European Journal of Geography Volume 5, Number 4:56- 66, November 2014

VISUAL QUALITIES OF FUTURE GEOGRAPHY TEXTBOOKS

Yvonne BEHNKE
Humboldt-University Berlin, Ph.D. Student Geography Education, Berlin, Germany
Graduate Designer (Visual Communication)
www.behnke-design.com
kontakt@behnke-design.com

Abstract

The capacity for spatial orientation and associated faculties are closely related to visual competencies. Consequently, the practice and acquisition of visual competencies are vital prerequisites to successful learning and teaching of geography. Today, geography can be understood as a visual discipline and as such may develop strong links to visual communication. In geography, textbooks may establish this link in an everyday context. This Ph.D. project aims to build the bridge between subject content and design. The result will be a visually convincing geography textbook prototype. Fifty-six geography textbooks from different European countries were analysed, focussing on the design concept. Furthermore, double-page spreads of current German geography textbooks were evaluated by observing students' textbook usage via eye tracking. Eye tracking monitors students' reactions to varying contents and designs. Findings from both analyses form the basis for the textbook concept, which is to be developed.

Keywords*: geography education, visual communication, geography textbook, textbook analysis grid, eye tracking research, visual competencies*

1. GEOGRAPHY AS A VISUAL DISCIPLINE CULTIVATING VISUAL COMMUNICATION

Today, geography can be understood as a visual discipline and as such may develop strong links to visual communication. As Rose (2003:212) says: *„With the exception of anthropology, geography is unique in the social sciences in the way it has relied and continues to rely on certain kinds of visualities and visual images to construct its knowledges."* But while philosophy, psychology, cognition studies, communications science, visual studies and art history explicitly study the typology, use and functions of images, *geography is primarily a discipline that uses images* (Schlottmann, A., Miggelbrink, J., 2009).

Analysing, decoding and providing visual input is a key part of visual communication. The creation of effective image/text combinations as well as the use of iconography and visual language could be named as basic tools in communication design.

Or as Schlottmann/Miggelbrink say about images: *"Viewed critically, these are not an image of the world but are powerful means to create worlds."* (Schlottmann, A, Miggelbrink, J., 2009:2).

In geography, textbooks may establish the link between geography education and visual communication in an everyday context.

The capacity for spatial orientation and associated faculties is closely related to visual competencies. Consequently, the practice and acquisition of visual competencies are vital prerequisites to successful teaching and learning in the field of geography. Spatial orientation may be seen as one aspect of visual literacy. This includes the ability to analyse, decode and interpret visual input. Or as Thornes says: *„Visual literacy is an important new skill that geography as a whole needs to embrace for both constructing and deconstructing images. The creation and interpretation of visual images has always been important to geography and is what makes geography unique.*" (Thornes, J. E., 2004:793).

A strong focus on visual factors can be found in geography textbooks, where visual input is provided in many different forms. Geography teachers and textbooks make use of visual information e.g. from satellite images, GIS, GPS, maps, photographs, illustrations, paintings, diagrams and statistics. In current geography textbooks, varying visual information is applied to guide students in analysing, decoding and amplifying text input to solve research questions or to complete tasks from the exercise section.

2. STUDY OF EUROPEAN GEOGRAPHY TEXTBOOKS ACCORDING TO A DEVELOPED DESIGN BASED ANALYSIS GRID

2.1 Analysis of selected European Geography textbooks

After considering the theoretical implications, an investigation of the current state of European geography textbook design and conceptualisation built the first step towards a possible new approach in geography textbook design.

Fifty-six selected Geography textbooks from 12 European countries (Western Europe, Southern Europe, Central Europe and Scandinavia) were analysed with regard to innovation in their approach to design and conceptualization. The focus was on books published after 2005, and in certain cases after 2001 (especially innovative in design).

The goal was to analyse the exact design structure of each textbook. What exactly is the concept behind the design? How is the book organised(systematic structure, inner logic, appendices, materials)? Exactly how – using precise and conceptual means – is the textbook design realized? Are typical national traits evident? How are they expressed?

A textbook analysis grid was developed to analyse the design concept of geography textbooks in relationship to communications design and geography education.

2.2 Design and structure of the design based textbook analysis grid

The grid (see fig. 1) was used to systematically analyse the textbooks based on criteria ranging from their external characteristics and general structure to the more specific points of their design and conceptual details. The conclusion of each analysis consisted of a short (subjective) summary of overall substantive and aesthetic qualities of the textbooks. Topic selection and editing of topics were also researched.

Bibliographical information	**country, title, authors, date of publishing, number of pages, information about the authors, contributors, medial interlacing, format, paper, cover**
Structure	**outline, chapters, special sections, additional materials**
Key factual and conceptual aspects	**themes and topics covered, internal structure**
Design and structural elements	**teaching and learning aides, support systems (type and function)**
Layout and typography	**organisation of the layout, page grid, columns, typographical hierarchy, colour concept, picture to text ratio, font mixtures**
Use and type of design for …	**photos, captions, graphics, tables, charts, maps, illustrations**
Practical and aesthetic overall impression	**brief summary + cultural characteristics (if detectable)**

Figure 1. Developed design based textbook analysis grid

2.3 Further research

A preliminary conclusion of the analysis clearly revealed typical national characteristics as well as typical distinctions regarding design and thematic choices. Reciprocal influences are evident. A detailed analysis and research results will be published in the dissertation. The results of this analysis provide additional support for the planned geography textbook.

The further research conducted to the following questions:

Which design elements and which kind of learning aides are used to support learning? How is the image/text relationship? How is information (visual input and text) visually linked in geography textbooks?

3. EYE TRACKING: A VISUAL METHOD OF DATA COLLECTION AND ANALYSIS

The textbook analysis led to the research question: How exactly students link different visual inputs on a geography textbook page? Eye tracking as a visual method of data collection and analysis precisely monitoring the eye movement, thus revealing which parts of a page attract attention to which degree. With this method, two kinds of eye movements (saccades and fixations) were recorded and analysed. Saccades are rapid eye movements from one area of interest to another. Saccades range in duration between approx. 10 ms and 100 ms. Fixations are eye movements that stabilize the retina over an area of interest. The duration of a fixation ranges between approx. 200 ms and 250 ms (Duchowski, A. 2007). By means of these eye movement measurements it can be calculated, in which chronological order and with which intensity the test subject observes different elements on a textbook spread for example.

Eye tracking is used as a data collection method in the neurosciences, perceptive and cognitive psychology, cognitive and clinical linguistics and reading research. As a commercial research method, eye tracking is also used in usability studies of websites; to improve way

finding systems of public buildings; or in optimizing the effectiveness of promotional material to name but a few. Eye tracking as a research method is relatively new to the field of textbook research in Germany.

3.1 Eye tracking research on geography textbooks (research design)

The research was conducted with the help of an EyeLink® 1000 (desktop mount) at the eye lab of the University of Potsdam, Germany. Pupil movements of test subjects were measured at a frequency of up to 1000 times per second (www.uni-potsdam.de/en/eyelab). The eye movement recording was monocular. The test subjects observed a screen displaying double-page spreads of a textbook. The test subjects' head was supported by a chin and forehead rest in order to avoid head movements. The operator ran the test on a control screen, calibrating test subjects pupils, observing test subjects eye movements and recording data (see *EyeLink® User's Manual.* 2007). An additional assistant supported the test subject throughout the entire test procedure.

Although the test setting does not reflect how students naturally work with textbooks, it allows a highly accurate recording of eye movements while a textbook is observed. It is therefore likely that eye movement in the test setting will differ from eye movement while reading a textbook lying on a table. However, the alternative of a student observing the textbook with eye tracking glasses causes less exact measuring results due to a lower frequency of measurement as well as to head movements.

After having evaluated data from pilot tests, tests were carried out with 20 students of 15 years and older from secondary school and university students. No Geography students were tested. A two-stage test was developed.

3.1.1 Objects of research

The objects of the research were double-page spreads of current German geography textbooks covering an identical topic and taken from five separate textbooks (A – E). On each of the selected double-page spreads the content is explained using similar textual and visual elements but with different designs (see fig. 2).

The topic "nutrient circle in tropical rainforest" was selected on grounds of the following criteria:

1. The topic is covered in the current curricula and in all prevailing geography textbooks for secondary schools in all federal states of Germany.
2. The topic had already been taught in the geography lessons of the test subjects (students aged 15 and over).
3. The topic is presented using similar elements, such as photographs, graphics and text, and does not include supplementary visual inputs such as satellite images or illustrations to explain the content.
4. The topic is developed by similar tasks.

The listed criteria aim to ensure the greatest possible comparability of the textbook spreads regarding the content comprehension of the students.

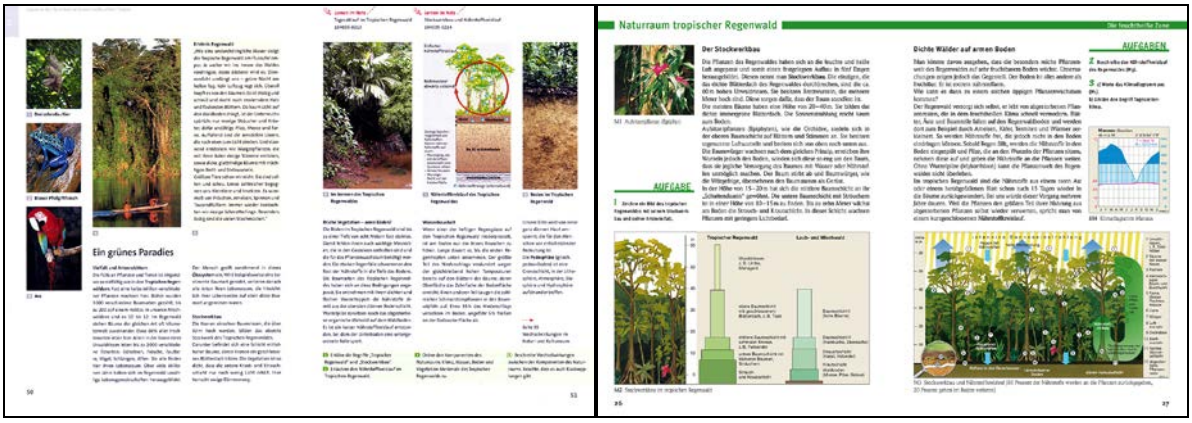

Figure 2. Test spreads (selection)
(2a Krause, K., Werner, S. 2013) (2b Heit, E., Ernst M. (ed.) 2012.)

Areas of interest (AOI) from each page were identified (see fig. 3). AOIs are defined as those elements of textbook spread that are required to solve the set task. Fixation-based data from each selected AOI were recorded to provide exact analyses (fixation count, total dwell time and proportion of fixations and dwell time relative to the trial totals (see *EyeLink® Data Viewer User's Manual, 2007*).

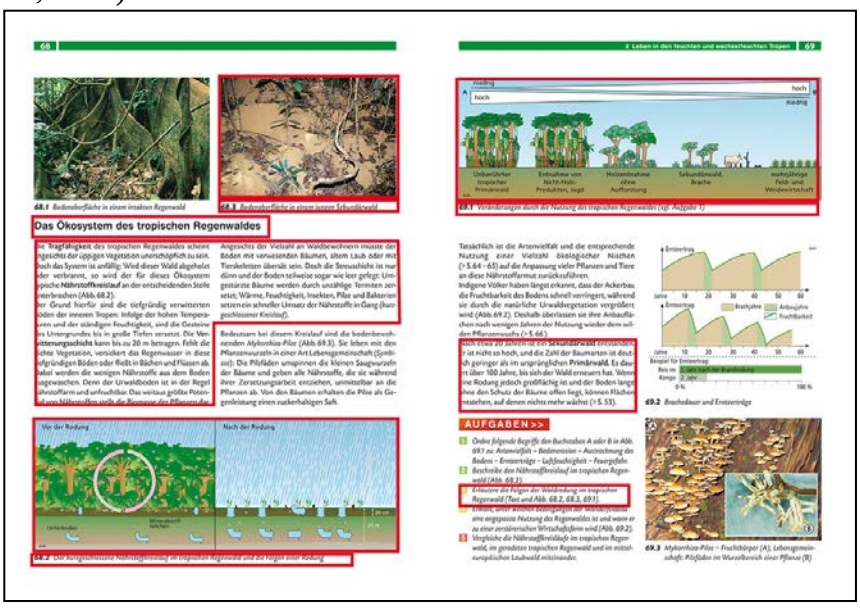

Figure 3. Defined AOI (Example Spread) (Felsch, M., Heß, H., Marth, U. 2012)

The test sequence was randomized. Each test subject viewed the double-page spreads in a different order to disperse the learning effect of each test spread. The focus of the study was on recognising strategies for content comprehension of the two-page spread. Subsequent to the eye tracking test, an evaluation took place by means of a short questionnaire (see fig. 4) and also an additional written evaluation of content comprehension.

Leading questions were: On which page was the information most quickly absorbed? Were all relevant aspects of the information understood? Which path did the test subject's eye take across the two pages? How much time did the test subject require to comprehend the relevant contents?

Which elements of the textbook spread drew the main focus of attention? How exactly the test subject visually linked the provided information in order to solve the test task? Does the textbook design contribute to content comprehension? Which preferences in textbook design do students have? Can correlations be recognised between preferred textbook design and content comprehension?

3.1.2 Test procedure

Each test subject was given the task of first looking at the entire textbook spread in order to determine what exactly was being explained on the pages. The eye movement was recorded (first stage). After finishing the first task, the test subject pressed the stop button and the recording stopped.

At the second stage, the test subject was asked to solve one of the tasks from the exercise section of the double-page spread. The same spread appeared a second time. The eye movement recording started a second time. After completing the task, the test subject pressed the stop button again. The student was asked to write down the answer in short keywords on a prepared evaluation sheet, while the same textbook spread appeared a third time and the eye movement was recorded third time. After completing the task the test subject was asked to pass the evaluation sheet to the assistant. The next test phase started and the next textbook spread appeared on the test screen.

Overall, every test subject observed five different textbook spreads (A – E); every spread was shown three times (a total of 15 eye movement recordings per test subject). Every test subject was asked to complete five test tasks (one per test spread) by observing the page on the screen and additional in written form. After completing the eye tracking test every test subject was asked to complete a questionnaire (see fig. 4).

Assign points from 1 point (best) up to 5 points (least) for each of the following questions. Each number may only be used once per question.	**Spread A**	**Spread B**	**Spread C**	**Spread D**	**Spread E**
Which double-page spread was most appealing visually?					
On which page was the topic easiest to understand?					
Which page had the most understandable graphics?					
On which page could the text be most easily understood?					
On which page did you find the information for completing the exercises quickly?					

Figure 4. Questionnaire

3.2 Test evaluation

The eye tracking test provided three different kinds of data to analyse and to interconnect: the written form (questionnaire and written test evaluation), visualisations (heat maps as jpg-files, trains of vision as jpg-files, trains of vision as mp4-animations) and numerical data sets (eye movement data e. g. trial duration, data from each AOI).To generate the optimal analysis precision, all collected data was separated into two groups, university students and secondary school students. In addition to the individual analysis, an overall analysis summarised the results.

3.2.1 Questionnaire and written test evaluation

Every question from the questionnaire (see fig. 4) was evaluated individually. Furthermore the questionnaire was evaluated under the following research questions: Which spread reached the best marks altogether? Which spread received the best evaluation from university students, which from secondary school students? Which correlations between favoured spreads and eye movement can be established, if any?

By means of the written test evaluation was analysed which spread enabled students to complete the task with the best results, which with the least. Could correlations between test results and eye movements (data sets, trains of vision and heat maps) be ascertained?

Can correlations between most popular spreads and the results of the written test evaluation be determined?

3.2.2 Visualisations of test subject eye movements

The heat map shows the main areas of attention while the test subject was observing the textbook spread superimposed on the background image of each page (test spread). Fixation duration is depicted with different colours. The heat map reveals what attracted a given test subject’s attention to which degree (see fig. 5).

Heat maps were produced for every test subject (three test stages, five test spreads, in total 300). In addition, sample heat map averages combining all test subjects were produced for each of the five test spreads in each of the three test stages (in total 15).

The heat map visually demonstrates which parts of test spreads were observed most, which of the provided materials a student focussed on in order to solve the set task and which materials the test subject ignored. During both test phases, different areas of main attention were visible, showing individual strategies to solve the set task.

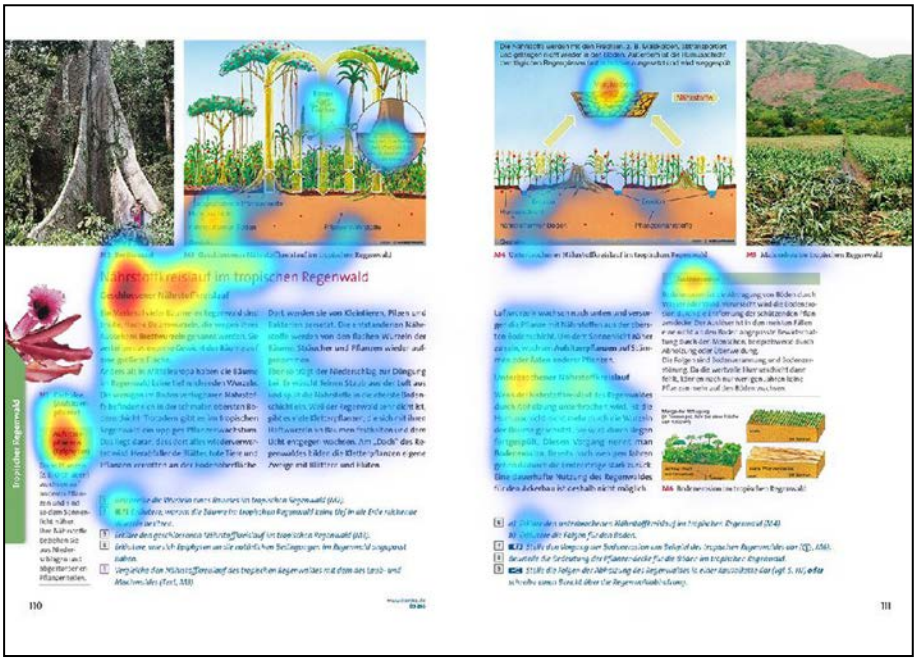

Figure 5. Heat map (example) (Bahr, M., Frambach, T., Hofemeister, U., Lüdecke, T., Teschner, H., Wendorf, M. 2013)

A test subject's train of vision is expressed in two different types of jpg-images and animated in mp4-video. The train of vision is superimposed on the background image of each page (test spread). Saccades are displayed as lines. Fixations are displayed as dots. In one form, the train of vision is illustrated in dark blue (see fig. 6). In a second version, observance time is colour-coded (from blue to yellow, yellow to red) and AOIs are marked in light red.

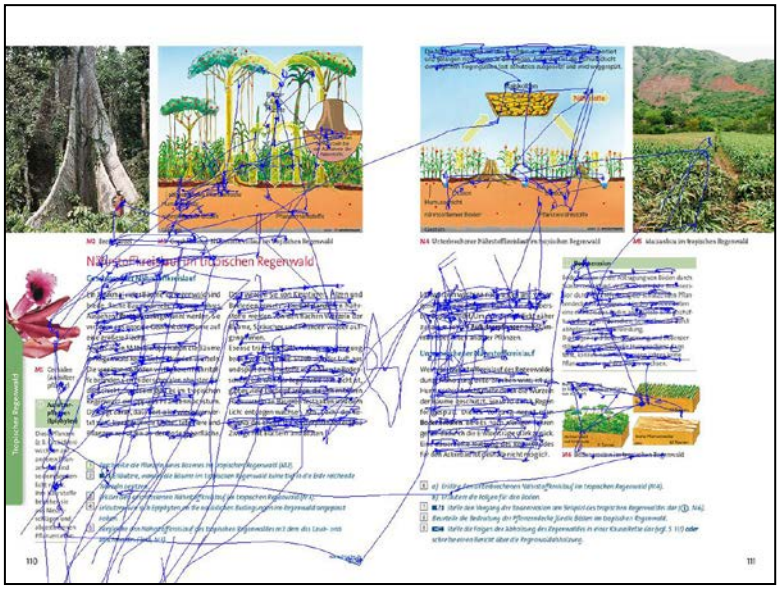

Figure 6. Train of vision (example)
(Bahr, M., Frambach, T., Hofemeister, U., Lüdecke, T., Teschner, H., Wendorf, M. 2013)

The train of vision shows the time, quantity and the order in which the test subject passed every single AOI. The animated mp4-file shows the path of a test subject's eye movement over the textbook spread in 2,4x speed.

Trains of vision depict students' strategies for collecting and interconnecting textbook spread information. They illustrate conclusively whether all relevant aspects of the provided information were found on the spread or not.

3.2.3 Data sets of recorded eye movements

The eye tracking test provided four different sets of eye movement data from every test subject: one data set on the trial duration and three data sets on the AOIs (order of actuated AOIs, proportion of time in the AOIs, duration of focus in the AOI).

The trial duration data (five test spreads, three test stages) shows the time (in seconds), which every test subject needed in order to solve the test tasks (*stage 1* what exactly is explained on the textbook spread, *stage 2* completing one task from the exercise section).

Interconnected research questions were: On which textbook spread was the information most quickly absorbed? How much time did the test subject require to comprehend the relevant contents?

The order of actuated AOI shows in which order the test subject activated every single AOI. Only a length of stay of over 500 ms was recorded. The data set also shows when each AOI was actuated for the first time. The data set may show strategies of content comprehension depending on the task: Which page element comes first and in which exact order were the AOIs activated to collect all relevant information?

The proportion of time spent in the AOI provided a data set average for all test subjects. It shows the distribution of time spent in every single AOI in percentage of the trial duration. An additional data set shows the average duration of stays in seconds for every single AOI. The time based AOI data sets show how much time every test subject spent collecting relevant information from every single AOI.

Research questions that arose were as follows: Are there clear correlations between the number of AOIs activated and the results of the written evaluation? How much time did students spend on a textbook spread, how much time exactly on which page element? Which kind of information (photographs, graphics, and text) did students prefer solving a task or answering a research question? Are there discernable strategy differences between secondary school students and university students in the recorded eye tracking data?

3.3 Conclusions thus far

The eye tracking test showed that many students had difficulties to interlink complex image-text-relations in geography textbooks in order to solve tasks from the exercise section.

The research task is now to analyse all collected data in view of content comprehension and correlations between main areas of attention (heat maps), written test results, numerical data sets (AOI, trial duration) and trains of vision. The recorded eye movement data are currently being analysed.

A key aspect of geography education is working with, describing and analysing visual inputs such as maps, photographs, diagrams and modern media as much as GIS, GPS and satellite

images as well as to relate visual input and text to each other. Acquiring and implementing visual competencies is important to successful learning and teaching of geography. Consequently, the ability to decode and analyse visual inputs as well as interconnecting different forms of information (visual inputs and texts) should be trained more often.

When teachers are aware of students' strategies for absorbing textbook information, they are better equipped to give targeted assistance for completing tasks or answering research questions.

The detailed analysis of all collected data and final conclusions will be published in the dissertation.

4. CONCLUSION

The design quality in textbooks may contribute to students' learning success. Functionality and relevancy from the student's perspective should be given more consideration in geography textbook design.

In future textbook concepts, the design of visual information and the interrelationship between visual inputs and text should be improved. Various forms of information should support one another in greater efficacy.

Analysing and interrelating assorted visual input with text requires a capacity for abstraction and systemic thinking. Systemic thinking is also vital to understanding complex global relationships and should also be a factor in the conceptualization of a geography textbook. As Lambert says: "*Thinking geographically allows young people to make connections from the personal to the global scale.*" (Lambert, D. 2009:4). The guiding principle for geography textbooks should be encapsulated in the concept of geography as it contributes to a better understanding of the world (see Taylor, Liz. 2011).

The research results form the base for the development of design based strategies to improve students picture text comprehension, which could be applied in geography textbooks.

REFERENCES

Bahr, M., Frambach, T., Hofemeister, U., Lüdecke, T., Teschner, H., Wendorf, M. 2013. *Durchblick. Erdkunde 7/8. Niedersachsen. Differenzierende Ausgabe*. Westermann. Braunschweig. 110-111.

Driver, F. 2003. *On Geography as a Visual Discipline.* Antipode (35) 2: 227-231.

Duchowski, A. 2007. *Eye Tracking Methodology Theory and Practice*. Springer. London: 40-47.

Felsch, M., Heß, H., Marth, U. 2012. *Seydlitz 9/10 Geographie Berlin*. Schroedel. Braunschweig: 68-69.

Flath M., Rudyk, E. (ed.) 2012. *Unsere Erde Hessen 1*. Cornelsen. Berlin: 176-177.

Heit, E., Ernst M. (ed.). 2012. *Diercke Erdkunde Saarland Gymnasium 7. Schuljahr*. Westermann. Braunschweig: 26-27.

Krause, K., Werner, S. 2013. *Terra Geographie 9/10 Berlin und Brandenburg*. Klett. Stuttgart: 50-51.

Lambert, D. 2009. Introduction part 1: What is living geography*?* In Mitchell, D. *Living Geography: Exciting futures for teachers and students.* Chris Kington Publishing. London: 4.

Rose, G. 2003. On the Need to Ask How, Exactly, Is Geography "Visual"? In *Antipode 3*: 212-221.

Schelhaas, B., Wardenga, U. 2007. Die Hauptresultate der Reisen vor die Augen zu bringen oder: Wie man Welt mittels Karten sichtbar macht. In *Kulturelle Geographie. Zur Beschäftigung mit Raum und Ort nach dem Cultural Turn*. Ed. Berndt, Ch., Pueutz, R., transcript, Bielefeld, Germany, 43-166.

Schlottmann, A., Miggelbrink, J. 2009. Visual geograpies – an editorial. In *Social Geography 4*: 1-11.

SR Research Ltd. 2008. *EyeLink® User's Manual Version 1.4.0* Mississauga, Ontario, Canada.

SR Research Ltd. 2007. *EyeLink® Data Viewer User's Manual Document Version 1.8.221* Mississauga, Ontario, Canada.

Taylor, L. 2011. Basiskonzepte im Geographieunterricht. In *Praxis Geographie 7/*8: 8.

Thornes, John. E. 2004. The visual Turn and Geography. (Response to Rose 2003 Intervention). *In Antipode 36* (5): 787-794.

http://www.uni-potsdam.de/en/eyelab/research/introduction.html (30.06.2014)