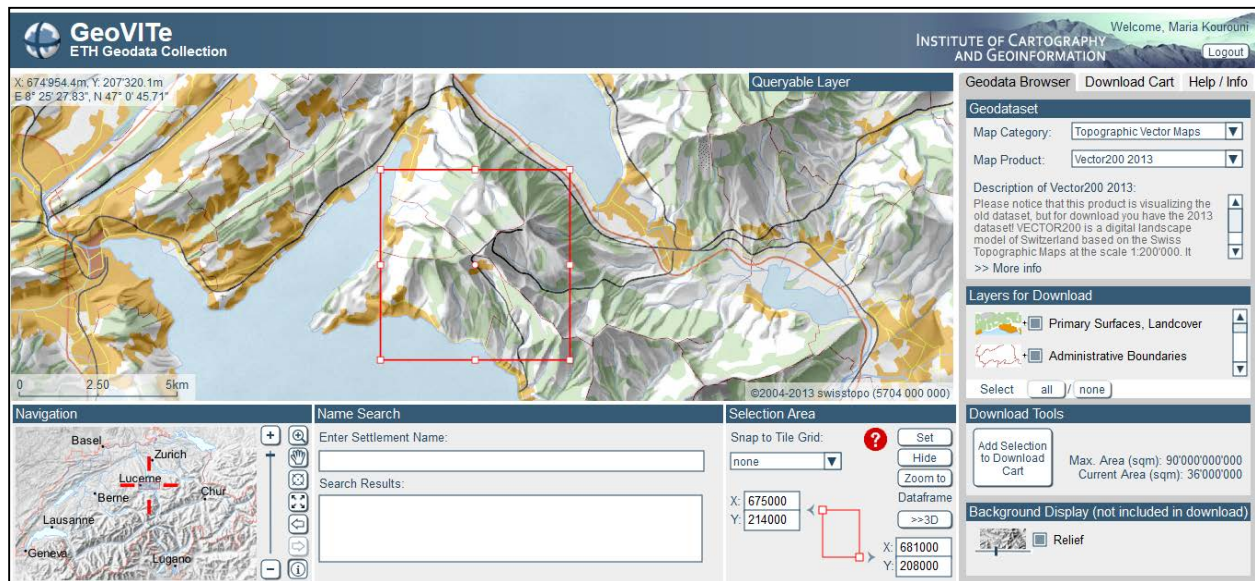


Figure 4: ETH's geodata portal GeoVITE

[GeoVITE, 2014]

Almost all the available geo-data, related to a hiking map, were downloaded. The vector geo-data were preferred to be downloaded in Vector25 format for a map of scale 1:50'000. The ordered vector data from GeoVITE should have as coordinate reference system (CRS) the CH1903 / LV03 (EPSG: 21781). Some of the vector geo-data that were selected from the platform GeoVITE were: buildings, hydrological network, railway network, road network, station areas, station points, administrative boundaries and points of interest. Additionally, some geo-data in raster format (raster 25 and raster50) were selected to download, such as relief, contour, lakes, rivers, national parks, situation and DHM (base and matrix model). However, from the downloaded geo-data, after their visualization and pre-processing in ArcMap ArcGIS 10.1, the vector ones were mostly preferred. From the raster ones, the contour and relief were initially selected to be used for the creation of the map.

Another subject to be thought was the selection of the base-map of the 2D visualization. In the beginning, the selection of a satellite image was considered as the optimal solution, because it would allow a better recognition of the real landscape. However, the storage capacity of a satellite image with good resolution was high, which would delay later the loading of the 2D visualization when it will be integrated on a website. Therefore, a land-cover was selected to be used as base-map for the 2D visualization.

Also, the road network was adapted and separated in categories for a better presentation of the transportation in ArcMap. The extracted classes were five: the principal highway, the secondary highway, the local roads, the urban roads and the hiking paths.

Still the downloaded data were not enough. Further additional information for the map was found in the sites google.maps.com, openstreetmap.org, map.search.ch and geo.lu.ch. Some hotels, some restaurants, snack points, panoramic viewpoints, fireplaces and some churches were digitized manually in ArcMap. As well, the coast line was digitized for a more obvious distinction between land and lakes.

Moreover, it was decided to create a new contour so that it would have height lines every 20 meters and be adjusted according to the map-designer's preferences. The available contours downloaded from the GeoVITE were not considered as the optimal ones. The function "Contour" from 3D Analyst menu in

ArcMap was used for the extraction of the contour with height lines every 20 meters from a raster format DHM25⁶.

The design of the visualization was decided to be pseudo-natural, so the further processing of the map was going to be continued in Illustrator. The Quantum GIS (QGIS) was used to export the map to Adobe Illustrator. There is no “Export to Illustrator” function in QGIS, but the map was exported as Scalable Vector Graphics (SVG) file instead, which is a XML-based file format for vector graphics so that it can be opened with Adobe Illustrator. The scale of the map was adjusted in the “item properties” on the right side of the “print composer” window, so that the map fills the map window.

4.1.4 Design of the 2D visualization

The design of the 2D visualization is carried out in the software Adobe Illustrator CS5. On this step, the cartographic design and symbolization principles has to be applied to the GIS data. The colours are decided to be in spring-summer and greenish colours so that the colours of the map represent a summer edition of the Rigi area.

The 2D visualization was adapted in accordance with the map requirements. The symbology (colours, stroke weight etc.) of all objects and layers was adjusted and the objects were arranged in reasonable layer structures. Moreover, the minimum gaps and the essential generalization were checked.

The Adobe Illustrator plugins were useful during the design of the 2D visualization. These plugins were used to correct, generalize, harmonize and symbolize the cartographic data set. Namely, some plugins that were used are: Connect Path, Line to Bezier, Close Path Objects, Adaption to One Path, Point Elimination, and Rectify Closed Path. (Figures 5, 6, 7) [Photoshop, 2014]



Figure 5: Line to Bezier: plugin to create Bezier curves of the local roads

⁶ DHM25 (Digital height model) Base Model –Vector: is a set of data representing the 3D form of the earth's surface without vegetation and buildings. It is essentially based on the Swiss National Map 1:25 000. This product is useful for terrain analysis or hydrological models. [swisstopo_DHM25, 2014]

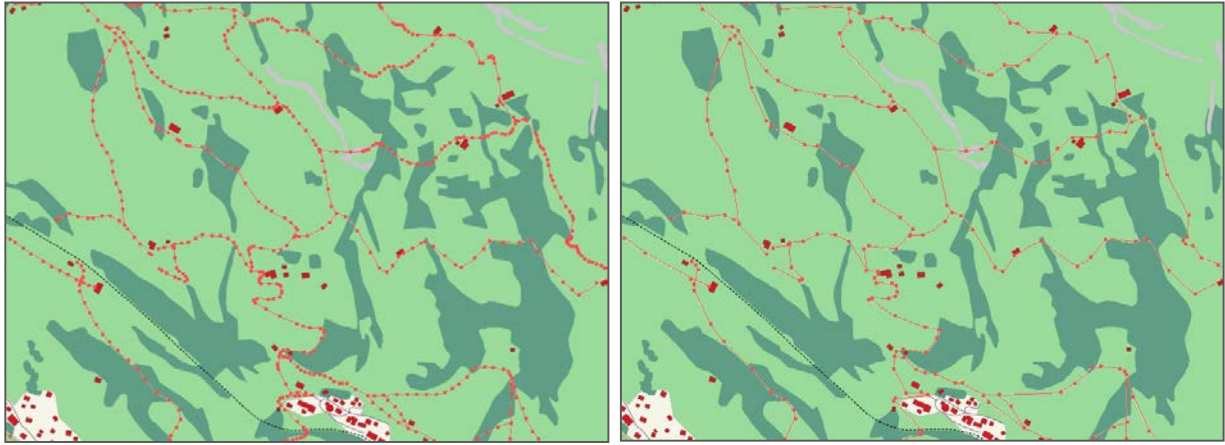


Figure 6: Point Elimination: the amount of vertices and anchor points is reduced by using this plugin

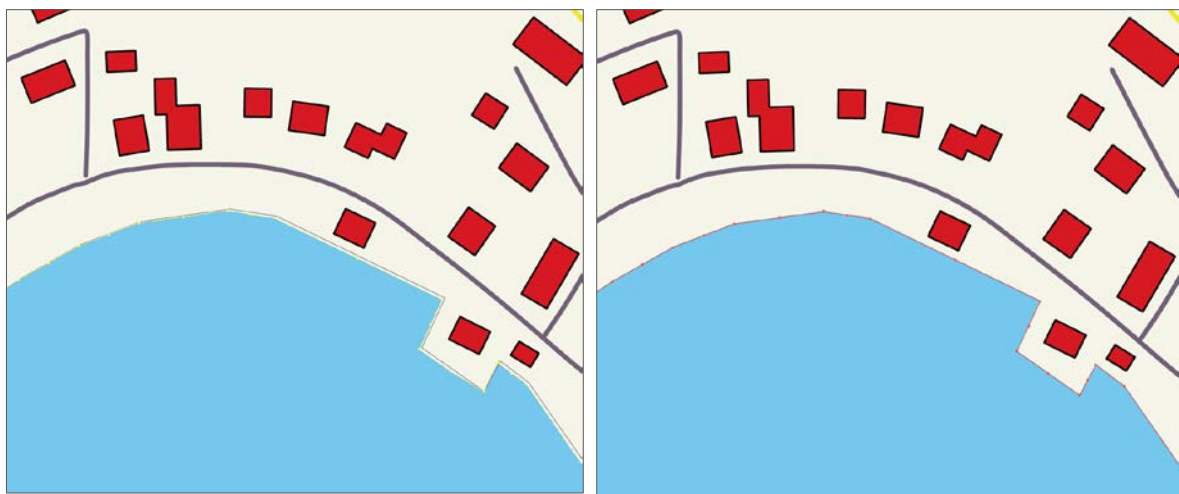


Figure 7: Adaption to One Path: if some path objects do not share the same border, this plugin helps to adapt one object to a selected reference object

Before exporting the map in jpeg format, the symbolization of the map features was implemented. Colorful map icons were selected to support the summer edition of the pseudo-natural map.



Figure 8: Map icons - Nicolas Mollet
[Nicolas_Mollet, 2014]

Furthermore, the symbolization of the road transportation was also important to be in the legend. Therefore, small icons, depicting the different categories of road transportation, were created in Adobe Illustrator.



Figure 8: Map icons representing the road transportation

In the end, the 2D visualization was exported in jpeg format. A prerequisite was that the 2D visualization should have good resolution because it would be on a website and zooming option would be possible. (Figure 9)

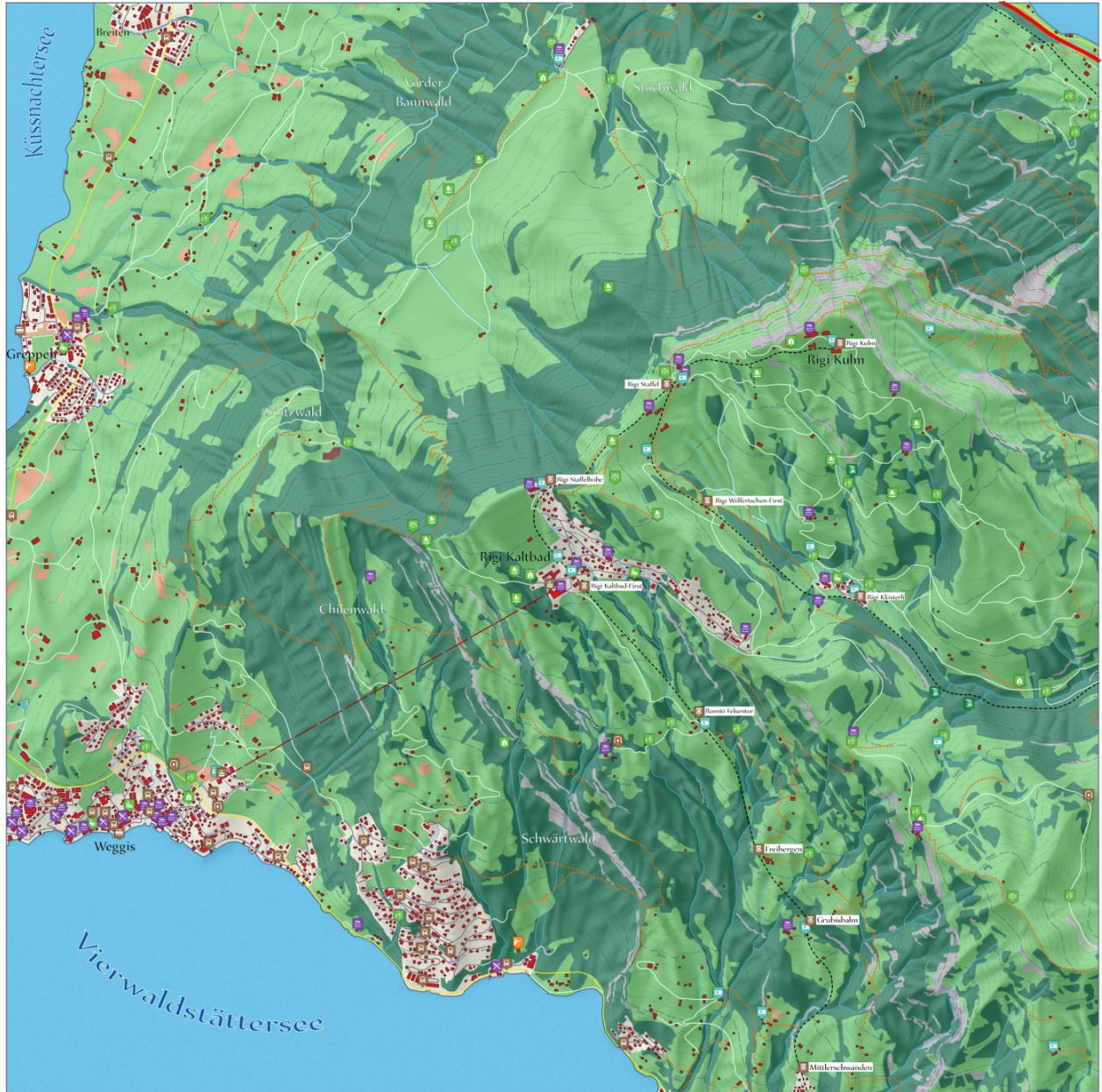


Figure 9: The final product – the 2D visualization

4.2 Creation of the 3D visualization

For the creation of the 3D visualization, a block diagram is supplied from the Institute of Cartography, ETH Zurich. A digital height model, a set of data representing the 3D form of the earth's surface, for the selected Rigi area is needed to give the heights to each corresponding point of the visualization. On the block diagram with the given heights, an appropriate texture is adjusted.

4.2.1 Creation of the texture

The texture is created from the 2D visualization. However, the resolution should be higher because the texture is stretched when it is adjusted on the block diagram and additionally because of the zooming when it is integrated on the website. For the creation of the texture, the same layers of Illustrator were used except of the shaded relief. In this case, the shaded relief is not needed, because the impression of the three dimensions is realized by of the block diagram. Furthermore, a compass sign is added for the orientation of the test-users. (Figure 10)

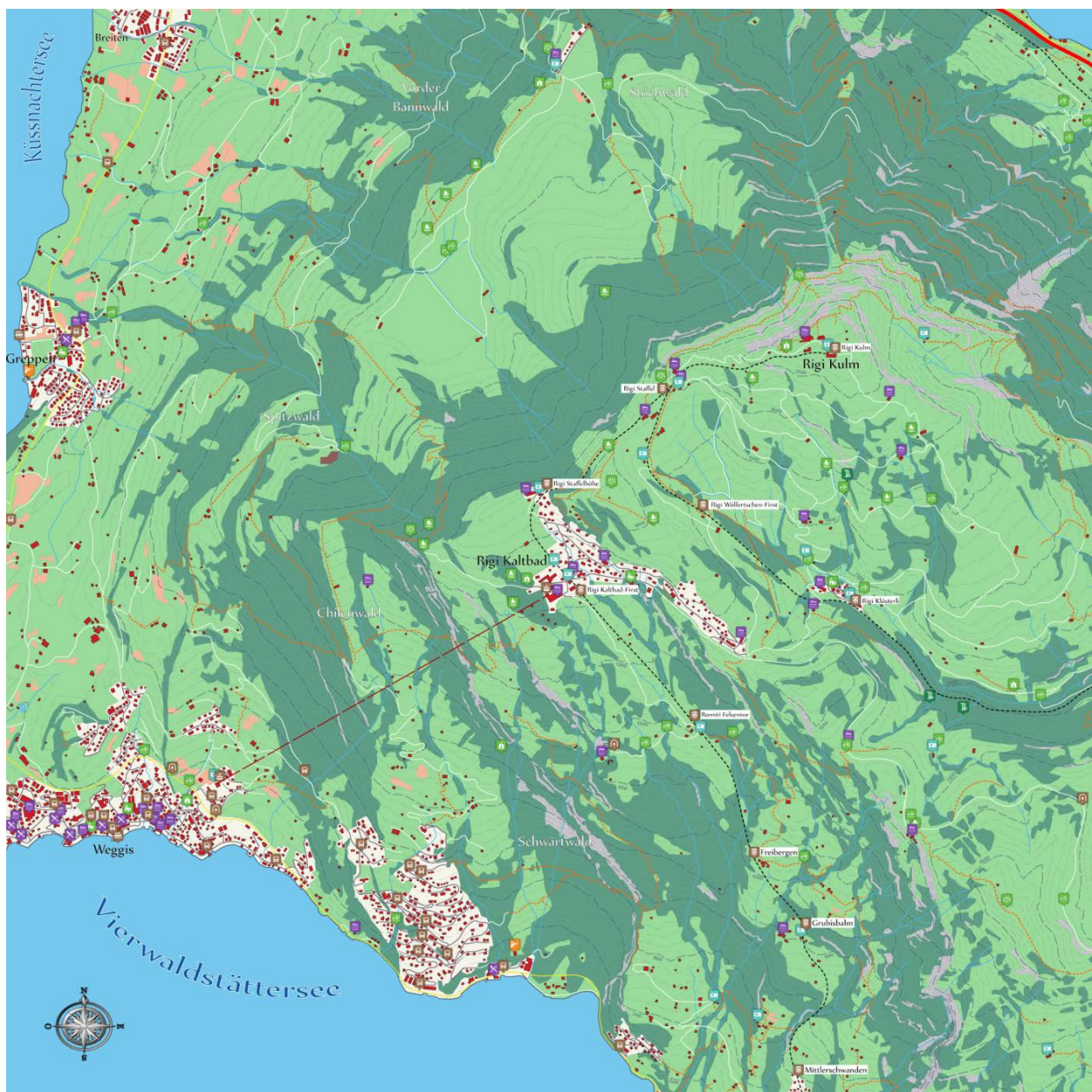


Figure 10: The texture of the 3D visualization

4.2.2 Creation of the 3D visualization

For the creation of the 3D visualization, a block diagram was supplied from the Institute of Cartography and Geoinformation and the needed DHM25 matrix model⁷ was downloaded from the platform GeoVITe.

For the creation of the block diagram, the libraries of WebGL⁸ and Three.js⁹ were used to create 3D computer graphics on the web browser. During this project, in the code only some adjustments were realized (eg. adjustment of the shader, no animation etc.). The DHM25 and the texture are loaded in the script Main.js. (Figure 11)

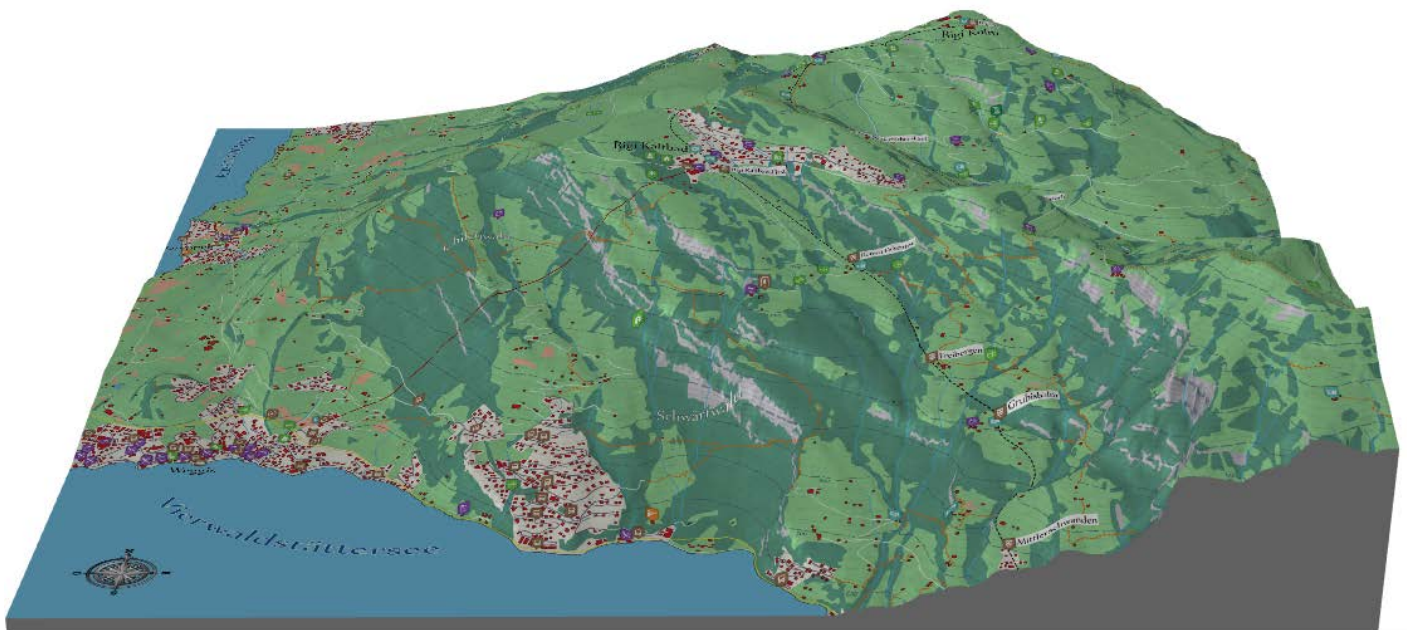


Figure 11: The final product - the 3D visualization

4.3 Creation of the poll

In this master project work, the selected technique of user testing for collecting data is the user-questioning. The questionnaire probes the major differences between two different visualizations, especially a 2D and a 3D visualization, from a test-user's point of view.

⁷ DHM25 - Matrix Model (Digital Height Model): The height matrix with 25 m grid is interpolated from the basis model (see footnote no6). The available formats of delivery are: ArcInfo ASCII Grid Format, coordinate list with X, Y, Z and DXF POLYFACE. [swisstopo_DHM25, 2014]

⁸ WebGL (Web Graphics Library): JavaScript API for rendering interactive 3D graphics and 2D graphics within any compatible web browser without the use of plug-ins. WebGL is integrated completely into all the web standards of the browser allowing GPU accelerated usage of physics and image processing and effects as part of the web page canvas. WebGL elements can be mixed with other HTML elements and composited with other parts of the page or page background. WebGL programs consist of control code written in JavaScript and shader code that is executed on a computer's Graphics Processing Unit (GPU). WebGL is designed and maintained by the non-profit Khronos Group. [Wikipedia_WebGL, 2014]

⁹ Three.js: a lightweight cross-browser JavaScript library/API used to create and display animated 3D computer graphics on a Web browser. Three.js scripts may be used in conjunction with the HTML5 canvas element, SVG or WebGL. Three.js allows the creation of GPU-accelerated 3D animations using the JavaScript language as part of a website without relying on proprietary browser plugins. This is possible thanks to the advent of WebGL. [Wikipedia_Three.js, 2014]

4.3.1 Formulation of the hypothesis (example questions)

Both 2D and 3D visualizations have their assumed advantages. Many cartographers think that inexperienced map users more easily understand 3D visualizations because they present the landscape in a realistic manner and mimic what people see while on a trail. The advantage of conventional 2D visualizations is that they require less time, effort and money to produce than 3D visualizations.

The point of the questionnaire was to test respondents' recall of information acquired exclusively from the two visualizations. The questionnaire is seeking answers to questions such as the following example questions:

- Which visualization facilitates more efficient cartographic communication?
- Which visualization allows test-users to orientate themselves better?
- Do certain demographic groups prefer one type of visualization to the other one?
- Do the test-users have any general comments about the visualizations, the questionnaire or even the website?

4.3.2 Formulation of the questionnaire

It would be much easier if someone could just see inside the test-users' heads while they are working with a 2D either a 3D visualization. The questions should capture the test-users' insight, but it should be done carefully so not to divert their choices to the path of the map-designer's preferences. Therefore, a questionnaire consisting of five different parts was created. Each part of the questionnaire examines a different aspect of the visualization. The questionnaire is the same for both visualizations so to compare the responses.

The questionnaire consists of 5 parts:

Part 1 – Individual characteristics

The first part of the questionnaire seeks background information about the test-user, including age, gender, whether the test-user had ever hiked/been at the depicted area and the experience of the test-user on reading maps. For instance, if the test-users have been at this alpine area, they would be familiar with the depicted area so this fact may have consequences on the time of map reading. Moreover, the cartographers or people who can be considered experienced map users apparently constitute a separate group of the sample and their results should be separately analysed, as soon as this sample group has advantage on conducting such a map-user-test.

Part 2 – Map content

The second part examines if the map features are easily recognised by the test-users and if the selected icons are easily interpretable.

Part 3 – Cartographic communication

The third part investigates the effectiveness of cartographic communication processes and the mental maps of the test-users. The purpose of this part is to examine if the test-user is able to read and successfully interpret the given information on the visualization as the map-designer wanted the information to be interpreted.

Part 4 – Orientation

The fourth part tests the ability of the test-users to be oriented by indicating their current position in the visualization. Actually, this part of the questionnaire is created to check the ability of orientation of the test-users in a 3D visualization. The same part exists also in the map-user-test on 2D visualization for the comparative evaluation of the responses on this part. The reason for creating this part of questions was to check if the three-dimensionality confuse and disorientate the test-user.

Part 5 – Map design preference / Map comparison

The last part of questions examines the preference of the test-users. A direct comparison between the 2D and 3D visualizations takes place at this part of the questionnaire. The test-users were asked to compare the 2D and 3D visualizations and which they preferred, which one represents better the reality, which one is easier to read and which one is more accurate.

Finally, the test-users are asked to write their own comments for each one of the two visualizations, but also to write their comments about the comparison of the two visualizations. Any further comments concerning to the questionnaire and the website are welcome.

4.3.3 Creation of the poll

On this step, a useful and easy-to-handle way of creating online polls was considered. Initially, a search for ready preformed polls that could be used as data collection tools was implemented. Survey Monkey, Google Consumer surveys, Survey Gizmo, Confiormit, Qualtrics and Zoomerang are some of possible data collection tools. However, Google Drive Forms was the selected tool for the collection of information via a questionnaire (Figure 12). The questions are integrated in the preformed polls and the responses are automatically stored to a spreadsheet with the same name.

During the conduction of the map-user-tests, the possibility of selecting which visualization the test-user prefers to evaluate first is given to the participants. When the first visualization is selected, the 2D either the 3D, the test-user has to answer the whole part 1 of the questionnaire, the part 2, the part 3 and the part 4. After the evaluation of the first visualization, the test-user has to evaluate the other visualization, the 3D either the 2D correspondingly. During the evaluation of the second left evaluation, the test-user has to give a password-id, which is required for the correspondence of the answers of the same test-user with his/her answers given for the first evaluation. After giving the password-id, the test-user has to respond to the part 2, the part 3 and part 4 of the questionnaire for the second visualization. In the end, the test-user has to answer the last part of the questionnaire, the part 5, concerning to the map comparison and the map design preference. To sum up, every test-user has to answer one time the part 1 and part 5 of the questionnaire, twice the part 2, part 3 and part 4 for each of the two visualizations.

Therefore, the total number of the polls that should be created is four. Two polls were created for the 2D visualization and two polls for the 3D visualization. The “poll_2D_A” and the “poll_3D_A” consist of the whole part 1, the part 2, the part 3 and part 4 of the questionnaire. The “poll_2D_B” and “poll_3D_B” consist of the part 1, which only asks for the password-id, the part 2, the part 3, the part4 and the part 5.

The test-user can respond by choosing radio buttons or check boxes and writing comments in text boxes. The responses are recorded when the test-user click the “submit” button.

Because each poll is consisted by many questions, only one part of the questionnaire is visible and the button “continue” presents the next part of questions until all the questions are responded and the questionnaire is submitted.

The structure of the questions of each poll is presented in the Annex.

Map user test on the 2D visualization

Part 1: Individual characteristics

***Required**

What is your age? *

- 15 to 20
- 20 to 25
- 26 to 40
- 41 to 60
- over 60

Gender? *

- male
- female

Have you ever hiked/been at Rigi, Switzerland? *

- Never
- Once
- Just a few times
- I often go to Rigi!

How often do you use maps? *

- I don't use maps at all!
- I just use them only when I cannot avoid it.
- I often use maps.
- My studies/work are in the field of cartography or a related field.

Please give an id to your map user test. (e.g. mariak87) *

This is only required to correspond the map user tests of the two visualizations.

 20% completed

Powered by
 Google Drive

This content is neither created nor endorsed by Google.
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Figure 12: Google Drive Forms
[source: <https://drive.google.com/>]

4.4 Creation of the Website

The layout and design of the website is created to be easy-to-handle and user-friendly so that the majority of the people are able to conduct the map-user-test.

4.4.1 Introduction web-page

The first web-page is the introduction page, where the test-user is welcomed and guided to select the evaluation of the 2D either the 3D visualization first. On the introduction web-page, two buttons are designed and each of the buttons leads to the evaluation of the selected visualization (Figure 13).



Figure 13: Introduction web-page

4.4.2 Integration of modules

The test-user actually has to interact with three web-pages; the introduction web-page, the map-user-test on the 2D visualization and the map-user-test on the 3D visualization. The order that the web-pages are displayed depends on which visualization the test-user selects to evaluate first. However, the whole website is consisted of five web-pages; the introduction web-page, two web-pages corresponding to the 2D visualization and two web-pages corresponding to the 3D visualization. Each of the web-pages, excluding the introduction page, corresponds to one poll (see chapter 4.3.3). The web-page “web-page_2D_A” contains the 2D visualization and the “poll_2D_A”. The web-page “web-page_2D_B” contains the 2D visualization and the “poll_2D_B”. The web-page “web-page_3D_A” contains the 3D visualization and the “poll_3D_A”. The web-page “web-page_3D_B” contains the 3D visualization and the “poll_3D_B”. So, on the introduction page, when the test-user selects to evaluate first the 2D visualization, the “web-page_2D_A” is displayed first and when selecting to continue with the evaluation of the 3D visualization, the “web-page_3D_B” is displayed. On the other hand, if the test-user selects to evaluate first the 3D visualization, the “web-page_3D_A” is first displayed and then when selecting to continue with the evaluation of the 2D visualization, the “web-page_3D_B” is displayed.

The integration of the visualizations in the web-pages was realized with the “onload” event and the integration of the polls was implemented with the <iframe> tag.

Furthermore, the design of a legend was implemented and a copyright button was added. By clicking the copyright button, a popup window, containing the imprint, opens. (Figure 14)



[Back](#)

Imprint

© 2009 Bundesamt für Landestopografie swisstopo, Wabern
Coordinate Reference System: CH1903 LVO3

© 2013 Google Maps/Google Earth APIs
<https://developers.google.com/maps/terms?hl=en>

© 2014 GoogleDrive
<http://www.google.com/intl/en/policies/terms/>

© Map Icons Collection
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Author : Nicolas Mollet
<http://mapicons.nicolasmollet.com/>

Master Project Work, Spring term 2014
Institute of Cartography and Geoinformation, ETH Zürich

Supervising Professor:	Prof. Dr. Lorenz Hurni
Supervisors:	Dr. Christian Häberling Aline Brüngger
Author:	Maria-Vasiliki Kourouni

Figure 14: Legend and Imprint

4.4.3 Collection of the responses

The responses were collected and automatically connected to a Google spreadsheet with the same name of the corresponding poll. The spreadsheet is populated with the test-users' responses. Furthermore, summaries of the responses are presented through pie charts.

4.4.4 Uploading the website on the World Wide Web

The possibility of publishing a personal homepage on the World Wide Web is offered to all ETH Zurich students by the IT¹⁰ User Services. The homepage URL (encrypted) was <https://n.ethz.ch/student/mariak/MPW/> or <https://n.ethz.ch/~mariak/MPW/>.

The website data were uploaded with the use of the FTP¹¹ client WinSCP¹². The FTP server, where the website data were uploaded, is called **hg.n.ethz.ch**. The test-users had unlimited access to the website during the period that was determined for the conduction of the map-user-tests.

¹⁰ Information technology (IT) is the application of computers and telecommunications equipment to store, retrieve, transmit and manipulate data, often in the context of a business or other enterprise. [Wikipedia_IT, 2014]

¹¹ The File Transfer Protocol (FTP) is a standard network protocol used to transfer computer files from one host to another host over a TCP-based network, such as the Internet. [Wikipedia_FTP, 2014]

4.5 Procedure of user questioning

The conduction of the map-user-tests was implemented in the sense of a pilot study. The results of this procedure will lead to conclusions concerning to the design of the proposed workflow.

4.5.1 Pre-testing of map-user-tests

Before the recruitment of the test-users and the conduction of the map-user-tests, it was considered that a pre-testing would lead to the recognition of probable deficiencies of the website. Pre-testing is a method often used in testing circles to check reliability. Because the invitation would be done through email and the test-users would complete the map-user-tests without the presence of a person to help them, the pre-testing could give useful feedback concerning to the problems that the test-users may face.

During the pre-testing of the map-user-tests, three test-users were asked to take part. All selected first to evaluate first the 2D visualization and then the 3D visualization. All of them had questions about the next steps they had to follow, but they were given no directions. All the questions were answered by themselves while searching on the website or in the visualizations. Moreover, it was observed to the one out of the three test-users that the presence of one other person made the test-user to carry out the whole map-user-test. Therefore, one question under examination is if the test-users will complete the questionnaires for both visualizations.

4.5.2 Recruitment of test-users

The feedback evaluations should be concise and useful for a fruitful deriving of conclusions. Experts in reading maps, such as cartographers, geographers, surveyors, graphic designers and map enthusiasts, are the most important user groups of the sample for the conduction of the map-user-tests. Moreover, nowadays the majority of people are able to interpret a map. Therefore, the selection of non-experts to carry out the map-user-test is also necessary to compare their answers with the ones the experts will give. Additionally, the non-experts may give important feedback concerning to issues that the experts may not notice because of a different perspective of view. However, their contribution is not going to be so profound in contrast to the experts' evaluations.

Totally 60 persons were asked by e-mail to participate to the map-user-test. The 35 out of the 60 persons are experts. Also, during the intermediate presentation of the master project work on 30th April 2014, Wednesday, the public which was consisted of experts was invited to take part to the map-user-test.

4.5.3 Procedure of map-user-tests

The conduction of the map-user-tests took place from May 5th to May 15th, 2014. The test-users were asked by email to participate to the map-user-test. The map-user-test was available for test-users with internet access and the participants could have unlimited access to it in the duration of ten days. It is not sure how many people were informed about the map-user-test and if other test-users except from the ones who were asked participated. The names of the test-users are not known except from the ones who used their names as usernames for their participation to the map-user-test.

¹² WinSCP (Windows Secure CoPy) is a free and open-source SFTP, SCP and FTP client for Microsoft Windows. Its main function is secure file transfer between a local and a remote computer. Beyond this, WinSCP offers basic file manager and file synchronization functionality. [Wikipedia_WinSCP, 2014]

4.5.4 Capturing the answers

As it was also referred in the previous chapter, the responses were collected and automatically connected to a Google spreadsheet with the same name of the corresponding poll. The spreadsheet was populated with the test-users' responses.

During the lifecycle stage of the map-user-test, the "poll_2D_A" was completed by 22 test-users, the "poll_3D_B" by 13 test-users, the "poll_3D_A" by 11 test-users and the "poll_2D_B" by 4 test-users.

From the submitted answers, 12 answers of the "poll_2D_A" and the corresponding ones of the "poll_3D_B" were considered as valid for further analysis and for the comparative evaluation of the two different visualizations. Similarly, 2 answers of the "poll_3D_A" and the corresponding ones of the "poll_2D_B" were considered as valid. However, all the comments of the test-users were kept to be analyzed and evaluated. (Figures 15, 16)

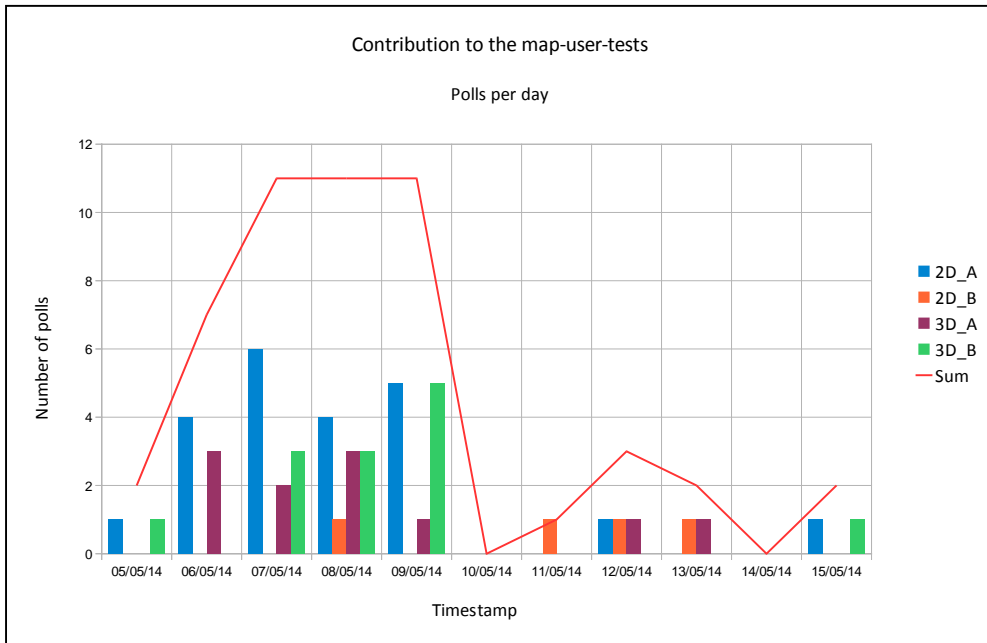


Figure 15: All the completed (valid and invalid) polls per day

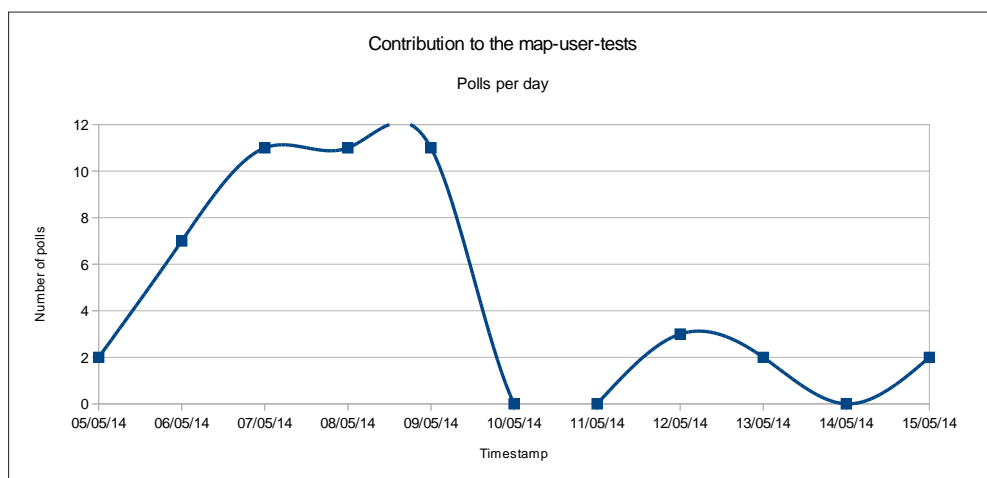


Figure 16: Smooth line (cubic-spline) representing the number of completed polls per day

4.5.4 Difficulties

Some difficulties were faced during the conduction of the map-user-tests. First of all, the invitation of the test-users to complete the map-user-test on a website any time did not motivate them to complete it. Actually, only one third of the invited persons took part in the map-user-test. It is assumed that in another case that the test-users would be invited to come to a meeting for the conduction of the map-user-tests, more answers would be recorded. Furthermore, it was observed that some of the test-users completed the questionnaire only for one of the visualizations. This could have happened because these test-users did not want to spend more time on completing also the other questionnaire because they did not press the button “submit” when they completed the questionnaire so the answers were not recorded. Additionally, there were some participants who selected to evaluate first the 2D visualization one day and another day they selected to evaluate the 3D visualization. However, because they selected to evaluate the 3D visualization from the introduction page of the website, they answered the “poll_3D_A”. Therefore, they answered twice the part of the questions “Individual characteristics”, but they did not answer the part 5, the last part of the questionnaire “Map design preference / Map comparison”.

5. Evaluation of the answers

5.1 Analysis and evaluation of answers

All the answers that were recorded during the conduction of the map-user-tests, excluding the answers of the pre-testing, are distributed below:

“poll_2D_A”: 22 submitted answers

“poll_2D_B”: 4 submitted answers

“poll_3D_A”: 11 submitted answers

“poll_3D_B”: 13 submitted answers

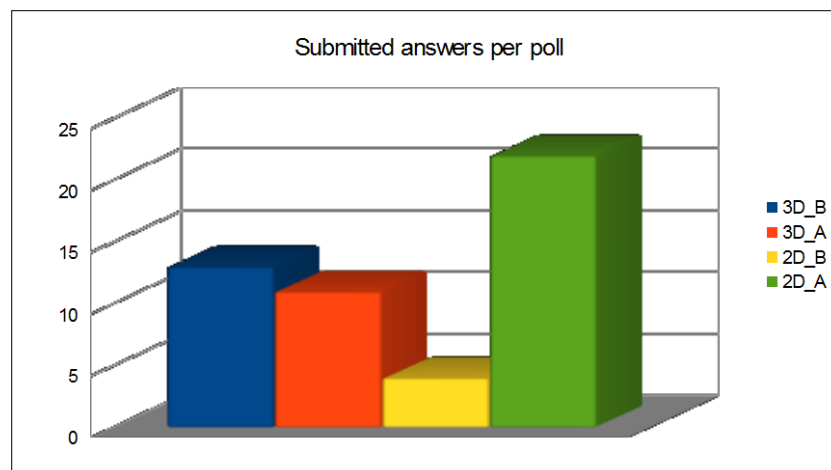


Figure 17: All the submitted answers per poll

The majority of the participants selected to evaluate first the 2D visualization and then the 3D visualization. This was expected due to their familiarity with the 2D visualizations (Figure 17).

The total number of the participants who first completed the questionnaire on the 2D visualization and then the questionnaire on the 3D visualization in this order was 12, whereas the total number who first completed the questionnaire on the 3D visualization on the 2D visualization in this order was 2. Therefore, the valid answers of the map-user-test when evaluating first the 2D visualization are 12, whereas the valid answers of the map-user-test when evaluating first the 3D visualization are 2.

In the beginning, the results of evaluating first the 2D visualization are analysed separately from the results of first evaluating the 3D visualization.

5.1.1 Analysis of the “evaluating first the 2D visualization” results

In the map-user-test on the 2D visualization, the whole part 1 of the questionnaire, “Individual characteristics”, was completed by the respondents. In the Figure 18, the age, the gender and the frequency that the test-users have gone at Rigi are depicted. Moreover, the frequency that the test-users use maps is described. Five persons out of twelve answered that their studies/work are in the field of cartography or related field. Also, five of twelve answered that they often use maps and only the two out of twelve that they only use maps when they can avoid it. Therefore, almost the 42% of the sample are experts and the 16% of the sample are non-experts. The test-users that answered that they often use maps could be assumed to be closer to the experts, but still their knowledge is not as profound as experts’. The test-users that often use maps were finally decided to be assumed as non-experts, so the non-experts group was 62% of the sample. (Figure 18)

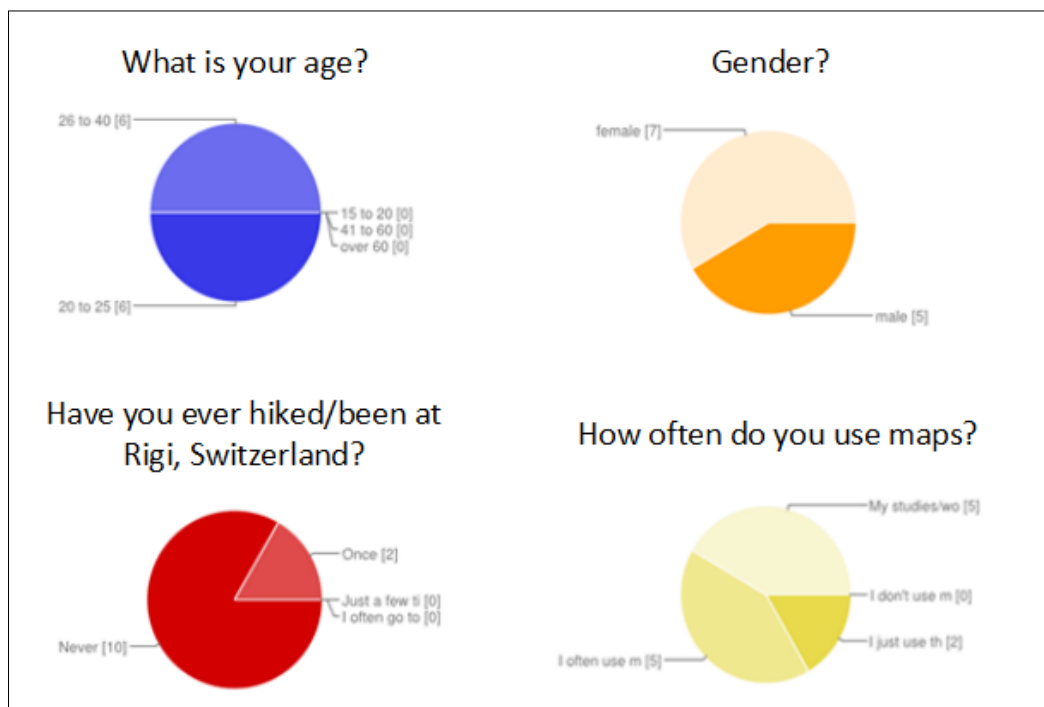


Figure 18: Individual characteristics of the test-users evaluating first the 2D visualization

The next part of questions to be answered was the part 2, “Map content”. On this part, it is observed that not all the test-users give all the correct answers when evaluating the 2D visualizations. However when evaluating the 3D visualization, the test-users gave incorrect answers, even if they did not give these answers when evaluating the previous 2D visualization. This means that the 3D visualization did not facilitate the test-users for the recognition of the map content.

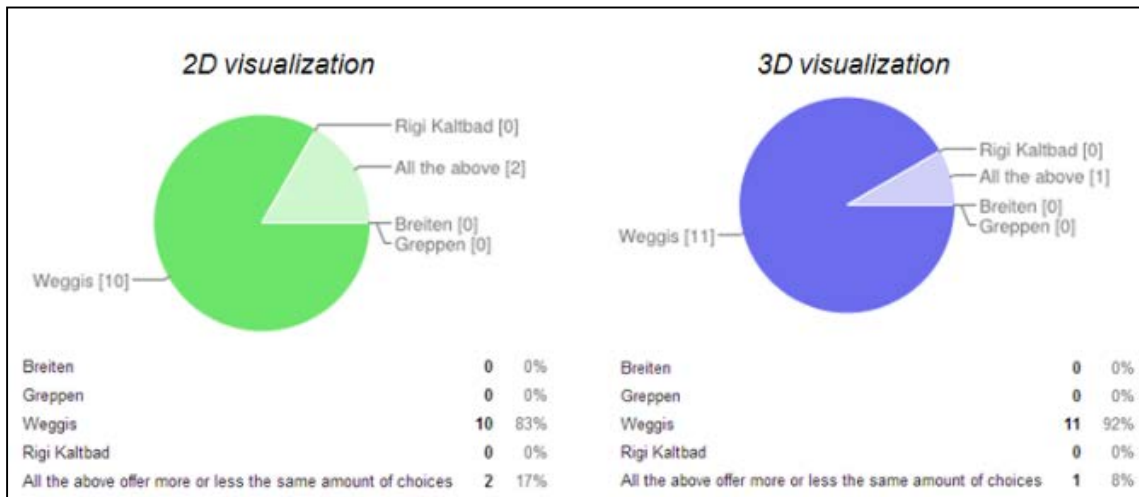


Figure 19: “Which depicted region does offer more choices for accommodation and food?”

The correct answer of the question “Which depicted region does offer more choices for accommodation and food?” is “Weggis”. It is observed that when evaluating both the visualizations almost all the test-users answered correctly. (Figure 19)

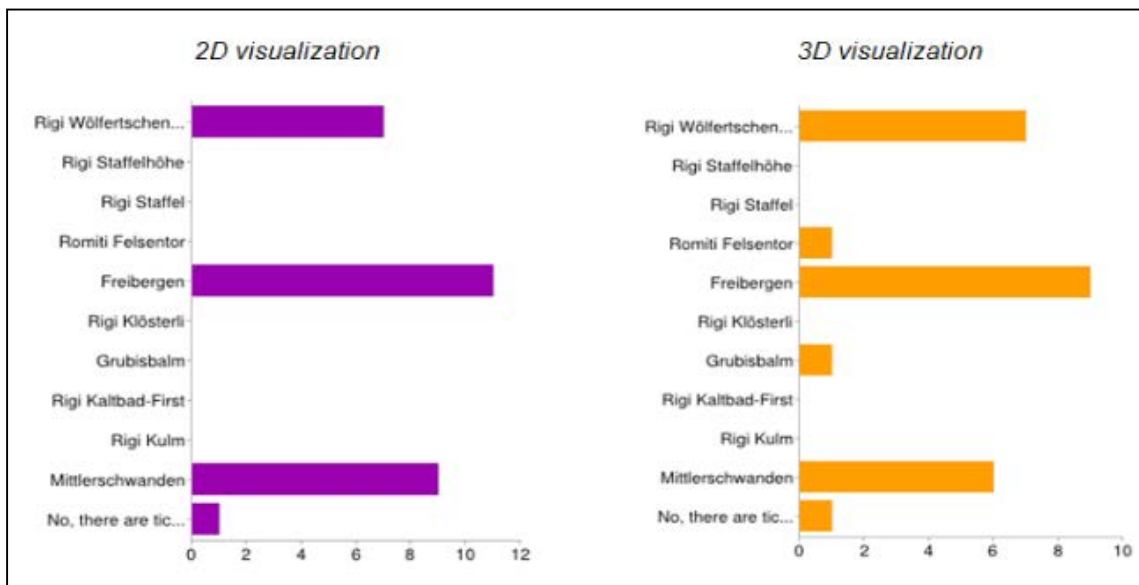


Figure 20: “Is there any railway station, close to which there is no ticket office? If yes, which one(s)?”

The correct answers of the question “Is there any railway station, close to which there is no ticket office? If yes, which one(s)?” are “Rigi Wölfertschen-First”, “Freibergen” and “Mitterschwanden”. It is obvious that when evaluating the 2D visualization, only one test-user answered “No, there are ticket offices close to all railway stations” and all the other test-users gave maybe not all the correct answers, but they did not give any wrong answer. However, when evaluating the 3D evaluation, there were test-users who gave also wrong answers. (Figure 20)

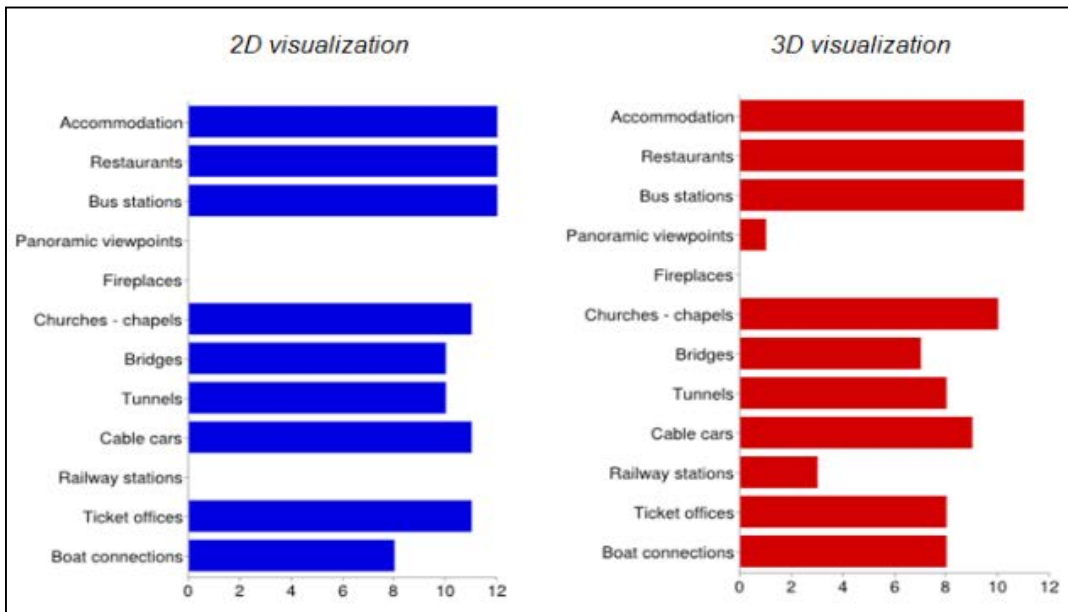


Figure 21: "What information is available for Weggis?"

The correct answers of the question "What information is available for Weggis?" are "Accommodation", "Restaurants", "Bus stations", "Churches – chapels", "Bridges", "Tunnels", "Cable cars", "Ticket offices" and "Boat connections". When evaluating the 2D visualization, 67% of the test-users gave all the correct answers and the rest gave most of the correct answers, but no wrong ones. When evaluating the 3D visualization, it is observed that some test-users, even if they had answered the same question during evaluating the 2D visualization, gave also wrong answers. (Figure 21)

The part of the questionnaire "Cartographic communication", part 3, showed that only in the first question the test-users were facilitated when evaluating the 3D visualization. While the nine of the twelve test-users gave the correct answer when evaluating the 2D visualization, whereas when evaluating the 3D visualization all of them gave the correct answer. (Figure 22)

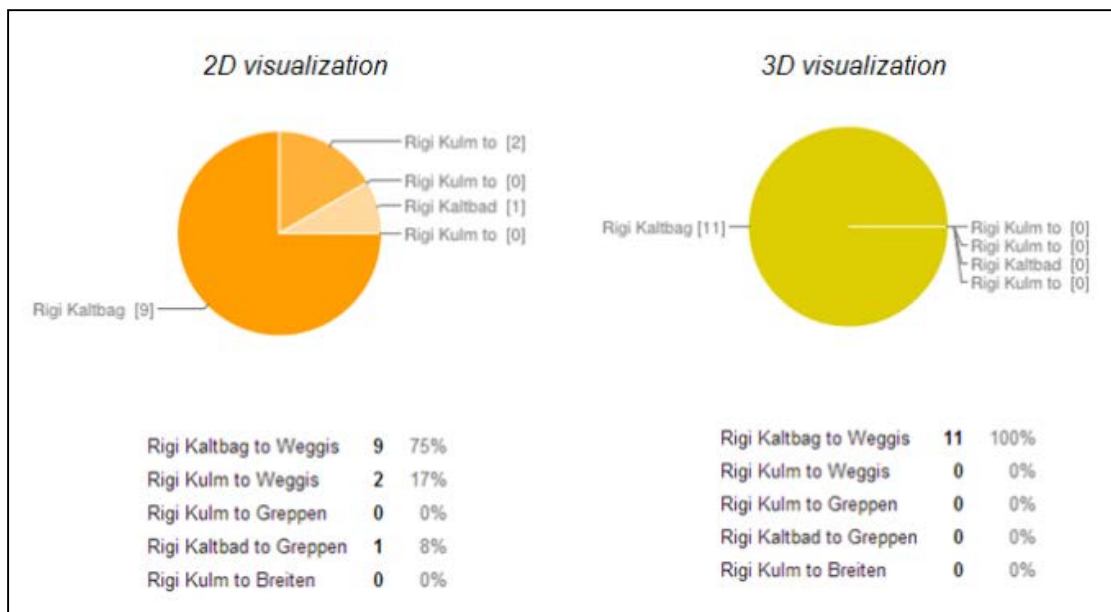


Figure 22: "There is the possibility of transportation with cable cars from ... and reverse."

The correct answers of the question “Which are the possible ways to go from Rigi Wölfertschen-First to Rigi Kaltbad?” are “Hiking”, “By train” and “By car”. As it is depicted in the figure, the most of the test-users gave correct answers when evaluating the 2D visualization, but again when evaluating the 3D visualization some did not give the same answers. (Figure 23)

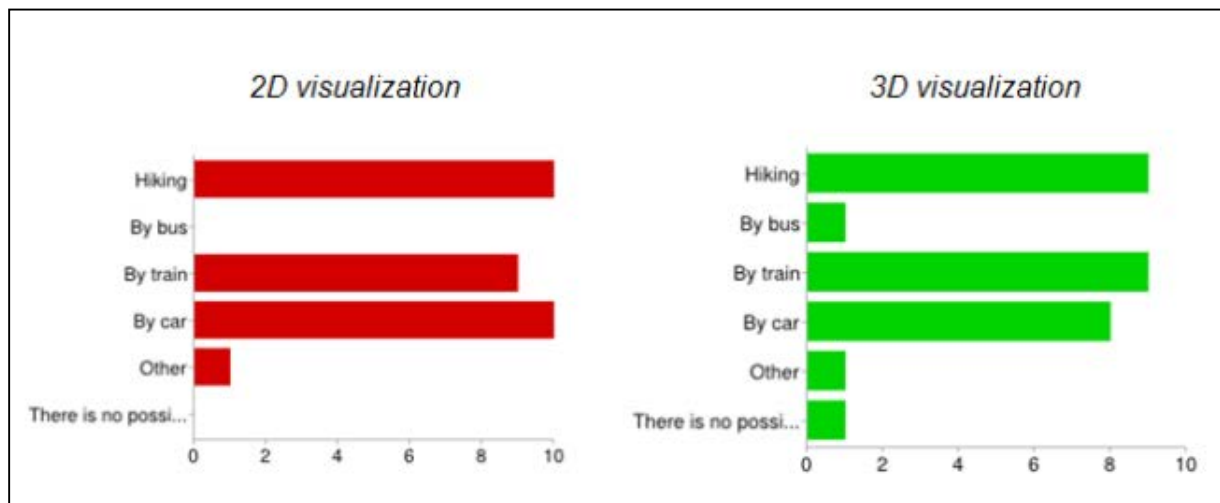


Figure 23: “Which are the possible ways to go from Rigi Wölfertschen-First to Rigi Kaltbad?”

The correct answers of the question “Is there any region which offers the possibility for a boat trip? And if yes, which one(s)?” are “Greppen” and “Weggis”. The test-users who responded gave all the correct answers, whereas when evaluating the 3D visualization there were some persons who gave incorrect answers. (Figure 24)

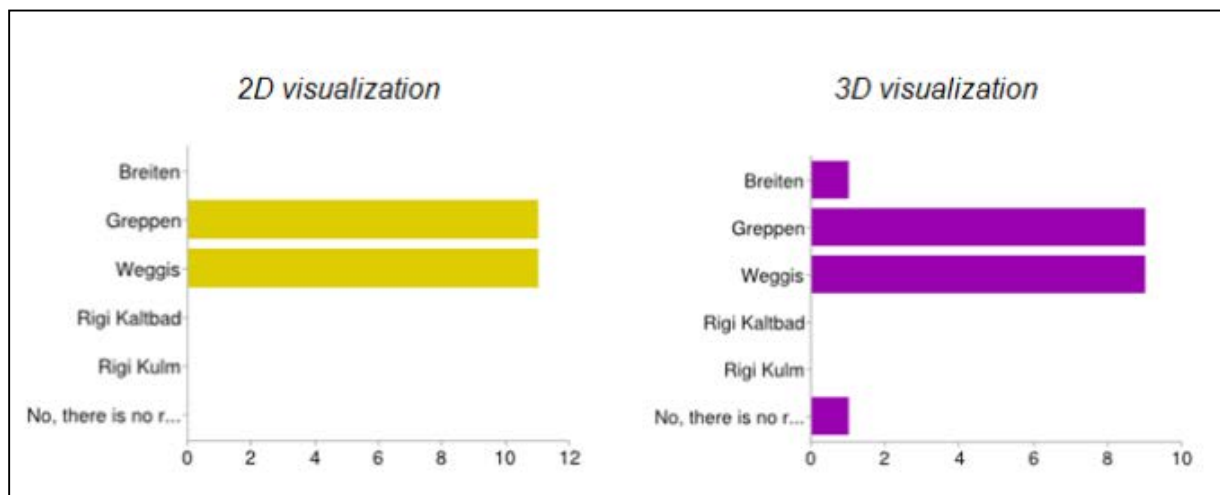


Figure 24: “Is there any region which offers the possibility for a boat trip? And if yes, which one(s)?”

Therefore, the 3D visualization facilitated the test-users to respond the first question, but confused them to answer correctly the two other questions concerning to the cartographic communication. The part 4 of the questionnaire, “Orientation”, examined the possibility of the test-users of being oriented with the use of a 2D or a 3D visualization.

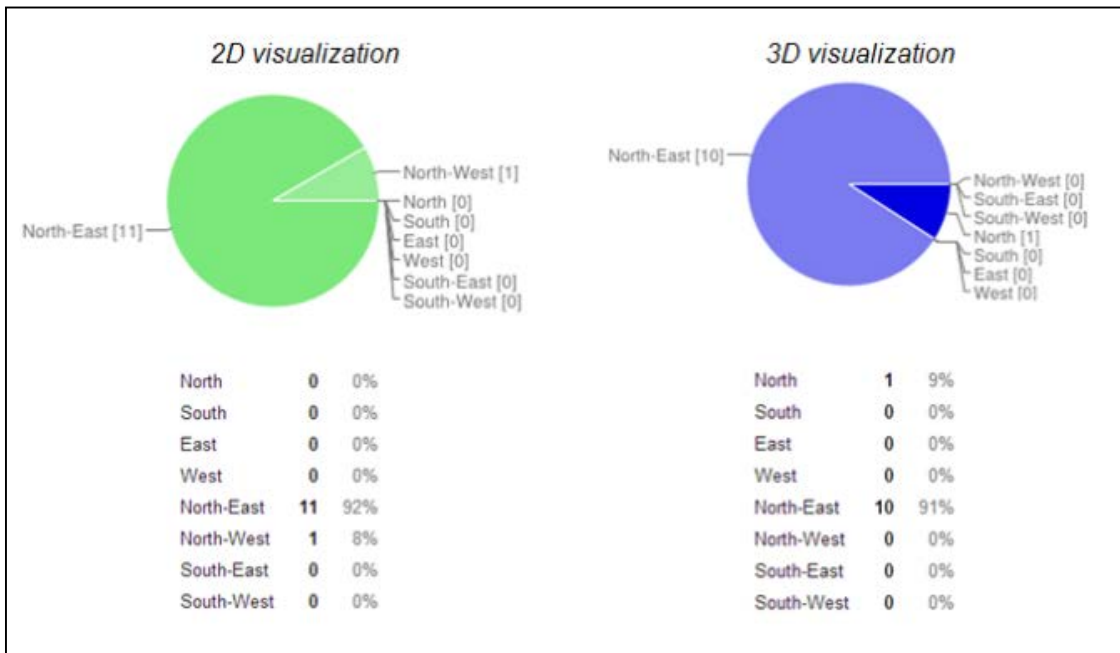


Figure 25: “You are at Weggis. In which direction would you go to the peak?”

The correct answer of the first question of the part 4 is “North-East”. Most of the test-users did not have any problem of being oriented in both of the visualizations. (Figure 25)

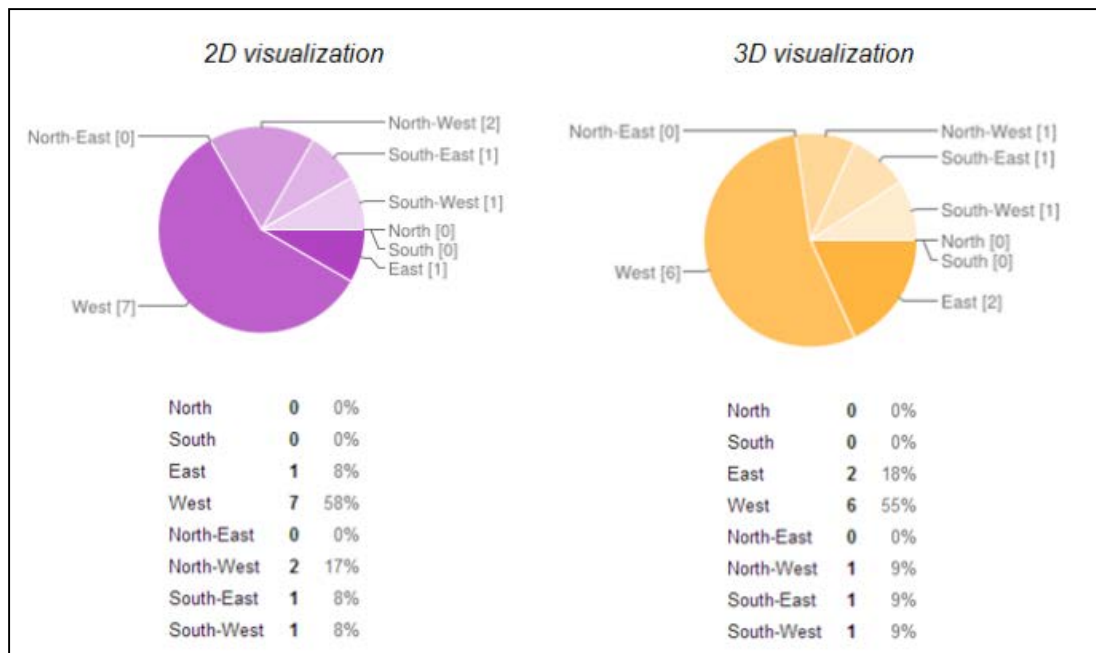


Figure 26: “Now you are at the peak. In which direction would you go to Greppen?”

The correct answer of the second question of the part 4 is “West”. This time, 58% of the test-users gave the correct answer when evaluating the 2D visualization, whereas 55% gave the correct answer when evaluating the 3D visualization. (Figure 26)

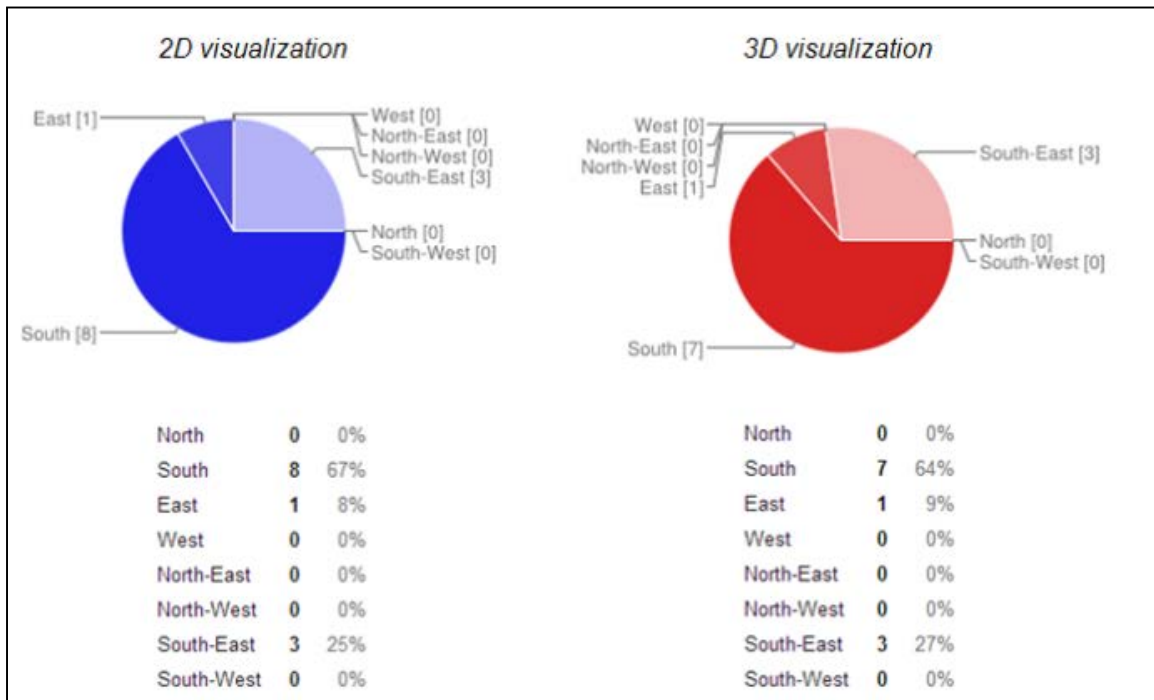


Figure 27: "And now you are at Greppen. In which direction would you go back to Weggis?"

The correct answer of the third question of the part 4 is "South". This time, 67% of the test-users gave the correct answer when evaluating the 2D visualization, whereas 64% gave the correct answer when evaluating the 3D visualization. However, the rest submitted answers cannot be assumed as wrong answers, because "South" and "South-East" could be assumed both as correct. Therefore, the most test-users could be more or less well oriented using either the 2D or the 3D visualization. (Figure 27)

To sum up, it is observed that the 2D visualization is more effective for cartographic communication than the 3D visualization. Concerning to the map content and the orientation, both of the visualizations are suitable for the interpretation of the map content and appropriate to allow test-users to be well oriented. However, because the test-users evaluate first the 2D visualization and this is an important help for completing later the questionnaire on the 3D visualization, it is believed that the 2D visualization is more effective for the interpretation of map content, cartographic communication and orientation. (Figure 28)

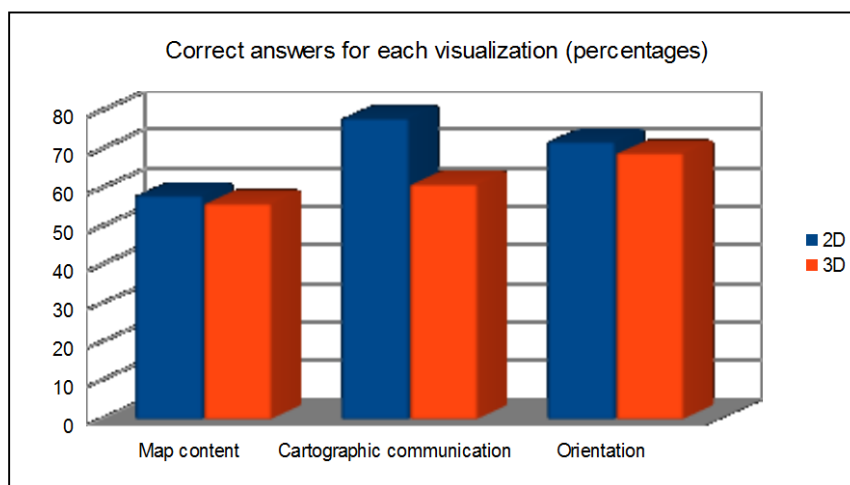


Figure 28: Comparison between 2D and 3D visualizations for each part of the questionnaire

The part 5 of the questionnaire “Map design / Map comparison” examined which map type is more suitable for the test-users. It was indicated that 84% of the test-users preferred the 2D visualization, the 8% preferred the 3D visualization and 8% responded that they have no preference. Furthermore, 75% answered that the 3D visualization depicts the reality better, 17% answered that the 2D visualization depicts the reality better and 8% answered that they don’t know. All the test-users selected the answer that the 2D visualization is easier to read. Additionally, 42% of the test-users selected the 2D visualization as more accurate, the other 42% selected the 3D visualization as more accurate and 17% answered that they don’t know. (Figure 29)

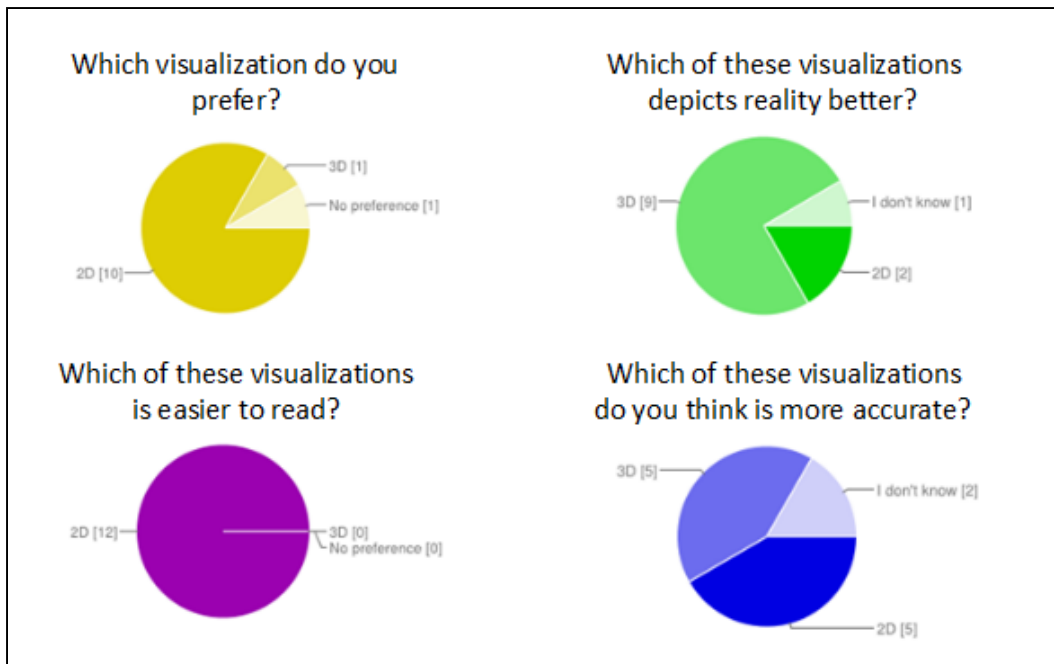


Figure 29: Map design / Map comparison of the test-users evaluating first the 2D visualization

5.1.2 Analysis of the “evaluating first the 3D visualization” results concerning to user-groups

Age-groups

Concerning the age-groups, it is observed that only the age-groups 20-25 and 26-40 participated to the map-user-test. 50% of the sample belongs to the age-group 20-25 and the other 50% belongs to the age-group 26-40. It is proved that the age-group 26-40 gave more correct answers in comparison to the younger age-group. (Figure 30)

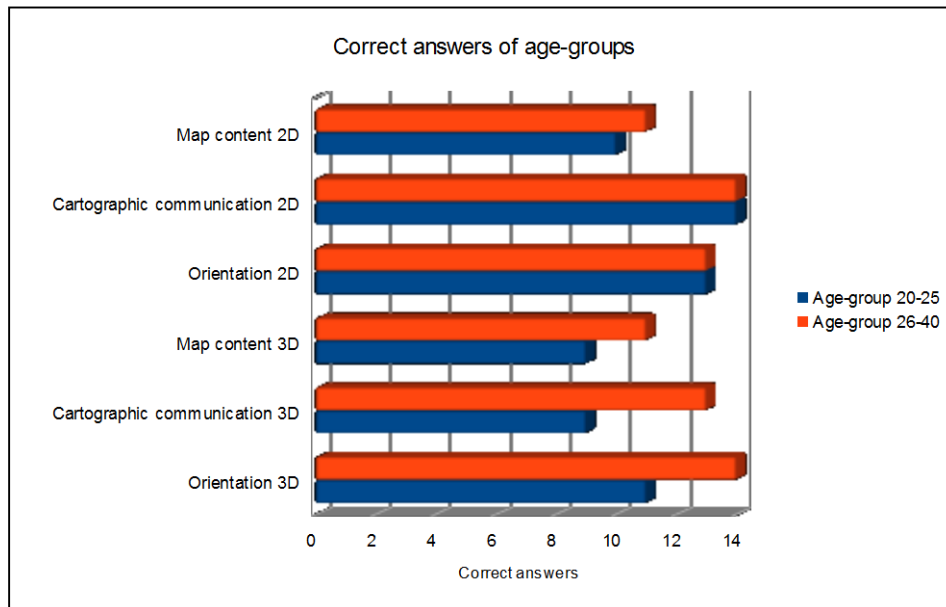


Figure 30: Number of correct answers of the two different age-groups

Also, it is important to refer that the majority of both age-groups prefer the 2D visualization, believe that 3D visualization depicts the reality better and the 2D visualization is easier to read. However, the age-group 20-25 believes that the 3D visualization is more accurate, whereas the age-group 26-40 believes that the 2D visualization is the most accurate one.

Gender-groups

Concerning the gender-groups, 58% of the sample belongs to the gender-group female and the other 42% belongs to the gender-group male. It is proved that the males gave more correct answers in comparison to the females except of the part of “Map content” of the 3D visualization. It is important to refer that females are not easily oriented when using a 3D visualization in comparison to the males. (Figure 31)

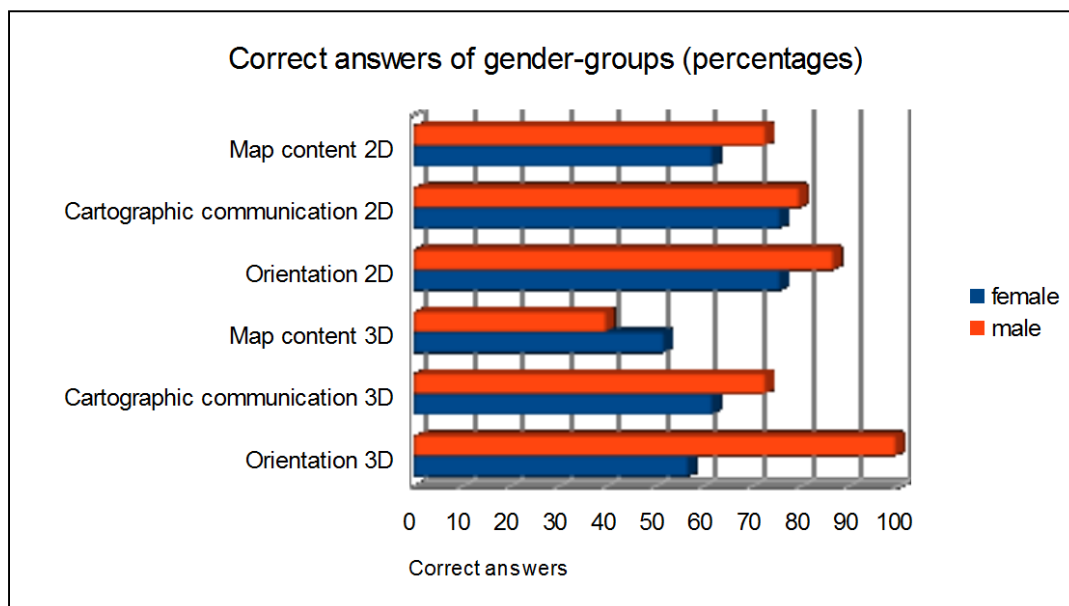


Figure 31: Percentages of correct answers of the two different gender-groups

Also, the majority of both gender-groups prefer the 2D visualization, believe that 3D visualization depicts the reality better and the 2D visualization is easier to read. However, the males believe that the 3D visualization is more accurate, whereas the females believe that the 2D visualization is the most accurate one.

Experts vs non-experts

The 42% of the sample belongs to experts and the other 58% belongs to non-experts. It is observed that the experts gave more correct answers in comparison to the non-experts except of the part of "Orientation" for both visualizations. The non-experts are really well oriented in contrast to the experts and, as it is shown in the figure below, they are better oriented when using the 2D visualization.

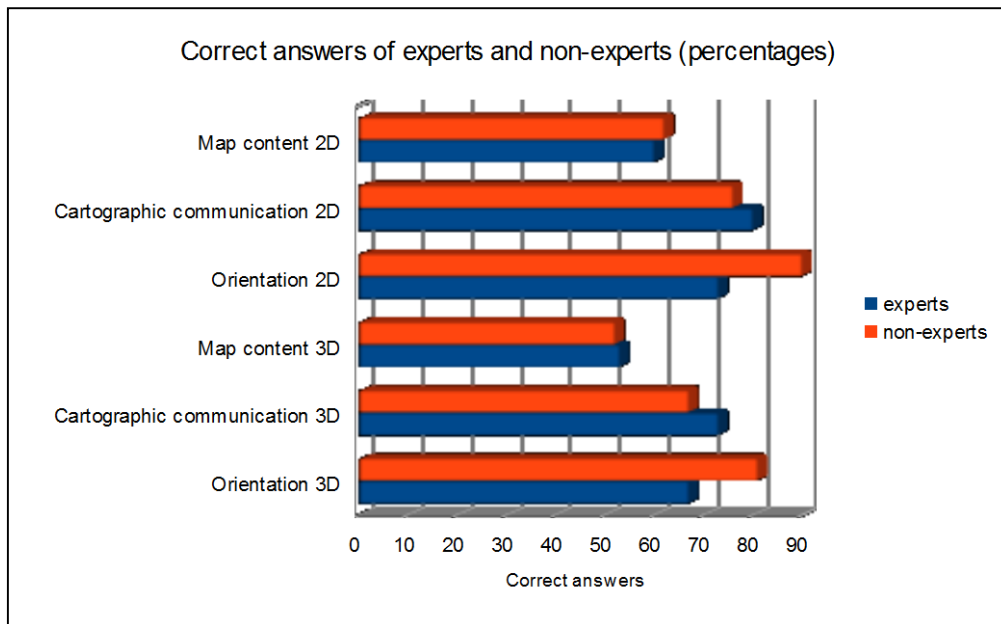


Figure 32: Percentages of correct answers of experts/non-experts

Also, the majority of both groups prefer the 2D visualization, believe that 3D visualization depicts the reality better and the 2D visualization is easier to read. However, 60% of experts believe that the 2D visualization is more accurate, whereas 57% of non-experts believe that the 3D visualization is the most accurate one.

5.1.3 Analysis of the "evaluating first the 3D visualization" results

The valid submitted answers from test-users selecting first to evaluate the 3D visualization are 2. The results cannot be representative because the number of the submitted answers is too low. On this subchapter, only the answers that are important to be referred will be described.

Concerning to the part 1 of the questionnaire, "Individual characteristics", one female and one male participated to the map-user-test evaluating first the 3D visualization. The one of them belongs to the age-group 20-25 and the other one belongs to age-group 26-41. Both of them do not belong to the user-group of experts. (Figure 33)

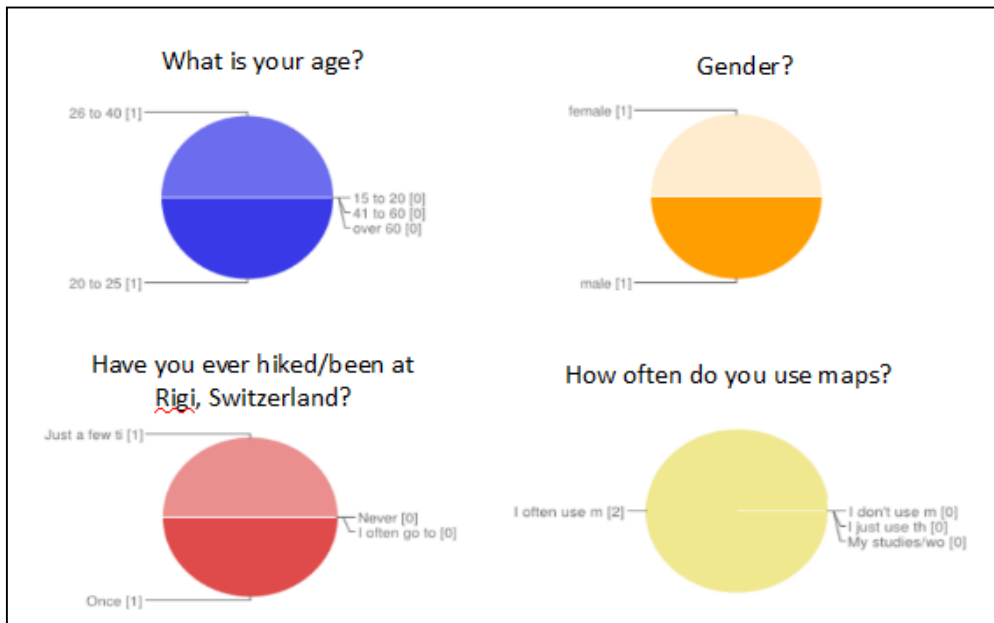


Figure 33: Individual characteristics of the test-users evaluating first the 3D visualization

In the part 2 “Map content”, the correct answers of the question “Is there any railway station, close to which there is no ticket office? If yes, which one(s)?” are “Rigi Wölfertschen-First”, “Freibergen” and “Mittlerschwanden”. It is observed that when evaluating the 3D visualization the one test-user gave all the correct answers and the other test-user gave only one correct answer. When evaluating the 2D visualization the first test-user this time gave only two of the correct answers, whereas the second test-user gave all the correct answers. (Figure 34)

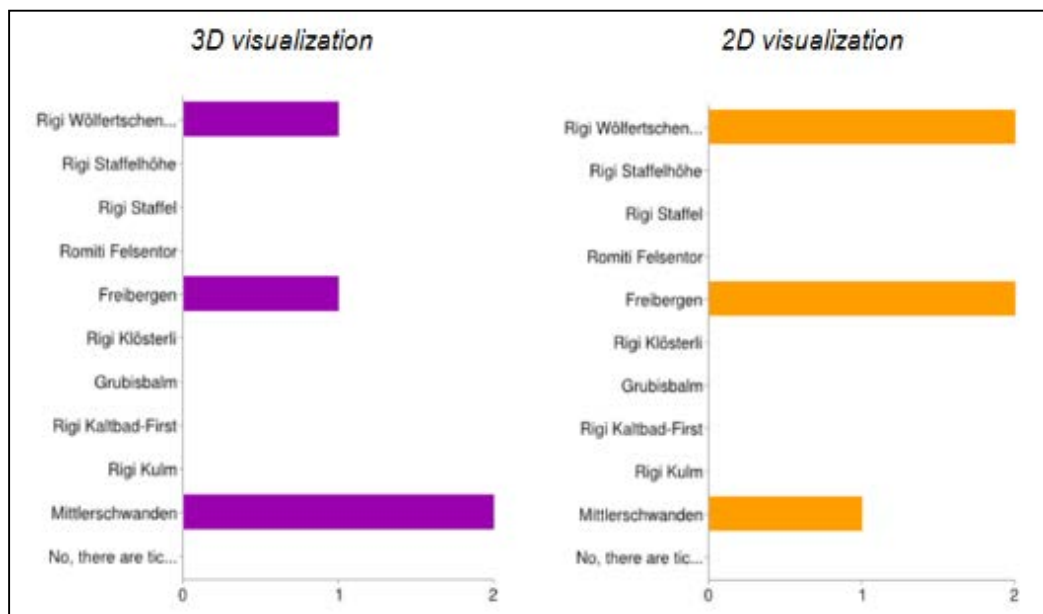


Figure 34: “And now you at Greppen. In which direction would you go back to Weggis?”

The correct answers of the question “What information is available for Weggis?” are “Accommodation”, “Restaurants”, “Bus stations”, “Churches – chapels”, “Bridges”, “Tunnels”, “Cable cars”, “Ticket offices” and “Boat connections”. When evaluating the 3D visualization, it is observed that the test-users gave only one wrong answer and the most of the correct answers, whereas when evaluating the 2D visualization, both of the test-users gave all the correct answers (Figure 35). In comparison to the

“evaluating first the 2D visualization” map-user-test where most of the test-users did not give all the correct answers for the 2D visualization, this time after having evaluated the 3D visualization the test-users gave all the correct answers for the 2D visualization, as it is shown in the Figure 21.

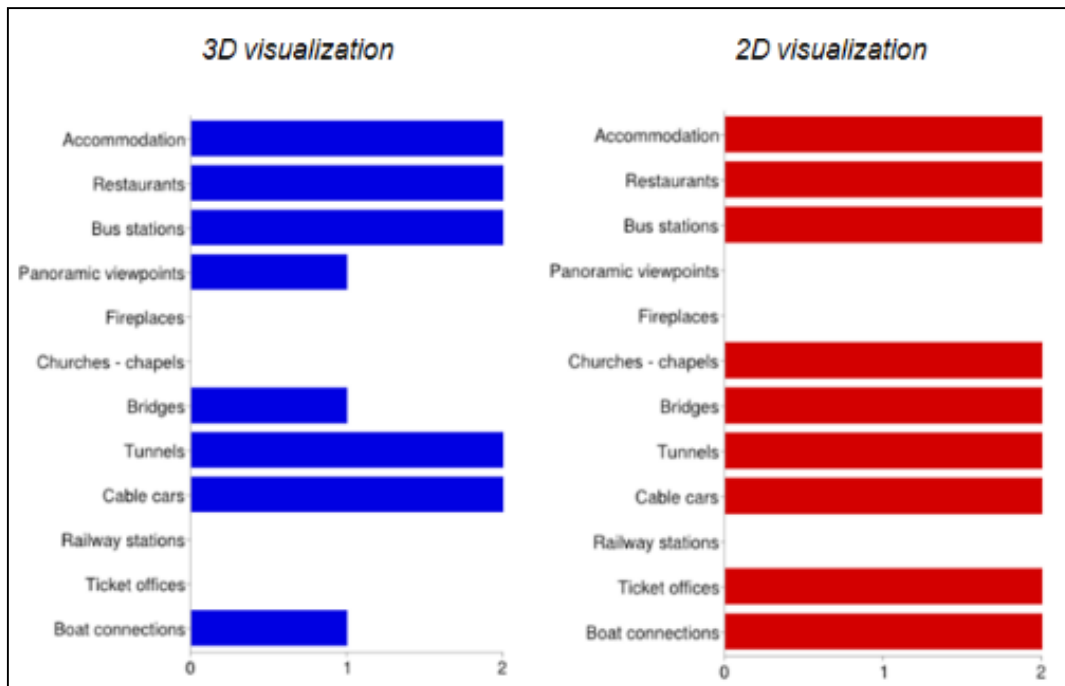


Figure 35: “What information is available for Weggis?”

As it is observed in Figure 36, both of the test-users prefer the 2D visualization and both believe that the 2D visualization is easier to read. The one of them believe that the 2D visualization depicts reality better, whereas the other test-user believes that the 3D visualization depicts the reality better. Only the 2D visualization was considered as more accurate by the one test-user.

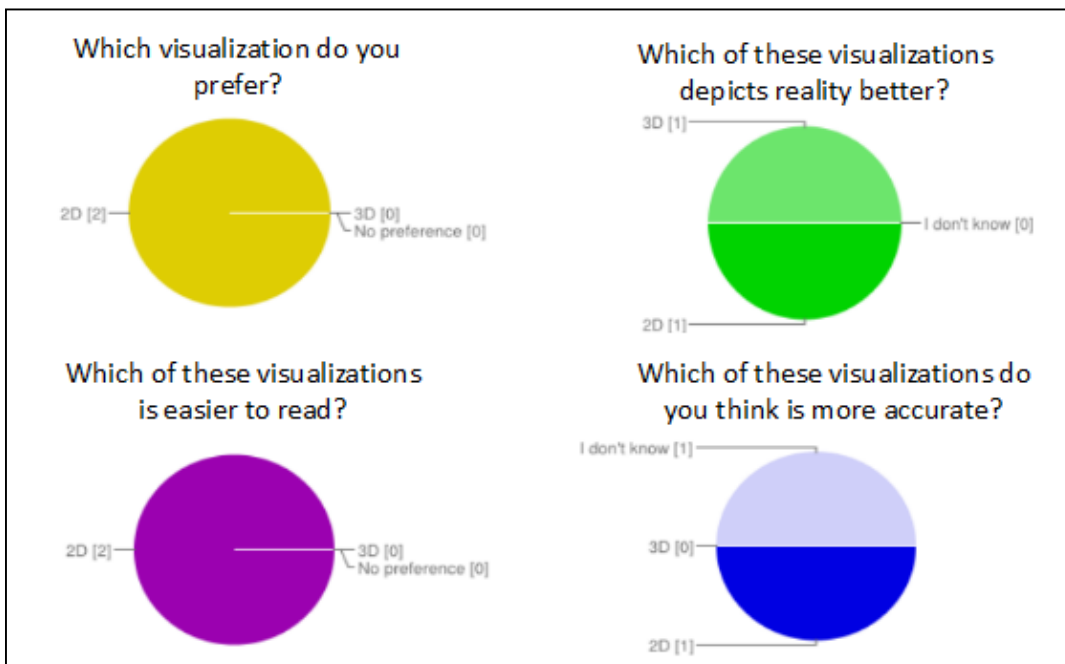


Figure 36: Map design / Map comparison of the test-users evaluating first the 3D visualization

In fact, the results of the map-user-tests cannot be taken into consideration because of the really small number of test-users. However, one important conclusion is derived from the short analysis of the “evaluating first the 3D visualization” results. The 3D visualization is much more difficult to be read and being interpreted than the 2D visualization. The test-users can give some correct answers, but they should try and spend more time to read the 3D visualization. This is obvious in Figure 35. This leads to an ambiguity of the results of “evaluating first the 2D visualization”. The test-users may remember some answers, or they are helped because they have responded previously the same questions for the 2D visualization. If there was at least an equal sample for the “evaluating first the 3D visualization” map-user-tests, a comparison could be realized and probable answers to these questions may have been given.

5.2 Interpretation of the results

Initially, it is important to refer that the results of the map-user-tests are not really representative because the number of the test-users that participated to the map-user-tests are not satisfying for the reliable derivation of conclusions. Additionally, as it is analysed in the previous chapter the results cannot be considered really reliable because the results of the “evaluating first the 2D visualization” are basically taken into consideration for the derivation of conclusions on the comparative evaluation of the visualizations, although the answers of the map-user-test on the 3D visualization may have been influenced because of first responding the same questions for the 2D visualization. Another point worth mentioning is that the two visualizations were not equally easy-to-handle. The 3D visualization has still some deficiencies that need to be improved. Therefore, it was known from the beginning that the conduction of these map-user-tests is an effort to develop and provide a workflow for a comparative evaluation of two visualizations. Only some conclusions would be drawn concerning the 2D and 3D visualization, but the comparison of the two visualizations is not the goal of this master project.

To start with, it is undeniable that more correct answers were recorded at the map-user-tests of the 2D visualization. Besides that, there were more correct answers on the map-user-test of the 3D visualization when the first evaluated visualization was the 2D. As a matter of fact, the map content of both visualizations is similarly recognisable and interpretable. However, the 2D visualization is more effective for cartographic communication in contrast to the 3D visualization. Concerning to the orientation, the majority of the test-users (about 70%) can be well oriented on both of the visualizations.

Concerning to the test-users’ responses, the majority of the test-users prefer the 2D visualization and they believe that the 2D is easier to read. Conversely, most of the test-users believe that the 3D visualization depicts the reality better and concerning to which visualization is more accurate, the opinions of the test-users differ. The same amount of test-users voted correspondingly the 2D and 3D as a more accurate visualization.

Concerning to the age-groups, the age-group 26-40 gave more correct answers when evaluating the 3D visualization in comparison to the age-group 20-25. However, the age-group 20-25 voted for the 3D visualization as more accurate, while the age-group 26-40 choosed the 2D visualization as more accurate.

Concerning to the gender-groups’ results, the males gave more correct answers than females did. Also, it was observed that the males are really well oriented using the 3D visualization in comparison to the females and males selected the 3D visualization as more accurate visualization, whereas the females voted for the 2D visualization as more accurate.

Concerning to the experts/non-experts groups, non-experts are better oriented than experts in both visualizations. Probably this is because non-experts devoted more time to answer the questions and they were more careful than the experts.

6. Conclusions

In this last chapter, the conclusions of this Master project are drawn and probable future works and tasks are described.

6.1 Attainment of the goal

The effort to develop and provide an easy-to handle and useful workflow for a comparative evaluation between two different visualizations, especially a 2D map and a 3D perspective view of an alpine region is achieved. Therefore, the main goal is achieved. The specific workflow could be used for future comparative evaluation of two other visualizations of an alpine region. The visualizations may be both either 2D or 3D visualizations, differently they may be again one 2D and one 3D visualization.

6.2 Final evaluations of the workflow

Although the design of the 2D visualization is a step which can be easily implemented by a map-designer, there are some difficulties when creating the 3D visualization of the same test-area. Some functionalities, which would make the 3D visualization easier to read, are missing. Even if the 3D visualization is able to allow the zooming and its turning around the three-dimension axes (X, Y, Z), the panning of the whole object is not possible yet. Furthermore, the icons and the labels are integrated on the texture of the 3D visualization which does not facilitate the interpretation of the map content by the map users. Their integration on the block diagram as 3D objects would be the optimal way of their presentation for a good recognition and interpretation of the map features. Additionally, the 3D presentation of other map features, such as the buildings, would help significantly in the effectiveness of cartographic communication.

What is more, an important step of the workflow is the formulation of the questions. After analysing all the results, it is considered that it would be better if the questions were different for each one of the two visualizations, but again on the same difficulty level. It was observed that after the evaluation of the 2D visualization, some test-users may remember the answers of the questions which leads to not so reliable conclusions. After the formulation of a questionnaire, its integration on preformed GoogleDrive polls is really easy.

The creation of the website is an easy step to be implemented because it does not require expert programming skills. Indeed, some practise is necessary for the creation of a nice looking website. Furthermore, the integration of the three different modules, i.e. the 2D, 3D and polls, at the website was implemented easily.

It is important to refer that the sample that conducted the map-user-test was not a satisfying one. Firstly, the number of the test-users was really low, so that at the “evaluating first the 3D visualization” map-user-tests the recorded valid answers were just two. The consequence of this fact was that there were no results to analyse for the case of “evaluating first the 3D visualization”. Only some observations were possible to be done. Moreover, the sample was too homogeneous, i.e. there were no more than two age-groups and the majority of the test-users have never visited the depicted region of the visualizations. Probably, a reason for the sample’s homogeneity is the small number of the test-users that participated to map-user-tests.

Additionally, the data collection method that was used for the conduction of the map-user-tests was not successful. The test-users were asked by email to participate to the map-user-tests. The result of this movement was that some of these persons just ignored the invitation. Also, some of the persons who began conducting the map-user-tests, they never completed both of the two map-user-tests or they implemented the two map-user-tests but in an incorrect order, so these participations were later considered as invalid. Despite these cases, it is also observed that because the test-users were conducting the map-user-tests privately, i.e. there was no person inspecting the conduction of the map-user-tests, they may have not devote to the map-user-tests the time that was necessary to be implemented or they were careless with their answers.

The comparative evaluation between two different visualizations was realized, even if the visualizations were evaluated separately. The visualizations were both examined on specific subjects. The subjects under discussion were the map content, the cartographic communication, the orientation and map

comparison/map design preference. Therefore, indeed the comparative evaluation was implemented, even though it was implemented indirectly.

Last but not least, the conduction of the map-user-tests led to general, but important conclusions about the two visualizations. The questions were in the sense of a general, i.e. not too detailed, comparison between a 2D and 3D visualization, so that the conclusions were so profound. A different selection of more detailed questions may give also more specific and detailed conclusions on subjects that may be set under examination.

6.3 Outlook

The proposed workflow of this master project is a basic skeleton and it has multiple prospects for improvement and adjustment. First of all, other visualizations may be integrated on the web-pages for their comparative evaluation. The visualizations may be both either 2D or 3D, but also they can be a2D and a 3D as it was implemented for the present project. Furthermore, the web-pages containing the visualizations may be improved. More interactivity is possible to be implemented on the 2D visualization and the graphical user interface may be improved significantly. Similarly, the 3D visualization and its corresponding web-page may be improved in the same way. Additionally, more functionalities may be added at the block diagram. An important improvement that should be implemented is the panning of the block diagram. Also, the creation of the billboards is a possible improvement for a better interpretation of the map content.

The proposed workflow of this master project may be useful for the examination of different subjects on the visualizations. New questionnaires could be formulated for the examination of more specific aspects on cartographic visualizations. For instance, an examination on design aspects of maps may be implemented with a really careful questionnaire examining this specific subject.

Depending on the kind of the map-user-tests, careful selection of the data collection technique should be implemented. The email invitation is not suggested for more specialized subjects. Probably, a combination of questionnaires and interviews is an optimal way for collecting detailed experts' opinions on specialized subjects.

What is more, another important aspect that should be taken into account in future works is the selection of the test-users and their population. The number of the test-users may be satisfying depending on the kind of the map-user-test that is going to take place. Furthermore, the user-groups of the test-users should be considered. For example, the selection of non-experts for the examination of specific design aspects on cartographic visualizations is fruitless.

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Annex

A. Questions of “poll_2D_A” and “poll_3D_A”

Part 1: Individual characteristics

Question 1: What is your age?

- 15 to 20
- 20 to 25
- 26 to 40
- Over 60

Question 2: Gender?

- Male
- Female

Question 3: Have you ever hiked/been at Rigi, Switzerland?

- Never
- Once
- Just a few times
- I often go to Rigi

Question 4: How often do you use maps?

- I don't use maps at all!
- I just use them only when I cannot avoid it.
- I often use maps.
- My studies/work are in the field of cartography or related field.

Question 5: Please give an id to your map user test. (e.g. mariak87)

This is only required to correspond the map user tests of the two visualizations.

Part 2: Map content

Question 1: Which depicted region does offer more choices for accommodation and food?

- Breiten
- Greppen
- Weggis
- Rigi Kaltbad
- All the above offer more or less the same amount of choices

Question 2: Is there any railway station, close to which there is no ticket office? If yes, which one(s)?

You may choose more than one answer.

- Rigi Wölfertschen-First
- Rigi Staffelhöhe
- Rigi Staffel
- Romiti Felsentor
- Freibergen
- Rigi Klösterli
- Grubisbalm
- Rigi Kaltbad-First
- Rigi Kulm
- Mittlerschwanden
- No, there are ticket offices close to all railway stations.

Question 3: What information is available for Weggis?

You may choose more than one answer.

- Cable cars
- Accomodation
- Bridges
- Panoramic viewpoints
- Fireplaces
- Churches – chapels
- Boat connections
- Railway stations
- Bus stations
- Restaurants
- Ticket offices
- Tunnels

Part 3: Cartographic communication

Question 1: There is the possibility of transportation with cable cars from ... and reverse.

- Rigi Kulm to Breiten
- Rigi Kaltbad to Greppen
- Rigi Kulm to Weggis
- Rigi Kulm to Greppen
- Rigi Kaltbad to Weggis

Question 2: Which are the possible ways to go from Rigi Wölfertschen-First to Rigi Kaltbad?

You may choose more than one answer.

- Hiking
- By bus
- By train
- By car
- Other
- There is no possible way.

Question 3: Is there any region which offers the possibility for a boat trip? And if yes, which one(s)?

You may choose more than one answer.

- Breiten
- Greppen
- Weggis
- Rigi Kaltbad
- Rigi Kulm
- No, there is no region offering the possibility for a boat trip.

Part 4: Orientation

Question 1: You are at Weggis. In which direction would you go to the peak?

- North
- South
- East
- West
- North-East
- North-West
- South-East
- South-West

Question 2: Now you are at the peak. In which direction would you go to Greppen?

- North
- South
- East
- West
- North-East
- North-West
- South-East
- South-West

Question 3: And now you are at Greppen. In which direction would you go back to Weggis?

- North
- South
- East
- West
- North-East
- North-West
- South-East
- South-West

Any comments?

Feel free to write what you liked most and least and recommend any possible changes or adjustments.

B. Questions of “poll_2D_B” and “poll_3D_B”

Part 1: Individual characteristics

Question 1: Please give an id to your map user test. (e.g. mariak87)

This is only required to correspond the map user tests of the two visualizations.

Part 2: Map content

Question 1: Which depicted region does offer more choices for accommodation and food?

- Breiten
- Greppen
- Weggis
- Rigi Kaltbad
- All the above offer more or less the same amount of choices

Question 2: Is there any railway station, close to which there is no ticket office? If yes, which one(s)?

You may choose more than one answer.

- Rigi Wölfertschen-First
- Rigi Staffelhöhe
- Rigi Staffel
- Romiti Felsentor
- Freibergen
- Rigi Klösterli
- Grubisbalm
- Rigi Kaltbad-First
- Rigi Kulm
- Mitterschwanden
- No, there are ticket offices close to all railway stations.

Question 3: What information is available for Weggis?

You may choose more than one answer.

- Cable cars
- Accomodation
- Bridges
- Panoramic viewpoints
- Fireplaces
- Churches – chapels
- Boat connections
- Railway stations
- Bus stations
- Restaurants
- Ticket offices
- Tunnels

Part 3: Cartographic communication

Question 1: There is the possibility of transportation with cable cars from ... and reverse.

- Rigi Kulm to Breiten
- Rigi Kaltbad to Greppen
- Rigi Kulm to Weggis
- Rigi Kulm to Greppen
- Rigi Kaltbad to Weggis

Question 2: Which are the possible ways to go from Rigi Wölfertschen-First to Rigi Kaltbad?

You may choose more than one answer.

- Hiking
- By bus
- By train
- By car
- Other
- There is no possible way.

Question 3: Is there any region which offers the possibility for a boat trip? And if yes, which one(s)?

You may choose more than one answer.

- Breiten
- Greppen
- Weggis
- Rigi Kaltbad
- Rigi Kulm
- No, there is no region offering the possibility for a boat trip.

Part 4: Orientation

Question 1: You are at Weggis. In which direction would you go to the peak?

- North
- South
- East
- West
- North-East
- North-West
- South-East
- South-West

Question 2: Now you are at the peak. In which direction would you go to Greppen?

- North
- South
- East
- West
- North-East
- North-West
- South-East
- South-West

Question 3: And now you are at Greppen. In which direction would you go back to Weggis?

- North
- South
- East
- West
- North-East
- North-West
- South-East
- South-West

Any comments?

Feel free to write what you liked most and least and recommend any possible changes or adjustments.

Part 5: Map design preference / Map comparison

Question 1: Which visualization do you prefer?

- 2D
- 3D
- No preference

Question 2: Which of these visualizations depicts reality better?

- 2D
- 3D
- I don't know

Question 3: Which of these visualizations is easier to read?

- 2D
- 3D
- No preference

Question 4: Which of these visualizations do you think is more accurate?

- 2D
- 3D
- I don't know

Any comments?

Feel free to compare the two visualizations.



Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Declaration of originality

I declare that the written work that I submit entitled
“A useful workflow to compare different 2D and 3D visualizations of an alpine region”
is an original work.

Author: Maria-Vasiliki Kourouni

Supervising Professor: Prof. Dr. Lorenz Hurni

Supervisors: Dr. Christian Häberling
Aline Brünger

With this signature I declare that I have been informed regarding normal academic citation rules and that I have read and understood the information on "Citation etiquette" (http://www.ethz.ch/students/exams/plagiarism_s_en.pdf).

Place and date

Signature