International Cartographic Association
Association Cartographique Internationale

Sharing knowledge

Joint ICA Symposium

Event organized within the activities previous to the 26th International Cartographic Conference

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Dresden University of Technology, Germany

Participating ICA Commissions:

Commission on Cartography and Children
Commission on Education and Training
Commission on Maps and Graphics for Blind and Partially Sighted People
Commission on Planetary Cartography

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FOREWORD

The International Cartographic Association (ICA) celebrates its most important event for cartographers all over the world, the International Cartographic Conference every two years. During the last years, the organization of pre-conference events (joint meetings, symposia and workshops) became a tradition for the ICA Commissions. In 2005, before the 23rd International Cartographic Conference in A Coruña (Spain), five commissions had a Joint ICA Seminar organized at the Technical University of Madrid. Later, in 2011 four commissions and a working group organized the Joint ICA Symposium entitled "Maps for the Future: Children, Education and Internet" at the University of Orléans in France.

This year ICA organizes the 26th International Cartographic Conference in Dresden, Germany. Keeping alive our tradition, four commissions organize a Joint Symposium entitled „Sharing Knowledge" at Dresden University of Technology on 23 August 2013. The four participants are the Commission on Cartography and Children, on Education and Training, on Maps and Graphics for Blind and Partially Sighted People and on Planetary Cartography.

The members of these Commissions present the results of their research in the last two years in three thematic sessions, and a special workshop is dedicated to distance learning. A special characteristic of the majority of papers is that they are interdisciplinary, offering a coloured fusion of the themes representing each of the participant commissions in this one-day meeting.

The International Cartographic Association makes notable efforts to widen and deepen its relations with international organizations working on fields very close to Cartography. This year, our joint symposium also wished to contribute modestly to the active and fruitful dialog with other organizations. We invited representatives from the International Geographic Union and the National Geographic Society to have special presentations in the Opening Ceremony: Joop van der Scheep (The Netherlands) presented the IGU Commission on Geographical Education (of which he is Co-Chair) and Sean O'Connor (USA) talked about the role of the Education Division of the National Geographic Society in the K-12 Education.

The success of an event is first of all assured by the presented papers, but it could not be possible without the logistic support of local organizers. Participant ICA Commissions wish to thank for the valuable help given by the German members of the ICC2013 Local Organizing

Committee and colleagues from the Dresden University of Technology, headed by Manfred Buchroithner.

Organizers would like to thank the commission chairs for their active collaboration, as well as the participation of members of our Commissions or just visitors interested in our activities. With joining our professional experiences we make the ICA and first of all Cartography a stronger factor of a more sustainable and equitable global development…

Budapest, 20 June 2013

László Zentai
ICA Secretary General

Jesús Reyes
Chair, ICA Commission on Cartography and Children

Trends in Academic Cartography Education: The Austrian Way

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Keywords: Cartography, education, university, geodesy, geoinformation, bachelor, master

1. Introduction

The only constant in academic surveying education is the change: These words describe significantly the situation of universities and institutes who are providing study courses in the field of surveying and geoinformation.

The spectrum of changes is manifold: new technologies caused the integration of new subjects (e.g. location-based services, Geographic Information Systems) to curricula. Modern information and communication technology opened new ways of knowledge transfer and the paradigm shift in academic education from “teaching to learning”. Besides these technical orientated impacts the universities were faced with new frame conditions in educational management: The implementation of the Bologna process forced universities – at least at European level – to make a complete redesign of all their study courses. In Austria the introduction of New Public Management opened the academic institutions more autonomy in managing the research and education activities, but raised extra administrative tasks and work for academic staff.

Dependent on study courses and study sites universities nowadays have to face additional challenges for delivering academic surveying education and training: New employing models and tenure tracks for scientific staff, which soften the educational principle of Wilhelm Freiherr von Humboldt (767-1835) of an entity between research and teaching activities, have to be adapted to guarantee further on excellence in education. And finally universities have to cope with the situation of decreased budgets, national and international competition, and - especially teaching institutions providing technical study courses - with low numbers of students.

After presenting an overview of the cartography education in Austria, the key challenges for the academic institutions providing such an education will be identified and the following three megatrends will be discussed – from an Austrian perspective: Harmonisation & Globalisation; Autonomy of Universities; New Forms of Teaching and Learning.

In the final chapter conclusions will be formulated and an outlook regarding the Austrian situation in academic surveying education will be presented.

2. Trends

Continuously academic institutions are adapting the existing study programmes and techniques of knowledge transfer to the changing political and administrative frame conditions as well as to new developed methods and requirements in the professional fields. In Austria all bodies involved in cartography education have to cope with three key impact factors:

- Harmonisation & globalisation of educational programmes,
- Implementation of autonomic management, and
- Delivery of new contents using modern teaching and learning techniques.

2.1. Harmonisation & Globalisation of Educational Programmes

The Bologna Declaration was adopted by the Ministers for Higher Education of 29 countries in spring 1999 with the objective to create a European Higher Education Area (EHEA) by 2010. Every two years the Bologna Action Lines - a bundle of strategies to achieve the ambitious goal - are revised and amended. At the Ministerial Conference in 2009 the Ministers in charge established the priorities for the EHEA up to 2020. They highlighted especially the importance of lifelong learning, of widening the access to higher education and of increasing the mobility of teaching staff as well as of students. Global aspects are included in all these action lines. Until 2010 the number of participating countries increased up to 47.

Within the last years Austrian Universities adapted their study programmes to the requirements of the Bologna Declaration. Experience shows that the implementation of the concept is only partly successful:

Successful Austrian actions:

- The formal implementation of the three-cycle-system. All universities providing curricula in the field of cartography and geoinformation

changed the system to Bachelor (6 semesters) and Master Study (4 semesters).
- The implementation of the credit system (ECTS) provides more transparency. That should be a gateway to more mobility.
- There is more focus put on students by the introduction of new learning and teaching methods.
- The change of system gives a modern touch to the studies and leads to an increasing number of first-year students.

Lesson to learn for the Austrian cartography education:

- The three-cycle-system is not accepted in professional practice – there are no jobs for bachelors (also in public institutions)!
- There is no involvement of the stakeholders in the educational concept of studies.
- Austrian students are still not flexible and mobile. Nearly all of them do their master study in the same course programme at the same university.
- The ECTS-system is based on the workload of the teachers and not at students.

2.2. Implementation of Autonomy at Universities

In 2002 the Austrian Parliament enacted a new law that introduced new public management at the universities with a high level of autonomy. The implementation of this law caused structural changes in the university management and had an essential impact to carrier models of scientific staff. The transition from the former central-controlled university to a modern economy-driven service and research organisation is still ongoing with all the advantages and lacks appearing in such processes.

The following key aspects influencing this process:

- Impacts to institutions:
  - Free access to universities (no limitations on numbers of students per study course – no study fees)
  - Increased number of administrative staff (instead of scientific staff)
  - Globalisation of budget (positive)
  - Introduction of performance indicators (e.g. number of students)
  - Endangerment of cancelling study programmes with low number of students
  - Increased marketing of studies (as amount of students is a parameter for budget)
- Impacts to staff:

- Additional administrative tasks for teachers and researchers at the universities
- Definition of fields of competence for specific universities
- Introduction of performance indicators (e.g. number of students)
- New carrier models

2.3. Providing Knowledge Using Modern Teaching and Learning Technology

e-Learning

Traditional classroom lecturing is already being supported or even replaced by virtual media in the future. This trend is changing the traditional role of the universities. In spite of this, there is no doubt that the computer cannot replace the teachers and that the learning process cannot be automated.

In Austria the University of Salzburg is part of a consortium that is providing a virtual master course, called “UNIGIS”. The study programme started in 1993 and has already 1000 graduates.

All together there is no doubt that these changes in education represent new opportunities and also open and maybe redirect the universities. But the most important part of e-learning will be in the area of lifelong learning programmes. There is so much potential and e-learning can easily fulfill the needs graduates have on the system.

From Teaching to Learning; Swing from Measurement to Management

It is more and more important to use wisely the data, information, and knowledge in planning, decision-making, and management. The volume of data we have to deal with is increasing and becoming even more accurate and complex. There is no doubt that all the basic skills within measurement and mapping are very important but maybe in the future the focus will have to change. The major role of an academic surveyor is changing; engineering disciplines will take a back seat. Project management and also the interchange between different disciplines will have a more important role. Modern Cartographers have to learn to be flexible within all the changes and they have to deal with life-long learning.

Quality Assurance

In Austria´s university education the main focus is assuring a high-level education. Therefore the quality of the education is always measured and monitored. After every term an anonymous evaluation of the classes by the students is carried out.

Another part of the Quality Assurance programme is to compare programmes with different international examples. This way there is a high transparency and so universities can communicate with others about their results and maybe changes they can think of. At the Vienna University of Technology for example the first Best-Teacher Awards were given as a result of quantitative and qualitative measures. This is also a motivation for the teacher to improve their lectures and also a good thing for the students so that they can see that their opinion is very important. Of course many Teaching Skills Enhancement Trainings and workshops on didactical methods and workshops on applying e-Learning methods are offered by the university.

TU Austria (Cooperation between All Technical Universities in Austria)

Under the heading United through Excellence the University of Technology Vienna, the University of Technology Graz and the Montan-University of Leoben founded the TU Austria. With this federation they want to achieve better coordination in research, teaching and services, to realize synergies, lobbying and benchmarking to identify best practice. This network involves nearly 8.000 assistants and nearly 38.000 students.

3. Cartography at TU Vienna

Currently the Vienna University of Technology offers:

- Bachelor program “Geodesy and Geoinformation”
- Master program “Geodesy and Geoinformation”

The master program is intended for native and foreign students who have achieved a bachelor‘s degree and aim working as decision makers or leading scientists in geoinformatics, geodesy and navigation, engineering surveying, data adjustment, computer vision or remote sensing or cartography.

The master program includes theoretical and applied courses of contemporary topics of Geoinformation and Cartography. In detail the master program deals with the acquisition, modelling, analysis, visualization and communication of geo-data. Specific tasks include the combination of data from different sources, the integration into spatial information systems, and the establishing of user-adequate visualization techniques.

As a result of a broad discussion within the university the following strategic aims have to be applied at in all education programs of Vienna University of Technology:

- competitiveness
- efficiency
- responsibility

In detail this includes the overall strategy on ensuring high quality programs instead of mass education programs and aiming on producing students which are able to “compete” on an international level. More emphasis is at the moment and will in the future be put on at the following three important accents: internationalization of education, e-learning and continuing education.

4. The International Master on "Cartography"

The international Master’s program (Masters of Science, M.Sc.) in Cartography and Geoinformatics is a cooperation of the cartography departments at the TU München, TU Wien and TU Dresden. It is suited for students with a Bachelor or diploma degree in engineering or science, best in cartography, geodesy, geoinformatics or informatics, as well as geography with focus on GIS. Target audiences are high-qualified students from all over the world especially from Asia and Eastern Europe, as well as students from Europe, like degree holders in cartography. Start of the first program-turn was at winter semester 2010.

It is a 4-semester English-language Master program and has an intake between 15 and 25 students per year. Students obtain 60 ECTS credit points for each academic year in which they meet all commitments, thus altogether 120 ECTS credit points. The first semester offers different learning paths, addressing both the previous know-how and the requirements of the students (harmonization of knowledge). In general, the first 2 semesters contain mainly basic and advanced courses in cartography and geoinformatics taught at TU Wien and TU München. In addition, key competences (project management, research methods) are provided. Furthermore, a Summer School for special projects is planned. In the 3rd semester, students specify in a certain field of interest in cartography and geoinformatics, in which one of the 5 cooperating universities are specialized in. In the 4th semester, students are supposed to write their Master thesis.

The Master's program “Cartography and Geoinformatics” focuses on a comprehensive education in cartography and geoinformatics: spatial information technology, spatial data managing and analysis, as well as visualization of geodata and communication of spatial information. Besides of capability for solving practical and development tasks in the fields related to cartography and geoinformatics, the students are supposed to be trained for taking part in research projects and the continuation of their studies for the PHD degree.

One challenge will be to handle the mobility of students and lectures between the co-operating universities. Therefore, different options are used:

block courses, hold amongst others by distinguished guest lecturers; integration into existing courses and possibly lecture transmission via video streaming, respectively e-learning.

One of the main objectives of this program is to maintain the high level of cartography science in Europe and to create a "spearhead" in cartography and geoinformatics by the collaboration of 5 universities, which provide a very high concentration of scientific competence. Another goal is to enhance international relations and university collaborations in Europe, using the synergetic effects of 5 universities and combining their advantages. Furthermore, the program shall improve exchanges of students and scientists worldwide. The Master program will accept well educated students to prepare them for current workforce demands while giving them a life-long career path. There are a couple of unique features which justify this Master program. It is a top quality international Master program by international standards. Also, it will be the first English-language Master of Science in “Cartography and Geoinformatics” in the German-speaking part of Europe. One important aspect is an intensive and individual supervision of the students. There is no competition to other Master programs at the cooperating universities. The program is strongly supported by the ICA - International Cartographic Association. Another advantage is that the program focuses on both, cartography and geoinformatics, which offers the students excellent job perspectives, an access to an international research network and a scientific career. The program is supporting high-quality and top-level educated students. With their very high concentration of scientific competence, three top European universities are forming a unique "Cartography and Geoinformatics " Master program not only in Europe, but also worldwide.

5. Conclusion and Outlook

In this paper some general perspectives have been given on defining the current framework in which curricula have to be developed and a contemporary cartography education has to be ensured. Giving concrete examples of cartography education programmes at TU Vienna and in within the joined International master programme some promising strategies are outlined.

Maps for Spatial Thinking and Learning across the K-12 Education Continuum

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Abstract. National Geographic Education aims to increase geographic literacy across society, with a special emphasis on K-12 students in the United States, and their teachers. Towards this end, the education outreach division of the National Geographic Society has set out on a project to gain a better understanding of how maps can be used as tools for increasing geographic literacy, across school grades and ages. As part of this, National Geographic aims to develop map-based resources and materials optimized to enable geospatial learning and the development of geospatial thinking skills amongst both students and teachers and to develop exemplars that highlight developmentally appropriate uses of maps across this spectrum of school grades and ages. When teachers understand how maps can be used to build up geospatial skills and thinking for students, they will be more willing and prepared to bring these resources into the classroom in effective ways.

Keywords: National Geographic, education, K-12, geospatial learning

Bridging Distance in Cartographic Education

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Abstract. Learning about the mapping sciences can now be readily facilitated through distance education platforms and teaching practices. Distance education provides the cartography community with new means for engaging more larger and more diverse student populations. New modes of engagement, such as massive open online courses, offer the potential to radically increase the numbers of students who have exposure to cartography. This paper identifies several key challenges and opportunities that correspond to cartographic distance education.

Keywords: Distance Education, Cartography, MOOC

1. Cartographic Education at a Distance

Learning at a distance is not a new phenomenon, having much precedent in correspondence courses in the pre-digital age. Since the 1990's, digital means for learning at a distance, facilitated by the growth of the internet, has spurred the development of new modes of engagement in distance education and helped foster connections to new and more diverse student populations.

Distance learning online is now an area of rapid growth in higher education around the world. More and more students are taking online classes, and a wide range of types of institutions, including those that had initially been reluctant to engage in distance education, are now deeply engaged in this enterprise. Platforms for teaching online are now reasonably mature, and best practices for ensuring high quality in online courses are well-established and evaluated - including courses that specifically focus on geospatial topics (Unwin et al. 2011).

The domains of geospatial technology and geographic information science have benefited from a great deal of attention to defining possible learning objectives and core competencies from which educators of all kinds can draw upon when creating new courses and revising old ones. The GIS&T Body of Knowledge defines over 1600 educational objectives (DiBiase et al. 2007), and a new version covering an even wider set of topics is currently in development. A complementary effort by the U.S. Department of Labor to define a Geospatial Technology Competency Model provides a set of core competencies for working professionals in the field (DiBiase et al. 2010).

Cartographic skills and competencies are described in both of these frameworks, but few existing distance education programs touch on the full array of topics. At Penn State, we offer one cartographic design class in a broader curriculum of over 25 other online classes in geospatial analysis and technology (www.pennstategis.com). There remains much that can be done to broaden the scope of available distance education offerings in cartography topic areas.

2. Student Populations

We can engage cartography students on campus, as well as off-campus through distance education mechanisms. The former case may seem odd at first, but online classes are attractive for use in resident education programs for multiple reasons. Students increasingly expect to be able to engage with content and instructors in an asynchronous manner. Additionally, distance education platforms offer the opportunity for instructors to use "face-time" with students in classrooms for high-impact engagement; around discussion topics and project critiques, for example. The core topical content can be delivered online in an asynchronous manner and the classroom time can be focused entirely on those high-impact activities, rather than including a lot of passive engagement as well (students listening to a lecture, for example). This use of distance education is often called blended-learning (Garrison and Kanuka 2004).

For the cartography community, one could imagine using classroom time to focus primarily on the development and refinement of map designs, and using online mechanisms for delivering lecture content and reading materials.

In addition to undergraduate and graduate student populations who reside on campus, distance education in cartography has the potential to draw students who are off-campus and for whom access to higher education in a resident program is simply not possible or practical. Such students may already be pursuing a career full-time, while others may simply find it costprohibitive to migrate to another place to study. Furthermore, distance education is often more affordable than comparable resident education options, particularly when one considers the cost savings from not having to physically move to a new locale. At Penn State, for example, the total cost of tuition for the Master of GIS degree offered online is roughly half the cost of attending the Master of Science in Geography degree taught on campus (and that does not include the cost of living on campus).

3. Modes of Engagement

Students engage in distance education through synchronous, asynchronous, and blended-learning approaches (Wright and DiBiase 2005). In the synchronous case, students and faculty engage with one another at the same time, but via distance technology such as videoconferencing. In asynchronous online learning, students and faculty engage at different times, using common course content (which can include videos, readings, graphics, and interactive simulations, among other things), and discussions take place using asynchronous means such as message boards, email, or multimedia collaborative environments like VoiceThread (www.voicethread.com). As mentioned above, blended-learning uses some asynchronous engagement along with some synchronous (classroom) engagement.

A recent advance in asynchronous distance learning is the rise of the Massive Open Online Course (MOOC), which relies on scalable learning technologies to deliver courses for free to very large numbers of students around the world (Fini 2009). Multiple platforms now exist for hosting MOOCs, including Coursera (www.coursera.org), EdX (www.edx.org), and Udacity (www.udacity.com), which at the moment are the most popular major MOOC environments, each having millions of registered student users.

At present, there are only two MOOCs on Geography topics. Penn State (led by the author) has announced a MOOC called *Maps and the Geospatial Revolution*. University of Wisconsin-Madison has announced a MOOC called *Globalizing Higher Education and Research for the Knowledge Economy*. Both courses are to be offered on Coursera in 2013. At the time this article was written (April, 2013), over 10,000 students had already enrolled for *Maps and the Geospatial Revolution*.

Clearly, there is a huge potential for academic cartographers to develop a wide range of MOOCs around mapping topics to expand awareness of the discipline and deliver high-quality map education experiences to much more diverse audiences (+60% of Coursera students are from outside the U.S.).

4. Challenges and Opportunities

The Cartography community faces a range of challenges when it comes to taking advantage of distance education and new modes of engagement. These challenges include:

- How do we create rich map design studio experiences through asynchronous technology?

- How can the Cartography community strengthen the value proposition for working professionals to take courses in the mapping sciences?

- What can cartographic educators do to avoid the trap of designing digital content around technologies that change constantly?

At the same time, exciting opportunities now exist for the Cartography community to leverage from recent advances in distance education:

- We can engage students who cannot access our academic programs in on-campus settings.

- We can support discovery of what we do to much broader audiences through platforms like MOOCs.

- Many cartographic research problems could benefit from attention from broader audiences that include adult learners and international students who are frequently drawn to distance education programs.

5. Conclusion

Cartographers in the International Cartographic Association (ICA) community should be leading research, design, implementation, and evaluation of distance education models for teaching about maps. This paper has attempted to elaborate some of the emergent research challenges and opportunities, but there remains a great need for larger collaboration around this effort. While more people use and create maps than ever before in human history, we are still only educating a very small proportion of the population in the science and art of our discipline. New affordances for educating students at a distance constitute an important opportunity for us to change that trend.

References

DiBiase, D, Corbin, T, et al. (2010). The new geospatial technology competency model: bringing workforce needs into focus. URISA Journal 22(2): 55-72.

DiBiase, D, DeMers, M, et al. (2007). Introducing the first edition of the geographic science and technology body of knowledge. Cartography and Geographic Information Science 34(2): 113-120.

Fini, A (2009). The technological dimension of a Massive Open Online Course: The case of the CCK08 course tools. International Review of Research in Open and Distance Learning 10(5).

Garrison, D R and Kanuka, H (2004). Blended learning: Uncovering its transformative potential in higher education. Internet and Higher Education 7: 95-105.

Unwin, D, Tate, N, et al. (2011). Teaching geographic information science and technology in higher education. New York, NY, John Wiley & Sons.

Wright, D J and DiBiase, D (2005). Distance education in geographic information science: symposium and an informal survey. Journal of Geography in Higher Education 29(1): 91-100.

Archiving and Public Dissemination of Planetary Geologic and Geomorphologic Maps

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Abstract. Geologic and/or geomorphologic mapping is an established tool to communicate research results and provide an interpretation of the formation and evolution of planetary surfaces and bodies. Such mapping has historically been conducted either under coordinated control of geologic agencies or by research individuals. To ensure that the number of different maps and GIS-based mapping projects are re-usable and accessible for future mapping projects and research analysis, a platform is needed which provides not only access to maps but which also provides a common technical framework. The conceptual discussion presented here focuses on development of such a networked communication framework and data platform.

Keywords: Planetary Mapping and Cartography, GIS

1. Introduction

1.1. Background

Planetary exploration and mapping are cumulative processes: each mission provides new data and new data resources for analysis and interpretation. Mapping of planetary bodies has been an important asset in the space-based exploration since the 1960s. Based on these data several image maps (such as controlled photomosaics, shaded relief maps, topographic maps) and special-purpose (thematic) maps have been created and publicly released. These (secondary) maps are obtained by interpreting, abstracting and processing remotely-sensed data. The work we present here focusses on geological and/or geomorphological thematic maps, i.e. maps that provide information and interpretation results on the state and development of planetary solid surfaces. Maps such as these provide an abstract view on basic data, where generalized information has been extracted using thematic criteria and which have been displayed on a map. Until today, thousands of maps of planetary bodies including Mars, Moon and Venus were produced and officially published by mapping and space agencies.

So far, the only systematic geologic mapping program is jointly led by a collaborative initiative between the NASA science program (providing funding) and the USGS Astrogeology Science Center (providing guidance and coordination). The three main programs that are active today focus on global, regional and local mapping of the Moon (1:2.5M, e.g., Wilhelms & McCauley 1971), Venus (1:5M-1:10M, e.g., Chapman 1999) and Mars (1:200k-1:5M, e.g., Bleamaster et al. 2010). A fourth program addresses the Galilean satellites (e.g., Williams et al. 2011). USGS with support by NASA has coordinated a number of programs since the 1960s when first planetary probes started investigating solar-system objects. Resulting map data has been made publicly available and is today accessible via online catalogs. As of today, these USGS maps are the only resources that can be accessed.

Since the 1990s, Europe has become highly active in planetary exploration with spacecraft contributions (Mars Express, Venus Express, Huygens probe, ExoMars, BepiColombo, JUICE) and employment of dedicated mapping instruments, such as the High Resolution Stereo Camera onboard Mars Express (Neukum et al. 2004, 2009; Jaumann et al. 2007). Along with recent and upcoming missions also to Mercury, the Outer Solar System moons, and asteroids, systematic mapping of surfaces has received new impulses due to the involvement of European scientists in international mission collaborations, such as NASA`s Dawn mission to asteroid Vesta and Ceres and mapping participations.

Since the late 1990s the scientific mapping community has started to use Geographic Information Systems (GIS) for planetary mapping. Today, GIS have become an important tool in planetary science for performing analysis and thematic mapping. GIS frameworks are usually based on databases which represent an ideal tool for archiving and storing spatial data. Planetary maps, however, have historically been stored as static image files (digital copy of the paper analog maps, e.g. as *.pdf or *.jpg) and considerable effort is currently invested to transfer these static files into a more accessible data format.

1.2. Statistical overview of planetary maps with geologic and/or geomorphologic focus

Several hundred maps, conducted within the geological mapping programs, are published by the USGS store and are made available via their digital and analog archives (USGS 2012). Another platform for distributing geological maps is the Lunar and Planetary Institute (LPI) (LPI 2013) which host a copy of this dataset. Figure 1 show a statistical overview of published maps and their scales.

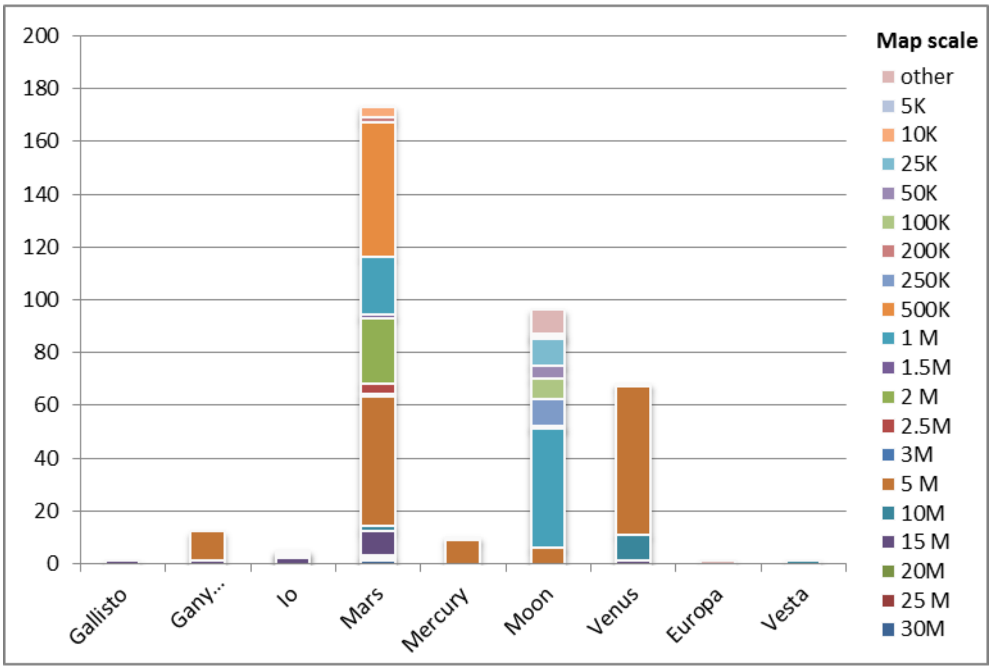

Figure 1 Statistical overview of planetary maps with geologic and/or geomorphological focus listed on USGS (2012) and LPI (2013). Statistic also includes maps in progress. (Abscissa shows the number of maps, ordinate shows the planetary body).

Apart from these officially released and peer-reviewed maps a huge number of larger-scale maps have been published in scientific journals. Here, these maps are termed *working maps*. Such maps are not collected at a single place but they are distributed across a large number of journals and publishers. Maps are usually only accessible as figure files via the publication portal. Such maps have undergone a scientific review process and represent an information abstraction of basis data, comparable to other maps published by the USGS. In this respect, such maps merit to should be archived in a sustainable way for subsequent investigations and dissemination.

To manage maps in a uniform way and at a central location it is necessary to create an accessible and well-designed map archive. Such a platform does not exist so far. By transferring geological map contents to a uniform storage platform using a well-designed data framework, researchers and users can not only efficiently search for maps but also for map-data contents.

2. Multilevel collection of existing maps and mapping

Existing planetary maps with geological and/or geomorphological contents are usually stored at different locations (see 1.2). To obtain an overview of all maps and, more importantly, their actual contents, it is necessary to build a higher-level data catalog and collect required information that allows searching for maps. This descriptive information, so called meta-information, should be recorded for all entries so that a user can search for the map and its contents. Table 1 shows an overview of potential catalog entries. The keywords are based on international standards for Metadata such as the Planetary Data System (PDS) (PDS 2009) and Federal Geographic Data Committee (FGDC) (FGDC 1998, 2000). For a detailed discussion of option for map description and management by spatial metadata see Naß et al. (2010, and references cited therein).

In order to account for already published maps as well as working maps (see 1.2), we follow a stepwise approach and formulate level 1-3 of map collection. These levels also reflect the chronological sequence of steps needed to develop a common framework.

Level 1: *Match and collect already published map sheets and map*-series products. This includes all the maps designed and published within the framework of systematic mapping programs (see 1.2).

Level 2: *Integrate individual maps from peer-reviewed publications* (e.g. journal papers, early LPI publications etc.). A large number of high-quality maps are published within scientific publications and are hidden from direct search. Outside of the publication, these maps are not listed and are hard to spot. Although these maps were already evaluated through a peer review process, cartographic aspects (representation, completeness etc.) must still be assessed.

Interface Label	Keyword	Value	Domain
Planetary Body	TARGET_NAME	"Vesta", "Ceres"	**coded value (extensible)**
Map Title	TITLE	"….."	**free text**
Mapper	FULL_NAME	"Andrea Naß"	**coded value (extensible)**
Institution	INSTITUTION_NAME	"German Aerospace Center"	**coded value (extensible)**
Mapping Peri-od	START_DATE FINISH_DATE	2008-04-13 2008-12-02	---
Mapping Keyword	KEYWORDS	"geomorphology", "fractures"	**coded value (extensible)**
(Map Purpose	PURPOSE	"Mapping Program", "Publication"	**coded value (extensible))**
(Map Status	STATUS	"Complete", "In work", "Planned"	**coded value)**
Map Projection	MAP_PROJECTION_TYPE	"Sinusoidal Equal Area", "Polar stereographic"	**coded value (extensible)**
or/and	MAP_PROJECTION_NAME	"Azimuthal_Equidistant", "Transverse_Mercator"	**coded value (extensible)**
Map Scale	MAP_SCALE	"1:500,000"	**coded value (extensible)**
Map Boundary Coordinates	MAXIMUM_LATITUDE MAXIMUM_LONGITUDE MINIMUM_LATITUDE MINIMUM_LONGITUDE	5.12 78.39 -2.03 94.39	**value range value range value range value range**
Base Data	IMAGE_ID	".... (image number) ….."	**coded value (extensible)**
Additional Data	ADD_DATA	"yes", "no", "N/A" (default)	**coded value**
if "yes" >>	ADD_DATA_INFO	"morphometric data", "age determination"	**coded value (extensible)**
	ADD_DATA_CREATOR	**"Andrea Naß"**	**coded value (extensible)**

Table 1 Meta information for geologic and/or geomorphologic map description (XXXX = PDS keyword, XXXX = FGDC keyword, XXXX = so far not standardized keyword; XXXX = optional fields).

Level 3: *Contact the European and Non-European institutes working on planetary mapping*. In addition to maps collected within level 1 and level 2, it is possible that individual institutions, engaged in geological mapping of planetary surfaces, have conducted mapping that has not been published yet. To take account of such products, these institutes should be contacted. Level-3 maps must also be checked under cartographical aspects. Potential contributors are universities and research institutes, e.g. in the US (Arizona State University, Brown University and many other locations), in Germany (German Aerospace Center (DLR), Planetary Sciences Group at FU Berlin, University of Münster), Italy (International Research School of Planetary Sciences (IRSPS), Pescara, Italy); the Netherlands (TU Delft/ESTEC), or, e.g., Moscow State University of Geodesy and Cartography, MIIGGAiK and many other places.

3. Access to digital, GIS-based mapping projects

Current developments of planetary mapping techniques involve the systematic use of GIS technology. Each mapping is based on a spatial data structure and therefore, maps do not represent static map sheets. Rather, it is defined as dynamic object-based data organized within the different data tables. This consequently means that not only meta-information has to be maintained in a uniform way but also geometry and semantic object information. As there are very few efforts to use object-oriented spatial databases for archiving map results so far the first step here is to describe the resulting map data structurally, visually and textually. For this purpose, a predefined data model which arranges every particular object by its generic properties provides an optimum solution. If such a data model is used, mapping data can be uniformly stored and accessed (van Gasselt & Naß 2011, 2013, and references cited therein).

Beside the data model for the organization of geological mapping results a guidance of the mapper is needed. This is due to the fact that many mappers involved in planetary mapping have limited basic knowledge of cartographic visualization. Geologic mappers are usually researchers with a core expertise in different field, such as geology or physical geography. In order to ensure that the map results are homogeneous, supporting cartographic representation rules are needed (Naß & van Gasselt 2013, and references cited therein).

4. Conclusions and Outlook

In order to provide wide and easy access to planetary geologic map data products, it seems feasible to organize and distribute such data from a central data repository allowing to conveniently searching for data products. An iterative procedure for map-data collection as presented here provides a usable concept to build such a centralized access. In order to establish a map collection as complete as possible, an extension of level 3 in non-US and non-European direction is required and cross-links to generic planetary map archives can also be established (see, e.g. International Planetary Cartography Database, Hargitai 2009).

Furthermore, this work can also be linked to support initiatives working on sharing and collecting planetary data in general, e.g. the European Research Infrastructure for Planetary Science (Europlanet, 2013).

References

Bleamaster, L. & D. Crown (2010): *Geologic map of MTM -40277, -45277, -40272, and -45272 quadrangles, eastern Hellas Planitia region of Mars*. U.S. Geological Survey Scientific Investigations Map 3096, 11 p., scale 1:15,000,000.

Chapman, M. (1999): *Geologic/Geomorphic Map of the Galindo Quadrangle (V–40), Venus*. U.S. Geological Survey Scientific Investigations Map 2613, 13 p., scale 1:5,000,000.

Europlanet (2013): *A European Network for the Development of Planetary Sciences*, http://epn-fp6.cesr.fr/. Accessed 22 February 2013.

FGDC (1998, 2000): *Content Standard for Digital Geospatial Metadata* (Workbook), FGDC-STD-001-1998, Metadata Ad Hoc Working Group, URL: http://www.fgdc.gov/metadata/geospatial-metadata-standards.

Hargitai, H. (2009): *International Planetary Cartography Database*, In: ICC Conference Proceedings (CD-ROM). International Cartography Conference 2009, 16-21 Nov, Santiago de Chile, Chile.

Jaumann, R. et al. (2007): *The High Resolution Stereo Camera (HRSC) experiment on Mars Express: Instrument Aspects and Experiment conduct from interplanetary cruise through the nominal Mission*. Planetary and Space Science, 55(7-8), p 928-952, doi:10.1016/j.pss.2006.12.003.

LPI (2013): *Lunar and Planetary Institute*, http://www.lpi.usra.edu/resources/. Accessed 02 March 2013.

Naß, A., van Gasselt, S., & R. Jaumann (2010). *Map Description and Management by Spatial Metadata: Requirements for Digital map legend for Planetary Geological and Geomorphological Mapping*. In: 18th International Research Symposium on Computer-based Cartography, AutoCarto 2010, 15-19 Nov, Orlando, FL, USA.

Naß, A. & S. van Gasselt (2013). *A framework for planetary geologic mapping*. In: M. Buchroithner, N. Prechtel & D. Burghardt (eds.), Cartography from Pole to Pole. Selection from ICC 2013 Lecture Notes in Geoinformation and Cartography, Springer Verlag.

Neukum, G., Jaumann, R. & HRSC-Team (2004): *The High Resolution Stereo Camera of Mars Express*. ESA Special Publication, SP-1240, p 1-19.

Neukum, G. et al. (2009): *HRSC: High Resolution Stereo Camera*. ESA Special Publication, SP-1291, p 15-74.

PDS (2009), *Planetary Data System Standard Reference, Technical Report*, Jet Propulsion Laboratory, California Institute of Technology, California, URL: http://pds.jpl.nasa.gov/tools/standards-reference.shtml.

Planetologia (2012): *Planetary Cartography*. ELTE University Budapest. http://planetologia.elte.hu/. Accessed 16 January 2013.

USGS (2012): *United States Geological Survey, Astrogeology Science Center*, http://astrogeology.usgs.gov/PlanetaryMapping/. Accessed 11 October 2012.

van Gasselt S & Naß A (2011). *Planetary mapping – The datamodel's perspective and GIS framework*, Planetary and Space Science, vol. 59, no. 11-12, pp. 1231-1242.

van Gasselt S & Naß A (2013). *Planetary Geologic Mapping: initial thoughts on an ontology framework*. 26th International Cartographic Conference: Sharing Knowledge Joint ICA Symposium, Dresden, 23 August.

Wilhelms, D. & J. McCauley (1971): *Geologic Map of the Near Side of the Moon*. USGS Map I–703, 26 p., 1:5,000,000.

Williams, D. et al. (2011): *Geologic map of Io*. U.S. Geological Survey Scientific Investigations Map 3168, 25 p., scale 1:15,000,000.

Planetary Geologic Mapping:
Initial Thoughts on an Ontology Framework

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Abstract. This work is intended to provide initial considerations on building a domain ontology in the field of planetary geologic mapping and cartographic representation. It introduces formal aspects of a higher-level planetary geologic map data ontology using an OWL-based taxonomic description of objects and object properties. It is intended as a first step towards providing a common knowledge framework covering vocabularies, semantic classifications, interdependences in order to (a) build a common understanding of what planetary mappers perceive when mapping different planets and to (b) build and infer objects, properties and constraints. By establishing a focused formalism through a domain ontology, a targeted knowledge representation is created which provides means to extract and distribute information from the planetary mapping domain and allows to consistently merge map-data information retrieved from dispersed sources. Such an ontology therefore represents all knowledge aspects when dealing with planetary geologic mapping and helps to define (a) the nature and (b) the special purpose of planetary mapping in the context of geological mapping *sensu lato*.

Keywords: Ontology, Mapping Data Model, Planetary Mapping and Cartography, Geologic Mapping

1. Introduction

1.1. Background and Aims

Data models, hereafter termed *software data models*, used in geographic information systems (GIS) are usually designed to streamline processes, to define data relationships, to formulate constraints for maintaining data integrity and consistency, and, in particular, for allowing an efficient work process. Software data models therefore represent the upper-most layer of a stack of abstraction layers of a common scientific worldview (see Raper 2005). The technically-oriented software data model builds upon a representation of relations, relationships and integrity constraints from the data viewpoint. Only during normalization, relational attributes are grouped and thematically related in order to establish a consistent data view. The software data model, however, does not allow to model and infer relationships on the semantical level and provides little means to maintain, extract and organize actual knowledge or to make to inferences based on initially defined classes and properties. To accomplish this, ontological models have been revived in recent years and as response to developments in the Web 2.0 era. The ontological framework forms one of the first worldview layers in which objects have been structured, organized and related to other objects in such a way that higher level inferences allow extraction of new information about a domain of interest and its objects.

Van Gasselt & Naß (2011a) in a special volume on planetary mapping described a mapping data model which followed a number of aims, covering (a) overarching workflows between various actors in the field of planetary mapping (so-called use-case scenarios), (b) organization of entities and map-data objects and their relationships and integrity rules, and (c) aspects of model and data exchange between organizations in order to facilitate and streamline integration of different map products and sharing data. This *data-only* model has been conceptually designed in response to a considerable increase of cartographic products created by different researchers who use state-of-the-art GIS technology to map and design maps but without having in-depth insights into cartography and communication through maps (for a discussion, see Kraak 2010). The model has also been created to find a solution for integrating planetary maps from a variety of sources within an overarching data model. This also includes finding a possibility to cope with non-standard demands that have historically been cultivated in the field of planetary geological mapping (cf. section 1.1).

In order to define planetary geologic mapping objects and their relationships within their specific (mapping) domain, we here focus on the formal description of planetary geologic mapping. Inherent information on geologic units, materials and geologic timing can be semantically related to each other by defining a common ontological vocabulary, taxonomy and relationships. While a formal attempt for establishing a joint vocabulary in geological sciences and geological data description has been started within the GeoSciML initiative its focus is not primarily put on map unit descriptions (Sen & Duffy 2005). Its formal hierarchical description, however, is built

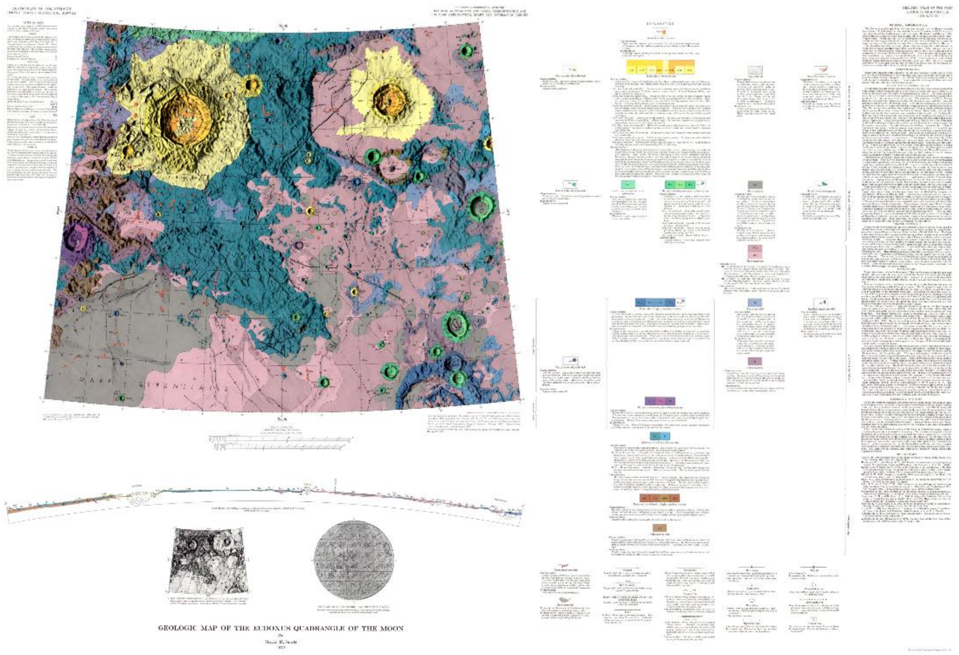

Figure 1. Example of a lunar geologic map, part of the Geologic Map of the Moon, I-705 (LAC-26) Eudoxus Quadrangle, 1:1 M by David H. Scott (1972), USGS. Color-coded map units are associated with a legend describing materials and timing of events.

on a larger domain ontology and provides formal descriptions and vocabularies. The level of granularity is much higher due to the complexity and huge amount of different data and methods applied in the field of (terrestrial) geologic sciences, including mapping. However, planetary mapping is not a simple subset of terrestrial geologic mapping due to the fact that (a) partly different methods are applied (see sect. 1.2) and (b) a variety of different objects are mapped. In the case of planetary geologic mapping, it seems appropriate to first build a common higher-level ontological framework which is then critically compared to existing approaches designed by terrestrial initiatives.

1.2. Geologic Maps vs. Planetary Geologic Maps

Classical geologic mapping and geologic-map cartography have a long history dating back to somewhere in the middle of the 17th century when N. Steno formulated his main axioms about the relationship of geologic layers and their relative timing (Steno, 1916). Over a hundred years later, in 1815, the first national geologic map covering major parts of Great Britain was crafted and published by W. Smith. Since then, national programs have led to systematic geologic mapping and the production of hundreds of thousands of geologic maps at various scales. In the 1960s space born exploration of the solar system heralded the start of planetary mapping programs coordinated by US and USSR authorities. Apart from photomosaics and topographic maps, geologic maps were among the first scientific products based on image interpretation that were put into a cartographic framework. Geologic maps are special-purpose maps that condense four-dimensional information on a two-dimensional sheet of paper. The third dimension is usually re-constructed using height information from topography data by means of isohypses and the superimposed information of the extent of geologic materials. This property is an essential asset of a geologic-map but it has received only little attention in modern planetary geologic mapping. Along with Steno's axiom on the principles of superposition and its derivatives, a relative timing can be reconstructed from simple geometric methods. In order to communicate time more directly and also to provide information about absolute geologic time, the fourth dimension is symbolized using an accompanying legend that relates color codes of geologic units to an overarching time frame (see *Figure 1*).

In summary, (1) map units with signatures and color codes relate geologic materials to (2) time and the combination of contour lines and material units provide information about (3) the unit's position in space. These three components are the main ingredients of conventional geologic maps. However, planetary geologic maps deviate from that scheme. First, contour lines are not always systematically employed in geologic maps, thus information on position in space and relative position in time is limited to non-existent. Much geologic information is lost in planetary geologic maps when compared to classic geologic maps due to the suppression of 3D information. Secondly, for historical reasons, units are not always described as (geologic) material units but as so-called *geomorphic* units which contain a description of a unit's appearance (e.g., *knobby*, *pitted*, *fretted*) rather than its composition. The term *geomorphic*, however, is highly misleading as discussed later (see *section 2.2*).

Geologic timing is usually established through age determinations based on remote-sensing data. A method, which again, deviates from terrestrial geologic age dating techniques. As a consequence, the underlying ontological model of geologic mapping is different from the conventional view on geologic maps and does not only form a subset of a terrestrial ontological framework.

Despite the generally positive development of "democratization of mapping" (Mattmiller 2006, Smith 2010) a number of issues dealing with the maintenance of cartographic quality have been raised and approaches in dealing with issues of *Neocartography* are being discussed (Kraak 2011). As for terrestrial cartography, the same problems apply for planetary mapping and cartography. Planetary cartography looks back on 50 years of modern "tradition" when the USGS Astrogeology branch was set up to define, organize and maintain planetary cartography in the context of the lunar exploration program. Today hundreds of high-quality maps of planetary bodies have been published by the USGS and new mapping programs have been set up to map (and remap) the Earth's moon, Mars and Jovian Satellites. The general acceptance of geographic information systems as tools for spatial data analysis and cartography in the planetary domain in the early 2000s have lowered the entry threshold to integrating planetary data and mapping other objects in the solar system. Most products, however, have not been cartographically checked, standardized or corrected and remain unpublished. Despite a large planetary mapping community, little motivation is given for non-US researchers to craft planetary geologic maps due to a lack of organizational coordination. Outside the US, little effort has been spent on formalizing and defining GIS-based cartographic products and as a logical consequence, researchers and mappers make use of GIS-integrated tools on an intuitive basis to build maps that are neither controlled in terms of technical cartographic quality nor in terms of their inherent message and the way in which information is communicated.

While organizational coordination of such an international mapping program cannot be established spontaneously, work towards a common understanding and framework for planetary mapping could be a first step towards homogenization of mapping attempts collected from different institutes in Europe.

2. Planetary Map Unit Ontology

2.1. Methodology

To ensure that a geologic map of Saturn's satellites is comparable to a map covering Mercury and to ensure that it is understood in Southern Europe in the same way it is read in Eastern Europe or elsewhere, the employed (higher-level) vocabulary and taxonomy must be the same for all map products. Once established, objects can be related to each other using predefined properties and it is possible to make new inferences.

The map-unit ontology is built as a low-level domain ontology. There is currently no formal approach in designing a domain ontology but it has been emphasized that the process is highly iterative (e.g., Smith, 2010). A number of methods have been established for creating ontologies and they usually consist of (a) a formal specification, (b) acquisition of knowledge, (c) conceptualization, (d) integration of pre-existing ontologies and vocabularies, (e) implementation, (f) evaluation, and (g) documentation. For a detailed treatment see Smith (2010) and references cited therein. For space reasons, we here focus on aspects of specification, in particular on the level of formality and some first-order competency questions. We here chose to build a formal domain ontology by addressing the following tasks:

- Definition of domain boundaries in order to limit the knowledge extent.
- Definition of a higher-level taxonomy within this domain.
- Definition of object properties.

First, we here describe the general taxonomy of classes (entities) and inheritances, followed by object properties. If the ontology is well-designed, it should provide answers to certain questions known as *competency questions* which are the actual motivation and validation scenario for the ontology. We here do not cover reasoning and inferences due to the ontology's initial state. Some of the fundamental questions to be addressed by the ontology cover:

1. Which different characteristics of a map unit are *necessary* to define a planetary geologic map unit?
2. Which characteristics are *sufficient* to represent a planetary geologic map unit?
3. What is needed to transfer a `FeatureUnit` to a `GeologicalUnit`?
4. How do units of a given time-span on planet `A` correlate with units on moon `B` and `C`?

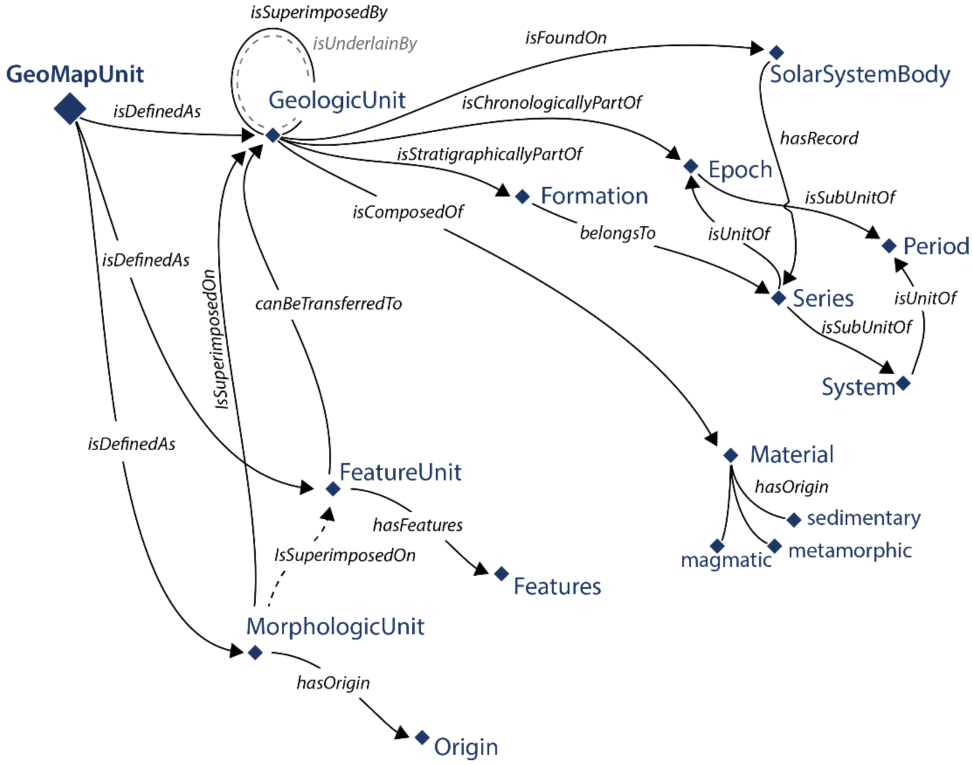

Figure 2. Simple taxonomic class display with basic properties. Classes are displayed as diamonds, properties are represented by lines with arrows.

2.2. Taxonomy and Object Properties

The `GeoMapUnit` forms the central class (see figure 2) of this approach and constitutes of three subclasses: a `GeologicUnit` which describes the well-defined geological unit in a conventional sense, a `FeatureUnit` which forms a unit described by non-genetic and non-material features, and a `MorphologicUnit` which is defined by its morphological expression and which is genetically related to the `GeoUnit`. These subclasses provide objects that have either geological properties (material, relative age, absolute age, associated stratigraphy, positional values, ...) or which only describe a feature or shape and appearance (coll. geomorphologic unit). The historically accepted term of a *geomorphologic unit* (in contrast to a geologic unit) is not well-chosen as it is intended to be used as a descriptive term. A geomorphologic unit, however, is more than just a description of shape and features as these already imply a set of potential forms of development, the unit has undergone. If a planetary map unit is described as, e.g., *pitted terrain*, nothing is usually said about its geologic composition nor its geomorphologic evolution. It is correctly suggested, that a unit consists of a geologic material deposited at a discrete time in which pits (as morphological expression) have been formed (at the same time or later during a non-distinct process). For this ontology, it is therefore suggested to differentiate between classical *geological units* (with associated materials and ages), superimposed *morphologic units* (with genetic implications) and *miscellaneous (non-material) feature units* carrying no genetic implications. Since feature units (`F`) can be transferred to geological units (`G`) and there exists an inverse property which allows to transfer `G` to `F` (`G canBeTransferredTo F`), and since morphological units (`M`) are superimposed on geological units (`M IsSuperimposedOn G`), it must be inferred that morphological units are not only superimposed on `G`, but also on feature units (`M IsSuperimposedOn F`).

`G` carries most of the map unit contents along with a number of properties relating temporal and stratigraphical classes to `G`. `G` shows several special object properties: it is reflexive as G always `isSuperimposedBy` another G. Its inverse property is `IsUnderlainBy` which again must be reflexive. It is also inferred that each G which `isUnderlainBy` another G does so because this property is by definition transitive (see *Figure 2*).

Unfortunately, many planetary geologic maps (also official ones) do not differentiate between geologic material units and non-material units so that a homogenization of different maps using different sets of descriptive terms becomes complicated. This problem has not been addressed thus far and no attempt has been started yet to "translate" feature units to geologic units.

Object properties concerned with the stratigraphic system (formation, series, systems) and absolute chronologies (epochs, periods) are independent of each other initially. A unit has a well-defined age and it therefore belongs to a geologic time. Along with knowledge about the unit's location and geologic material, a stratigraphic position is extracted. This must, axiomatically, be reflected in the unit's chronological position in time. Therefore, chronological and stratigraphical classes support each other but they are not equivalent (see `IsUnitOf` property in *Figure 2*).

Despite different planetary chronological and stratigraphical schemes, properties between these classes remain the same for each planetary object that is mapped geologically. Consequently, such an ontology can easily be utilized within a different geological context. The stratigraphic record of each planetary object is characteristic of that object (`hasRecord` property).

3. Conclusions and Outlook

The presented ontology models forms a first outline of basic taxonomic levels describing planetary map units as part of cartographic products. Much work needs to be accomplished in order to distill a vocabulary allowing to investigate data and relationships and to integrate the map units'-based taxonomy into an overarching ontology framework. Such works will help to provide a semantic platform in which a variety of different geologic map products are to be integrated (e.g. Naß et al. 2013).

In geological sciences, formal geological ontologies have been established in recent years. These attempts build on models that were initiated at various organizations and institutes, mainly in the US (e.g. Johnson et al. 2008, GMDM 1999, NADM 2001, Bedford et al. 2003, Soller et al. 2002, Richard et al. 2003, Richard & Soller 2008). GeoSciML forms a hierarchical approach to establish a structured geologic vocabulary on which science applications can be built (Sen & Duffy 2005). Planetary geologic classes are not being dealt with in that approach but it seems feasible to identify a common nomenclature to either expand GeoSciML taking into account planetary aspects or to adopt the GeoSciML vocabulary for building a formal ontological description for planetary geology and planetary geologic cartography.

Time is the fundamental building block of geologic sciences which establishes a link between material units as depicted in a map sheet and the timing of their formation as depicted in chronostratigraphic relationships. Time and its various relative and absolute expressions are not fully covered in neither relational nor hierarchical data models. A considerable amount of additional work needs to be invested to allow answering a richer set of *competency questions* in an appropriate OWL-based ontology (see van Gasselt & Naß 2013 and references cited therein: Peuquet 2000, Raper 2005, Le & Usery 2009).

Formal map ontologies as initially designed by, e.g. Richard (2010) have not been created so far for planetary thematic cartography. Addressing this topic would solve issues related to cartographic design and quality control in a growing mapping environment where map products are usually created by non-cartographers. Furthermore, due to the highly diverse nature of planetary mapping in which not only map scales, projections and symbols but also individual reference body characteristics (geometry and inventory) play an important role, a formal map ontology would significantly improve establishing cross relationships between target bodies and their map entities.

References

Bedford DR, Ludington S, Nutt CM, Stone, PA, Miller DM, Miller RJ, Wagner DL, Saucedo GJ (2003) “Geologic Database for Digital Geology of California, Nevada, and Utah, an Application of the North American Data Model”, U.S. Geological Survey, Tech. Rep. Open-File Report 03-135.

van Gasselt S & Naß A (2011a). Planetary mapping – The datamodel’s perspective and GIS framework, Planetary and Space Science, vol. 59, no. 11-12, pp. 1231-1242.

van Gasselt S, Naß A (2013) On the Concept and Integration of Geologic Time in Planetary Mapping. In: 26th International Cartographic Conference: From Pole to Pole, Dresden, 25-30 August.

MDM, Geologic Map Data Model Steering Committee (2001), “Progress Toward Development of a Standard Geologic Map Data Model,” in Digital Mapping Techniques ’99 – Workshop Proceedings, D. R. Soller, Ed., no. Open-File Report 99-386. U.S. Geological Survey, 2001. [Online]. Available: fhttp://pubs.usgs.gov/of/1999/of99-386/steercom.html.

Kraak, M-J (2011) Is there a Need for Neo-Cartography? Cartography and Geographic Information Science, 38(2): 73-78.

Johnson, BR and Brodaric, B. and Raines, G. L. and Hastings, J. and Wahl, R (1998), “Digital Geologic Map Data Model v. 4.3,” U.S. Geological Survey, Tech. Rep. Open-File Report 99-386. [Online]. Available: http://geology.usgs.gov/dm.

Le, Y. & E. L. Usery (2009). Adding Time to GIS” in: Manual of Geographic Information Systems, M. Madden, Ed. Bethesda: The American Society for Photogrammetry and Remote Sensing, ch. 19, pp. 311–332.

Mattmiller, B (2006) Technology helps foster ‘democratization of cartography’ (Sep 20, 2006). University of Wisconsin-Madison News. http://www.news.wisc.edu/12916 (12 March 2010).

NADM, North American Data Model Steering Committee (2001) “Developing the North American Geologic Map Data Model,” in Digital Mapping Techniques ’01 – Workshop Proceedings, D. R. Soller, Ed., no. Open-File Report 01-223. U.S. Geological Survey. [Online]. Available: http://pubs.usgs.gov/of/2001/of01-223/boisvert.html.

Naß, A, van Gasselt S, Jaumann R, Asche H (2013). 26th International Cartographic Conference: Sharing Knowledge Joint ICA Symposium, Dresden, 23 August.

Peuquet, DJ (1999). Time in GIS and Geographical Databases, in: Geographical Information Systems, 2nd ed., pp. 91–103, P. A. Longley, M. F. Goodchild, D. J. Maguire, and D. W. Rhind, Eds., Wiley (Chichester).

Raper J (2005) Multidimensional Geographic Information Science. Taylor and Francis, London.

Richard SM, Matti J, Soller DR (2003) Geoscience Terminology Development for the Natioanl Geologic Map Database. In: Soller DR (ed), Digital Mapping Techniques '03 Workshop Proceedings, Millersville, PA, 157-167.

Richard SM, Soller DR (2008) Vocabularies for Geoscience Information Interchange. In: Soller DR (ed), Digital Mapping Techniques '08 Workshop Proceedings, Moscow, 101-104.

Sen M, Duffy T (2005) GeoSciML: Development of a generic GeoScience Markup Language. Computers and Geosciences 31(9): 1095-1103.

Smith RA (2010) Designing a Cartographic Ontology for Use with Expert Systems. Special joint symposium of ISPRS Technical Commission IV & AutoCarto in conjunction with ASPRS/CaGIS 2010 Fall Specialty Conference, Nov 15-19, 2010 Orlando, Florida.

Soller, D.R. and B. Brodaric and J. T. Hastings and R. Wahl and G. A. Weisenfluh, "The Central Kentucky Prototype: An object-oriented geologic map data model for the National Geologic Map Database," U.S. Geological Survey, Tech. Rep. Open-File Report 02-202, 2002. [Online]. http://pubs.usgs.gov/of/2002/of02-202/of02-202.pdf

Steno, N (1916) The prodromus of Nicolaus Steno's dissertation concerning a solid body enclosed by process of nature within a solid (New York: The Macmillan company).

Cartography integrating the knowledge in School: Experiences in School Cartography in Brazil

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Abstract. The objective of this article is to present an overview of the cartographic concepts approached in Basic Education in the light of the guidelines described in the Brazilian National Curriculum Parameters (NCP, the position of the experts concerning the thematic and the reality of the school, based on published studies resulting from research carried out with the participation of Fundamental School teachers. Considering the Cartography teaching aspects presented in this study we can envisage the importance of the appropriation, by the teachers and students, of the elementary cartographic concepts since the first grades of Basic Education.

Keywords: School Cartography, experiences, continuing education

1. Introduction

The objective of this article is to present an overview of the cartographic concepts approached in Basic Education in the light of the guidelines described in the Brazilian National Curriculum Parameters (NCP), the position of the experts concerning the thematic and the reality of the school, based on published studies resulting from research carried out with the participation of Fundamental School teachers.

The National Curriculum Parameters, from the Brazilian Ministry of Education (MEC) are presented as a set of propositions with the function of orientate and ensure coherence in the educational actions in Brazil, with enough flexibility to allow decisions concerning the curriculum and the elaboration of programs which respect regional and local characteristics.

Given the diversity of possibilities concerning educational practices related to the pedagogic tendencies predominant in Brazil over the history of the

Brazilian education, the NCP were elaborated based on the most relevant aspects of each pedagogic tendency and their influence on the formation of contemporary students, considering:

> [...]the importance of the constructive participation of the student and, at the same time, the intervention of the teacher for the learning of specific contents which favor the development of the necessary capacities for the formation of the individual (Brasil 1997a).

In this context, Cartography emerges as an integrating discipline, combining different areas of knowledge, as it develops concepts from other disciplines such as Math, Science, History and Geography. In its applications in school, it has a great potential to address, direct or indirectly, different areas of knowledge and stimulates the abilities of the students, allowing, through practice, the mastering of concepts and techniques which contribute for their global formation in the first school years.

2. Geography NCP and School Cartography

Aiming to explore the potential of School Cartography in Geography Teaching, we initiated the investigation consulting the NCP approaching the theme Geography, searching the governmental references for the practice of Cartography in Basic Education.

The NCPs in Geography have the objective to broaden the capacities of Basic Education students to observe and interact with their living space, developing abilities concerning knowledge, differentiation and representation of the geographic space. Concerning the proposal of the use of graphic language and Cartography in Geography teaching, the National Curriculum Parameters indicate:

> [...] The study of the graphic language has increasingly reaffirmed its importance since the beginning of schooling. Not only does it contribute for the students to comprehend and use the basic tool of Geography, the maps, but also to develop capacities related to the representation of the space. Cartography is a knowledge which has been developing since pre-history until the present cay. This language allows the synthesis of information, the expression of knowledge, and the study of situations among other things, always involving the idea of the

> production of the space: its organization and distribution (Brasil 1997b).

Cartography is a discipline which theoretical and technical fundaments allow the exploration and the improvement of the Basic Education students' capacities, such as sense of observation, interpretation, comparison and representation of space and its transformations. Cartography teaching at school is usually started by the elementary topologic relations, followed by the elaboration of sketches and simplified representations of the students' living space, the nearby space and gradually by increasing the complexity of the activities through reading, interpretation and representation of different landscapes of the local, regional and global geographic space.

The theoretical-methodological basis of the cognitive development which found the Brazilian School Cartography is described in the studies by Piaget. According to Almeida (2003):

> Piaget, supported by a team of researchers, performed several studies which allowed the creation of one of the most complete genetic theories about the cognitive development of the human being. In the light of other theories, the study by Piaget suffers some restrictions; nevertheless, concerning the representation of the space, his studies remain fundamental (Almeida 2003).

In Brazil, the pioneer study by Lívia de Oliveira, formed the foundation of the School Cartography, based on the theoretical orientation of Piaget and served as reference to a great number of researchers. In her habilitation thesis, defended in 1978, presents the Methodological and Cognitive Study of the Map, Oliveira (1978), a contribution for the construction of the methodological bases of the study of the map in Geography. In a reflexive analysis of this study Oliveira (2008) presents a synthesis of his main contributions to this thematic. the author defends and proposes the teaching/learning process of the map, emphasizing the importance of the knowledge of the space, by the child, before the interaction with the map itself, and launches "the bases for a map methodology", preconizing:

> [...] The notion of space and its representation do not simply derive from perception: it is the subject, by the use on intelligence, who attributes meaning

> to the perceived objects, enriching and developing the perceptual activity (Oliveira 2008).

The author is supported by the explanation of Piaget concerning the intellectual development of the space, “which states that the spatial topological relations are the first to be established by the child, both in the perceptive and the representative plans; and it is from the topological relations that the projective and Euclidian relations will be elaborated” (Oliveira 2008).

Posteriorly, taking external references as the sun, the stars and the cardinal points, the children orient themselves in the geographic space using an “objective system of references” as a basis (Oliveira 2008).

Thus, it is assumed that, in what concerns Cartography learning, the child should acquire the notions of topological spatial relations and then the projective ones to, in a consecutive stage, initiate he work with the map. Much of this conceptual domain of the geographic directions emerge from the corporal experience of the child in the space [...] “to learn about the space, the child needs to move within it, locomote throughout it – space which in turn includes animated and inanimate entities, of various types” (Oliveira 2008).

We agree with Oliveira (2008) who stated that “the value of the map is in what the teacher is willing to do with it” indicating that it is up to the teacher to, having knowledge about this tool, use and apply this “model of reality” to the situations emerged during the classes (Oliveira 2008).

> In general, in the geographic learning of concepts, the teacher follows two paths: a) through the successive increase of the scale, from the classroom to the neighborhood and then to the district, the city, the state or the nation, and so forth; or b) through direct learning of non-familiar and non-perceived concepts, through the abilities of handling maps and globes (Oliveira 2008).

The author still mentions the difficulties of the schools to provide maps for the didactic activities, basing on her experience in the state of Sao Paulo. The economic factor is one of the indicated by the author concerning the acquisition of such documents (Oliveira 2008).

In our experience in the formation courses in the Center of Continuing Education in Mathematic, Scientific and Environmental Education of UNESP (CECEMCA) we observed the non-availability of maps at school in all states of the country, with few exceptions. The scarcity of cartographic material greatly impairs its use by the teacher. Today, most schools count on computational systems, and it is expected that digital maps can be made available for Basic Education in the near future. However, for this to happen, many advances in terms of infrastructure, mainly concerning access to high performance internet are still necessary, considering that, when existing, this access is restricted to dial-up internet, which is slow and inefficient for this type of document, which uses heavy files.

Considering this reality, we questioned which are the ways for the concretization of the inclusion of Cartography in the programs and school knowledge? How to help teachers in formation and those already working to overcome their formation difficulties in order to incorporate the study and teaching of maps in their daily practice? We consider that such necessary changes can be triggered by the inclusion of the theme Cartography in the initial and continuing formation of the teacher.

3. Cartography in the Initial Formation in Geography

Concerning the initial formation in Geography, we developed a study aiming to present an analysis of the discipline Cartography in the Graduation Courses in Public Universities in Brazil, emphasizing the aspects related to the syllabus, course load and current programmatic content and its interface with the different areas comprised by the geotechnologies. (Freitas 2010). In a first stage we performed the analysis of the Syllabus of the Courses trying to classify the disciplines in the cartographic and geotechnological areas. In a second stag we performed the analysis of the content of disciplinary programs available, trying to understand how the Cartographic Science and the Geotechnologies have been approached in the geography Graduation courses in Brazil. As a result of the study we call attention to the tendency, in some of courses here studied, to offer cartographic disciplines and specific geotechnologies for the Geography Graduate, mainly concerning the themes related to Cartography Teaching, School Cartography and the Elaboration of Didactic Material, which is critical for the improvement in the performance of the teacher in the classroom. We observed that, among the 27 Universities studied, 10 Universities; i.e., 37% of the evaluated institutions presented disciplines associated to Cartography Teaching and School Cartography in the syllabus, some of them not mandatory, In this sense, we found:

> Advances in this sense have been reported in some Universities, where specific disciplines for the formation of graduates can be found: Educational Practice in Cartography (mandatory for Graduation

> at UFJF – Federal University of Juiz de Fora); School Cartography (mandatory at UFSC – Federal University of Santa Catarina and optative at UFES – Federal University of Espírito Santo, UEM – State University of Maringa and UFSE – Federal University of Sergipe); Cartography Teaching Methodology (mandatory at UFSJ – Federal University of Sao Joao Del Rey); Conception and Elaboration of Didactic Material in Geography (mandatory for graduation at UERJ – University of the State of Rio de Janeiro); Mediator Learning for Computing (UFC – Federal University of Ceara) and Cartography Applied to Teaching (UFPA- Federal University of Para and UFAM – Federal University of Maranhao) (Freitas 2010).

This scenario indicates how incipient is the formation of the Geography Graduates in the disciplines of applied Cartography area, in the Geography Courses of Brazilian Public Universities. In this sense, we consider that the conditions of the Geography teachers of the country are concerning, considering that a minority attend Public Universities, from which little more than 1/3 have access to theoretical and methodological bases for Cartography teaching in schools, which in many cases compose the optative disciplines in the Graduation Courses.

In the article 'Different types of knowledge in the Formation of the Geography Teacher', Lopes Junior (2010) emphasizes the results of his analysis concerning Geography teaching:

> It can be noticed that the school, and in this case the geography teaching, needs to contribute with the explanation of the contemporary world through the reading of the space while totality – a world which expresses constant alterations. This geographic space, product of history which involves objects and actions expresses social practices that should be identified and comprehended by the student. (Lopes Junior 2010)

When we consider the formation of the Graduate in Geography, we refer to Santos and Kulaif (2006) who point the elements that should be observed in the initial formation courses, taking into consideration the specificities of school education, which should be one of the instruments of the promotion of the human being to a free and conscious individual. The authors still consider that, for the school geography to be efficient in the formation of a student aware of his/her spatial reality, it is necessary to have the actuation of the teacher in the sense of integrating, in the classes, the local spatial logic with the global spatial logic; i.e., there is no sense in teaching the part, not considering the whole.

In Sao Paulo State University – UNESP, in 2013 for the first time, we offered an optative discipline named Inclusive and School Cartography, combining didactical material and methodologies to teach Cartography, stimulating integrated activities in fundamental level involving blind and deaf students.

4. Cartography at School

In the study about Geography for children's learning Callai (2005) points the importance of Cartography for the formation of the child in basic Education:

One of the possible ways to read the space is through maps, which are the cartographic representation of a particular space. Academics in the Cartography teaching/learning area consider that, for the subject to be able to critically read the space, it is necessary that he/she knows what to do with the reading of the concrete/real space, and also that he/she knows how to read its representation: the map (Callai 2005).

In this sense, we consider that the disciplines destined to the formation of the Graduate should be valued, and among them are School Cartography and Cartography Teaching Methodology, which should be considered as important as the specific disciplines for the formation of the Bachelor in Geography.

Given the scope of the subjects addressed and the way the geographic contents are organized, for Simielli (1996), elaborating a course for the Basic Education is much more than a didactic transposition of the wise/university knowledge. We agree with the author, who considers that this task is:

[...] a real reconstruction of the geographic knowledge on partially other basis, as the purposes, the objectives and the means of the practice I Geography are not the same in University and in 1st and 2nd grades (Simielli 1996).

The author argues that, in Basic Education, the teacher usually adopts the intuitive method, which goes from the specific to the general; and not the deductive – which goes from the general to the specific. Thus, the teacher, in each lesson, should select and classify the facts proposed by the university knowledge within a coherent evolution and adapted to the capacities of the students and the objectives inherent to their general formation.

The author considers that, in the Basic Education:

- in the first cycle (today, from the 1st to the 5th grade) the teacher should basically approach the cartographic alphabetization, which would be the phase when the student needs to have contact with the elements and comprehend the process of elaboration of the graphic representation to, posteriorly, effectively work with the cartographic representation.
- In the second cycle of Basic Education (today, from the 6th to the 9th grade) the student occasionally needs elements of cartographic alphabetization; however, from the 7th grade, he/she is able to work with analysis/localization and correlation (Simielli 1996).

Concerning the initial grades, the author emphasizes that the basic notions of Cartography should actively involve the child, making him/her the main actor in the development of the activities, "for a better comprehension of the representation of space" (Simielli 2008).

Thus, the following Cartography themes are recommended for 1st to 4th grades (2nd to 5th year):

- Oblique and vertical views
- three-dimensional and two-dimensional images
- Cartographic Representations
- Structuration of Legends
- Proportion and scale
- Laterality, references and spatial orientation

Study as the ones developed by the author corroborate Oliveira (2008) indicating the need of Cartography as discipline in the initial and continuing formation courses for the adequate utilization of the concepts in the classroom practices.

5. Experiences in continuing formation of Cartography teachers

Assuming the need to introduce Cartography in the continuing formation of the teachers, we emphasize the work carried out by the group of researchers from the Center of Continuing Education in Mathematic, Scientific and Environmental Education of UNESP (CECEMCA) and some results obtained in formations in which they worked in the period between 2005 and 2010 in Brazil, presented in UNESP (2009) and Freitas (2010).

Preparing the children of Nursery School and in the first years of Basic Education to work the topological relations is a fundamental step to prepare them for the Euclidian and projective spatial relations. An example of an activity in Nursery Education is presented by the teacher Denise, from Naviraí – MS:

> In nursery education (5 year-old students) we had 50 minutes of the weekly routine to work in the park of tubes (a place at school). Exploring the proper space and according to week planning, the students and I, as mediator, observed everything around us. I asked them to move on the grass, facing the school wall; then I asked them to point what was on their right – the wall; what was on their left – the fruit garden; and finally questioned them about what was behind them – other wall.
>
> [...] I asked them about what was in front of them, on the right, on the left and behind each element. We also addressed the notions of near and far. The intention was not to form concepts, only notions. I wanted the students to comprehend the meaning of each term and located themselves and talked about their location sing the terms. This way I could work orality and logical thinking. Then in the classroom, I had them draw the activity and locate themselves circling their body in the drawing (Denise, Teacher in Naviraí – MS 2007).

In this example we see that the teacher organizes the activities in order to involve the students, exploring the elementary topological relations. The teacher gathers the children in a leisure space of the school and performs the observation of the surroundings, presenting questions and answers about objects around them. Posteriorly, activities of topological relations and orientation are performed in the classroom, observing the internal objects. The activities are concluded with drawings which are elaborated and exposed, deepening the topological relations, now represented on paper.

We observed that the teacher opts for the observation of the external space, followed by the observation in the classroom, the representation of the objects and the position of the child who draws. In this case, the drawing is not an end in itself, but a means which incentives the discussion about the topological relations. In the end of the activity the drawings are observed and analyzed by the group, trying to interpret the topological relations of the objects there represented, in an association between reality and representation.

The theme Elementary Topological Relations is easily incorporated to the daily school practices, fact that made the great majority of teachers select it to elaborate lesson plans and develop activities for the students.

In terms of cartographic representation we call attention to the account given by the Teacher Educator Rafael, who explores different moments of the formation course in Capão Bonito – SP - Brasil, using sketches and the observation of the environment aiming to stimulate the environmental perception of the participants:

> The first activities were sketches. There was a very nice activity in which they walked around a square next to the formation center [of Capão Bonito] and, nonchalantly [we said:] let's take a walk to chill out a little bit. And they visited the square and came back to school. Then they had to elaborate a sketch of the way. It was interesting because they started to understand they do not look around. Many teachers who proposed the activity included a particular place or point in their own sketches and the others hadn't noticed the existence of such place in the city. Formation Capão Bonito (Rafael 2010, verbal information)[1].

Stimulate the knowledge about the environment in which the student is inserted; experience the spaces of the school, of the surroundings and the life in the districts and the city; open the senses and perform activities to study, experience and perceive the environment can broaden the knowledge possibilities of the actors involved in the school routine, improving the formation of the teacher, who has the opportunity to form him/herself, form the study group in which he/she is inserted and form the

[1] Excerpt of an interview with Teacher Educator Rafael, carried out by the researcher in Rio Claro, on 11/25/2010.

students through experiences as the ones described here. In several moments the sketches and maquettes materialized such experiences.

The Teacher Educator Rafael also presents an account on the elaboration of maquettes in formation Capão Bonito – SP - Brazil, in a growth and evolution which have as primary scenario the classroom in the continuing education course. He describes the experience of a maquettes elaborated in a collective study, in the form of a big mosaic, being an instrument in the exhibition of the different realities of the schools in that locality.

> [...] Then the part of the maquettes was the following stage, and the scales fight started, as they had difficulties to calculate, and the first maquettes were made without any proportions: a door was the same size of the room, the windows were very small, [when] they started to make the maquettes in the classroom. Then the desks were disproportionate to the walls, and in this moment the scale appeared [and] they began to understand how the scale with thread worked, playing with the thread to make the scale. On the following day the maquettes started to get more elaborated.
>
> [...] So, they made some projects with maquettes. It was a project that involved seven schools, if I am not mistaken; they made the maquettes of their school, the school in their neighborhood and after it became a big jigsaw puzzle. On the city's anniversary they made this maquette setting the small maquettes as close as possible to form the central part of the city. It was [a] very nice activity because in addition to being interdisciplinary (involved several disciplines of the school), it was inter-schools. (Rafael 2010, verbal information)[2].

By the Teacher Educator's account we can observe that the sketches and maquettes were, in this case, more than instruments of representation of the living space or mechanisms for the study of concepts involving cartography, geography and environmental studies, as they allowed, in practice, to exercise the individual and collective capacity to learn.

[2] Excerpt of an interview with Teacher Educator Rafael, carried out by the researcher in Rio Claro, on 11/25/2010.

6. Final Considerations

Considering the Cartography teaching aspects presented in this study we can envisage the importance of the appropriation, by the teachers and students, of the elementary cartographic concepts since the first grades of Basic Education.

The experiments carried out in the scope of initial and continuing formation indicate as critical the integration of the university types of knowledge with the teaching types of knowledge concerning Basic Education, having as starting point themes related to the elementary topological orientations, sketches and maquettes, revealed by the experiences taken from formation activities organized by CECEMCA/UNESP.

The action in continuing formation have more chances to be successful if based on the constant dialogue between teachers and teacher educators, allowing them to grow together, creating a strong bond with the theme studied, deepening the personal relationship and the solidarity in the school environment, stimulating them to share experiences and knowledge.

In the continuing formation performed, the teachers in general opted to conduct, in the classroom, activities related to the topological spatial relations, making use of the school environment, both for Nursery School and for the first years of Basic Education. The cartographic representations of the students' nearby space were properly explored by the teachers, respecting the cognitive development and the perception of the environment by the students, which is compatible with the theoretical principles or the area. The collective maquettes showed to be cartographic instruments, catalyzing people and types of knowledge, giving a new sense to what was formerly considered a decorative object used in fairs and exhibitions, allowing changes in the behavior of individuals in relation to their place of living.

We hope that the experiences described here contribute with the construction of the global contemporary knowledge of the formation actions in school cartography.

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References

Almeida, R D (2003) Do Desenho ao Mapa: Iniciação cartográfica na escola. São Paulo, Editora Contexto

Brasil. Ministério da Educação. Secretaria de Educação Fundamental (1997a) Parâmetros Curriculares Nacionais: Introdução aos Parâmetros Curriculares Nacionais. Brasília, MEC/SEF

Brasil Ministério da Educação. Secretaria de Educação Fundamental (1997b) Parâmetros Curriculares Nacionais: História e Geografia. Brasília, MEC/SEF

Callai, H C (2005) Aprendendo a Ler o Mundo: A Geografia nos Anos Iniciais do Ensino Fundamental. Cadernos Cedes, Campinas, 25(66):227-247. http://www.cedes.unicamp.br. Accessed 10 December 2010.

Freitas, M I C (2010) A cartografia na formação do geógrafo brasileiro: uma reflexão sobre os conteúdos acadêmicos e as perspectivas de atuação profissional. Actas do VI Seminário Latino Americano e II Seminário Ibero Americano de Geografia Física. Coimbra

Freitas, M I C et al. (2010) A Cartografia no Ensino Básico: Experiências em Cursos de Formação Continuada de Professores. Rio Claro(SP), IGCE/UNESP. Associate Professorship Thesis

Lopes Junior, W M (2010) Os diferentes saberes na Formação do Professor de Geografia. Revista Acta Geografica, IV(7):169–183

Oliveira, L (2008) Estudo Metodológico e Cognitivo do Mapa. Almeida, R.D. (Org.) Cartografia Escolar São Paulo, Editora Contexto

Oliveira, L (1978) Estudo Metodológico e Cognitivo do Mapa. São Paulo: Novalunar Gráfica e Editora Ltda. Associate Professorship Thesis

Santos, C E Kulaif, Y (2006) O Ensino de Geocartografia nos Cursos de Formação de Professores de Geografia no Brasil: apontamentos e reflexões. Actas Simpósio Ibérico do Ensino de Geologia. Aveiro, Universidade de Aveiro

Simielli, M E (1996) Cartografia e Ensino: Proposta e contraponto de uma obra didática. São Paulo, Universidade de São Paulo. Associate Professorship Thesis

Simielli, M E (2008) O Mapa como Meio de Comunicação e a Alfabetização Cartográfica. Almeida, R.D. (Org.) Cartografia Escolar. São Paulo, Editora Contexto

Universidade Estadual Paulista (2009) Pró-Reitoria de Extensão Universitária. Programa do Centro de Educação Continuada em Educação Matemática, Científica e Ambiental. Relatório de Atividades CECEMCA/UNESP: 2007 - 2008. São Paulo, PROEX

Mapping my River: New Technologies applied to cartography to support environmental education in the teaching of Geography

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Abstract. The objective of this paper aims to develop and evaluate the methodology used for the addition of new technologies applied to cartography via environmental education in the teaching of Geography. This paper, as part of the research for my Master's Degree, is developing a website to support the process of teaching and learning Geography about the Alcântara River in São Gonçalo, Rio de Janeiro. New technologies used in cartography shall be used, such as Multimedia Cartography, Web Cartography and Remote Sensing, in accordance with the PCN – National Syllabus Guideline (Parâmetros Curriculares Nacionais) in Geography and the environmental transverse theme. The methodology is directed towards the creation of some digital media named MMR (Mapping My River) via the Internet and divided into three modules: Module 1 (Learning the basics of Cartography), Module 2 (Exploring the Alcântara River) and Module 3 (Socio environmental awareness of the Alcântara River). The main objective of this material is to allow students to interact in an active way in the construction of their knowledge about the socio environmental importance of the Alcântara River in São Gonçalo and, thus, raising their ecologic preservation awareness of the river through the cartographical activities proposed in each module; in order to achieve that the student may add photos, videos, text, audio, as well as satellite images according to each activity in the modules. This material is going to be evaluated in seventh grade classes of basic education of public schools in São Gonçalo city through practical tests during the first semester of 2013. After the evaluation of the results from the tests performed at the schools, adaptations and corrections of this material shall be made available and hosted at City Hall's webpage still being amendable.

Keywords: Cartography, New Technologies, Environmental Education

1. Introduction

Contemporary society punctuated by strides in technology development described as "the information age" (Castells 1999). This new reality is characterized by the easy access to modern means of mass communication and information, such as television broadcasts, telephony, school age children who use the computer a lot. The quick changes in the technology field draw in a new pace in teaching and learning (Kenski 1998).

Accordingly, the integrated introduction of new technologies applied to cartography, particularly, Multimedia Cartography, WEB Cartography and Remote Sensing in teaching has become important resources as aid to Geography classes. These technologies used in an integrated way in the teaching and learning process of Geography enable the student to analyze and participate actively in the construction of knowledge as they enter geographic information about the theme being studied into the modules from the combination of maps with assorted media: texts, pictures, videos, sounds, as well as satellite images according to the assignments.

Due to the limited production of cartographic material about the Alcântara River located in São Gonçalo city, as research project, the development and evaluation of a methodology to support environmental education in the teaching of Geography has been proposed for the ongoing Master's Degree.

The methodology consists on the creation of a website named MMR (Mapping My River) to support environmental education about the Alcântara River, to teach Geography to seventh grade students from the public city schools of São Gonçalo. New technologies applied to cartography to support environmental education in Geography classes shall be used, such as Web Cartography, Multimedia Cartography and remote sensing in order to teach environmental education, in particular, the Alcântara river in São Gonçalo, Rio de Janeiro. According to (Wiegand 2006), at this school stage, students are able to work with maps in a more analytical way.

This meets one of the propositions of the National Syllabus Guideline (Parâmetros Curriculares Nacionais) (Brazil 1999) for Geography, which suggests the usage of different sources of information and technologic resources for the construction of geographical knowledge.

Acccording to National Syllabus Guideline – Transversal Themes (Brazil 1999)[3], the main contribution of schooling is to "contribute with the educa-

[3] Parâmetros Curriculares Nacionais is a syllabus guide organized by subjects and grades for basic education in Brazil.

tion of conscious citizens, capable of making decisions and act in the socio-environmental reality in a way that is committed to life, with the well-being of each one and society as a whole, locally and globally".

Thus, this material aims to help the student learn about the socio-environmental importance of the Alcântara River from its natural dynamics and the occurred anthropic impact, in a more intense way, between 1970 to 2010, which resulted in the current state of degradation of this water resource, and thereafter raise their environmental awareness for the preservation of this river.

2. Theoretical considerations about new technologies applied to cartography to support environmental education in Geography classes

In the midst of the technologic innovations in Cartography, the map is increasingly more present in daily life through a large array of media, be it in books, magazines, newspapers, television newscasts or the world wide web; however many people don't have the skill to understand the geographic information presented in the maps (Elzakker 2001).

The improvement of the new technologies used in the developing of mapping has not been followed in the usage of combination of digital maps in basic education. The pedagogical practices of geography teachers, is mostly still based on analogical maps; and those, in their turn, represent an unchangeable static reality limiting the interaction of the user as a reader (Menezes 1999).

According to the methodological guide written by the Ministry of Education of Brazil named National Syllabus Guideline (Brazil 1999) of Geography, the process of teaching and learning of this subject must contemplate "the usage of different sources of information and technological resources for the construction of geographic knowledge (Brazil 1999)".

It is necessary to demystify the idea that technology is something that does not belong in basic education. Therefore, the use of Multimedia Cartography, WEB Cartography and Remote Sensing inserted into Geography classes allow for the teaching of environmental themes aiming to raise awareness in the student about the importance of the preservation through behavioral changes defended by (Leff 2005) as environmental rationality which is characterized as a new positioning of human beings in harmony with nature.

These technologies applied to cartography in environmental education have, as a primary role, to make classes more dynamic and interactive, as in virtual learning environments, the students are not only able to spot and identify, but they can also take a reflexive posture and a participative initiative about the importance of the river preservation and that benefits both the quality of life of São Gonçalo and the local environment, contributing to the biodiversity of this water resource.

2.1. New cartographic technologies as environmental education aids in the teaching of Geography

The development and improvement of cartographic techniques, via the internet, has increasingly made the understanding of geographic space dynamics easier, creating a brand new environment for mapping: interactivity, real time and a dynamic environment (Kraak 2001). According to (Elzakker 2001) the use of maps on the internet offers the possibility of easily checking up places, use pan tools to move around the maps according to the needs of the research and also use hyperlinks integrated to multimedia (pictures, sound and video) and, it mainly presents the advantage of updating geographic information.

Even though it has become increasingly more common in the student's daily life to use digital maps, many of them still do not have basic notions of Cartography to interpret the geographical information presented by those maps (Peterson 2007).

Schooling becomes a key element in the construction of a society based on information, in knowledge and learning (Takahashi 2000). It is up to the school to create an environment through which the new technologies allow for an interdisciplinary interactive teaching, set to prepare students to become subjects capable of thinking, creating and expressing themselves via different languages.

Thus, the proposition of this investigation is to allow the student to handle the map according to the pedagogic assignment in each module, such as the pan resource to move the map or through the paintbrush tool they will be able to create the proper symbols for the map information and insert information about the studied subject following the teacher's instructions, among others.

Therefore, Multimedia Cartography based on the combination of maps and other medias (text, pictures and video) supported by the computer (Peterson 2007) becomes an important tool to identify, understand and develop a mental representation of their local space; ergo, it is important to offer this technology to basic education. The use of the World Wide Web can make multimedia resources a potential tool for learning, as it permits collaboration, interaction and exchange of ideas between students and teacher; besides, the internet is a tool to gather, select geographical data. Wherefore, students would become involved in their own construction of maps according to their needs (Wiegand 2005).

According to (Peterson 2007) other benefits would be gathered from using Multimedia Cartography via the internet in geography education, among those interactivity and dynamics: the student would take an active participation in the construction of knowledge, greater motivation and flexibility in learning, once one works with the student's contemporary technology.

Didactic-pedagogical practices in Geography must meet the use of maps in Geography classes not being limited to the location of determined spots that are ready and made for the students, but leading students to become active and participative in the mapping process, in the selection and insertion of spatial data from their living space and, consequently, in other spatial scaling.

2.2. Remote Sensing in Environmental Education

In geographic science, remote sensing has become an important tool for "recognizing" Earth in different spatial and time scales (Santos 2002); that allows men to better recognize their living space, as they visualize the dynamics of geographic space. Didactical procedures used in Geography classes must follow this new culture in the teaching universe (Di Maio 2004).

According to (Carvalho & Cruz 2001) this new technology helps students understand geographic space in a less abstract way if compared to a map. In accordance (Santos 2002), the introduction of Remote Sensing technology in schools allows students to identify, relate and understand environments and their transformation, such the impact caused by natural phenomena and anthropic alike, in particular of the Alcântara River in São Gonçalo (Florenzano 2005).

3. Objectives

The hereby paper proposes a methodology to support environmental education in the teaching of Geography. The dynamics of the Alcântara River in São Gonçalo is approached between 1970 and 2010 using new Technologies applied to cartography, involving basic notions of Cartography, Multimedia Cartography, Web Cartography and Remote Sensing. In order to achieve that, the research aims to survey seventh grade Geography teachers to gather data about the didactic-pedagogical practices focused on environmental education in public city schools, to create a teaching methodology to support environmental education, namely, the Alcântara River in São Gonçalo, evaluate the use of new technology applied to cartography (media, internet, satellite images), via practical tests, in seventh grade classes of basic education in public schools from the city of São Gonçalo. Lastly, the main goal is to evaluate how these new technologies applied to cartography may contribute to the construction of environmental awareness in students about of this water resource in the teaching and learning process.

4. Methodology

The city of São Gonçalo is nestled in the metropolitan area of Rio de Janeiro, more precisely on the east shore of Guanabara Bay and has ten river basins being that that five basins are inserted fully in the county and two partially (Andrade, 2011). However, in the last few decades, the swift population growth in the city spiked from a total of 1970 431. 270 thousand inhabitants in the 70's to 999.978 thousand inhabitants (IBGE 2012) and it has not been followed by specific urbanization laws and regulations, which favored irregular erections with none or very little infrastructure of sanitation and, moreover, deforestation and embankments literally "crossed out" this water resource. That has resulted in the degradation of great part of the Alcântara River in São Gonçalo which nowadays is in high environmental degradation.

Due to the importance of the subject and the current situation of environmental degradation of the Alcântara River in São Gonçalo - Rio de Janeiro, this environmental theme has been chosen because of the limited works in Environmental Education performed in the public schools of the city according to the City's Environmental Education Sub Secretary. Therefore, the ongoing research aims to develop and evaluate methodology in seventh grade classes of basic education through the use of new technologies applied to cartography to support environmental education in Geography classes, such as Multimedia Cartography, Web Cartography and Remote Sensing, in accordance with the Parâmetros Curriculares Nacionais (PCN) of Geography and the transversal theme of Environment.

This research is creating a digital material about the "Alcântara River" located in São Gonçalo, Rio de Janeiro as transversal theme regarding Environmental Education named Mapeando Meu Rio (MMR – Mapping My

River). This website has been developed with XML files (texts, images and exercises) on WordPress, besides activities proposed on the Google Earth software. The MMR is a methodological proposition, developed in a Master's degree course to support environmental education, via the internet, structured into modules, texts, exercises, curiosities, further reading and website suggestions for interaction. The research website can be found at www.mmr.com.br, but it is not yet available for the World Wide Web. After the implementation of this instrument and future adaptations and corrections, this material shall be made available for free on the São Gonçalo's City Hall website[4].

Table 1 summarises the content of MMR.

This material shall be evaluated in seventh grade classes of basic education in the public city schools of São Gonçalo. The schools participating in the tests shall be defined by the end of the current year with the City of São Gonçalo Education Secretary.

5. Final Comments

The ongoing research investigates the introduction of new technologies to basic education, as is creating means for evaluation on the website, *Mapeando Meu Rio* (MMR – Mapping my River) that has as methodological proposition the usage of Multimedia Cartography, Web Cartography and Remote Sensing in environmental education in the teaching of Geography for the study of the Alcântara River in São Gonçalo city – Rio de Janeiro and shall create evaluation means for it.

It is expected that the evaluations of this website to support environmental education indicate positive perspectives promoting environmental awareness in students about the Alcântara River from the presence of this river in their city. To sum it up, we seek to contribute to the improvement of the quality of Geography classes, creating a bigger interest in students and teachers for science and technology.

[4] São Gonçalo's City Hall is available at: http://www.saogoncalo.rj.gov.br.

References

Andrade T A G, Ribeiro J C F (2011) Estudos Ambientais em regiões metropolitanas –São Gonçalo. Gestão de Bacias Hidrográficas no município de São Gonçalo- região metropolitana da Baía de Guanabara 8: 167-190

Banco de Dados Agregados (2007). Instituto Brasileiro de Geografia e Estatística. São Gonçalo, RJ. http://www.sidra.ibge.gov.br/bda. Acessado 3 outubro 2012

Braga M (1998) O município de São Gonçalo e sua história. Falcão, São Gonçalo

Cartwright W E, Peterson M P, Gartner G (1999) Multimedia Cartography. Multimedia Technology in Cartography and Geographic Education 25:271-280

Carvalho, V.M.S.G; Cruz.C.; Rocha, E (2009) Sensoriamento Remoto e o Ensino da Geografia – Novos Desafios E Metas. http://www.inpe.br/unidades/cep/atividades cep/jornada/programa/t-11_trab_15.pdf. Acessado 14 março 2009.

Castells, M (1999). A sociedade em rede. São Paulo, Paz e Terra

Di Maio, A. C (2004). Geotecnologias Digitais no Ensino Médio: avaliação prática de seu potencial. http://www.uff.br/geoden/docs/Tese Doutorado Di Maio 2004.pdf. Acessado 20 abril 2012

Elzakker, C (2001) WEB Cartography: developments and prospects. Use of maps on the Web. 21-36

Florenzano, T (2007). Imagens de satélite para estudos ambientais. São Paulo, Oficina de textos

Kraak M-J (2001) WEB Cartography: developments and prospects. Trends in cartography. 9-15

KENSKI, V (1998) Novas Tecnologias: o Redimensionamento do Espaço e do Tempo e os Impactos no trabalho docente. Revista Brasileira de Educação, n8, maio./junho./julho./agosto, 1998 b.

Leff, E (2005) Saber ambiental: sustentabilidade, racionalidade, complexidade, poder. Petrópolis (RJ) Vozes

Limonad E (1996) Os lugares da urbanização: o caso do interior fluminense. http://www.teses.usp.br/teses/disponiveis/16/16131/tde-27042005-162418/pt-br.php. Acessado 20 agosto 2012

MEC (1998) Parâmetros Curriculares Nacionais de Geografia (3º ciclo do Ensino Fundametal). http://portal.mec.gov.br/seb/arquivos/pdf/geografia. Acessado 4 april 2006

Menezes P (2009) Novas Tecnologias Cartográficas em Apoio às Geotecnologias e à Análise Geográfica. http://observatoriogeograficoamericalatina.org.mx/egal9/Nuevastecnologias/Cartografiatematica/03.pdf. Acessado 16 july 2009

Peterson M (1995) Interactive and Animated Cartography. Multimedia and Hypermedia 7:127-142

Santos, V (2002) Escola, cidadania e novas tecnologias: O Sensoriamento Remoto no ensino. São Paulo, Paulinas

Silva M (2002) Sala de aula interativa. Quartet, Rio de Janeiro

Takahashi, T (2000) Sociedade da Informação no Brasil Livro Verde, Ministério da Ciência e Tecnologia. http://www.soinfor.org.br. Acessado 23 abril 2009

Vaughan T (1994) Multimídia na prática. Makron Books, São Paulo

Wiegand P (2005) The Best of the both worlds. http://lazarus.elte.hu/cet/madrid-2005/wiegand.pdf Acessado 20 junho 2012

Wiegand P (2006) Learning and Teaching with maps. Pratical map activities age 11 to 14: 106-115

	CONTENT	OBJECTIVES	ACTIVITIES
MODULE 1 Learning the basics of Cartog-raphy	Orientation Geographic Coordenates Scale Projection	- identify the basic elements of cartography; - Reinforce the basic notions of cartography and fill in possible gaps from previous school years;	Exercises Websites for interaction Curiosities Further reading
MODULE 2 Exploring the Alcântara River	The Alcântara River and its environmental degradation	- learn about the Alcântara River and understand in time-space scale the environmental causes and impact over this water re-source between 1970 and 2010 via several medias, such as drawings, pictures, texts, sound, video, and satellite images.	
MODULE 3 Socio environ-mental aware-ness of the Alcântara River	Preservation and conservation of this river	- understand the importance and the role of this water resource for the environment attempting to develop environmental awareness in students about the river.	

Table 1. Structure of the MMR website

Analysis of spatial representation of students on 6th year of Primary School: An approach through descriptive drawings and texts in home-school route

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Abstract. This presented study aimed to investigate the different cognitive process involved in representing through the mental map of the home-school route yielded by students on 6th year of primary school, performing a comparison between the expression obtained by a bidimensional representation in form of a mental map and the textual representation obtained by a practice activity performed with 78 students on 6th year of primary school. Yet, it aimed to classify the representations in different levels, from the simplest ones to the most complex ones, intending to establish from these results strategies for Geography teaching based on the use of cartographic language. For the results obtained, they were considered three analyzes with the representations constructed by the students. Two analyzes of the drawings, one related to type of vision adopted to represent the elements included in the drawing (lateral or vertical) and the other taking into consideration the arrangement of the represented elements, the orientation of the base of these elements on the sheet of paper, and further, if the student represented only the home-school route or if he also represented the surroundings of the route. Results showed that great part of the students presented a good performance on textual expression of elementary topological relations of laterality based on the observation of mental map, as well as on the usage of vertical vision over lateral vision in the representation of mental map, whereas for analyzes of disposal and spatial elements connection, great part of the students represented them simply, including onto map only the distance traveled with no representation of its surroundings.

Keywords: Scholar Cartography, home-school route, basic education

1. Introduction

The teaching of Geography has great importance for the student in school age to comprehend the processes and the relations established between the man and the environment. The lecture of geographical space occurs, above all, through the usage of a specific language of Geography: Cartography.

Cartography is a spatial language that must be apprehended by the students during all school life long, being widely recommended its use by the documents that treats Brazilian scholar Geography´s contends: the National Curriculum Parameters (PCN, its acronym in Portuguese).

In this document, the usage of cartography as a way to understand the geographic discipline is highlighted, where, at the end of Primary School the student shall know to utilize the cartographic language to obtain information and to represent the spatiality of geographic phenomena (Brasil 1997).

Based on this context, the presented study aims to investigate, via representation of home-school route elaborated by the students of 6th year of primary school, performing a comparison between expression obtained by a bi-dimensional representation in form of a mental map and the textual representation. Yet, it aimed to classify the representations in different levels, from the simplest ones to the most complex ones, intending to establish from these results strategies for Geography teaching based on the use of cartographic language.

2. Methodology

The means used to investigate knowledge on spatial representation of the participating students on the practice was the expression in form of a mental map and its description in form of a written text, having as basis the distance traveled by the students between the school and their homes.

According to Pontuschka et al (2009), mental maps are important and effective tools to comprehend the values one assigns to different places, having its main parameter the lived space.

The lived space refers to a space experienced through the movement and the displacement of the individual, it´s the space in which the kid is in direct contact and connects directly (Almeida & Passini 2004).

The mental maps, or drawings, are representations where there is no preoccupation with the perspective or any cartographic convention. When working this kind of representation, the student can use his creativity or to establish his own criteria of representation using as basis his own memory (Castellar & Vilhena 2010).

This category of representation is still frequently utilized as methodological resources to investigate how the signs are constructed and decoded (Kozel 2006), to analyze mental maps constructed by kids at scholar age, can yield important clues to comprehension of the geographical space and its representation.

The development of the proposed practice aimed, beyond to establish the students´ comprehension degree in relation to expression and graphical representation, to develop on them elementary topological representations and the vertical and lateral vision.

Between analyzes performed with the drawings and texts elaborated by the students during the practice is the notion of elementary topological relations.

Elementary topological relations are the spatial relations that establish among the elements in the space next to the kid. Between the concepts are part of these relations are, e.g., the neighborly relations, the order and the laterality.

The neighborhood is the most elementary level of spatial perception of the kid. In it, the kid realizes the objects are realized on a same plan and they have proximity and contiguity (Almeida & Passini 2004). When the kid dominates this kind of perception, it realizes the objects distributed on the space are arranged accordingly to its proximity to each other. This notion is primordial to represent the traveled route between home and school, as requested to the students during the practice activity.

The relation of order yields the relation of neighborhood. In this process, the student can comprehend the objects spatially distributed have an organization, i.e., an element precedes and succeeds another (Almeida & Passini 2004). This relation is evidenced in the mental map´s registers obtained by the practice activity as the elements perceived by the students are represented according to an order, since the point of origin, the school, to the point of arrival, the home, in the route represented by the students.

The laterality develops in the child between 8 and 11 years old and with its domain, the kid is capable to define what´s at the right and what´s at the left of what. When it domains totally this question, the child identifies not only the left from its body, but also the left from objects that are in front of it, or projected on a plan, like the paper (Almeida & Passini 2004). The domain of laterality designates, in a very practical way, the preparing of the child to understand the elements used in the cartographic language, such as latitude and longitude, and rotation movement of the Earth.

For Almeida and Passini (2004) this question of laterality can be considered by the teacher to take the student to the necessary decentralization for understanding of geographical references.

Another explored aspect analyzed on the mental maps elaborated by the participant students of the practice refers to lateral e vertical vision of the elaborated representations.

Made clear the main concepts addressed by performed analysis with mental maps and written texts of the students, it´s necessary to describe the practice carried out.

3. Practice performed in school

The practice was performed during four classes of Geography with three classes of students on 6th year of Primary School on the State School Teacher Odécio Lucke, situated at Cordeirópolis, SP, Brazil, during the first week of class on the month of February 2013, being obtained 78 mental maps and written texts.

At first, it was request for the students to draw a mental map that represents the route traveled daily between home and the school in which they study. The word “map” was used to verify what idea it means for the students, indicating previous cartographic knowledge apprehended in Primary School I (1st of 5 years).

Following that, after the students have finished constructing their mental maps, it was asked for them to observe and, from the observance, to write a little text indicating the represented route.

For the obtained results, a data collection was carried out considering three analyzes with the representations constructed by the students. For the results obtained, they were considered three analyzes with the representations constructed by the students. Two analyzes of the drawings, one related to type of vision adopted to represent the elements included in the drawing (lateral or vertical) and the other taking into consideration the arrangement of the represented elements, the orientation of the base of these elements on the sheet of paper, and further, if the student represented only the home-school route or if he also represented the surroundings of the route.

From other texts, it was yet performed an analysis on the presence or absence of indications of elementary topological relations. The articulation between these three analyzes can ground the adoption of teaching strategies for Geography, taking as basis the use of cartography.

4. Kind of vision adopted to represent the mental maps

Regarding the kind of vision adopted to represent the elements present on mental maps elaborated by the students; these were sorted into three categories.

Into the first category, they were included the drawings whose representation presented the elements on a camp of lateral view (simple representations). From the total of drawing elaborated by the students during the practice, 28 of them represented the elements seen in lateral perspective.

Into the second category, they were included the drawing that presented both elements presented from a lateral view and elements presented from a vertical perspective (intermediary representations). This category represents a group of students with intermediary comprehension, between spatial representation by a lateral view and the representation via vertical perspective. From the total of drawings obtained to perform the practice, 18 were included into this category.

The drawings with elements represented from a lateral perspective were included into a third category (elaborated representations). These drawings presented a greater representation of the process of cartographic representation, being obtained a total of 32 representations.

The classification values from the perspective of the representations elaborated by the students can be observed in the *Figure 1* below.

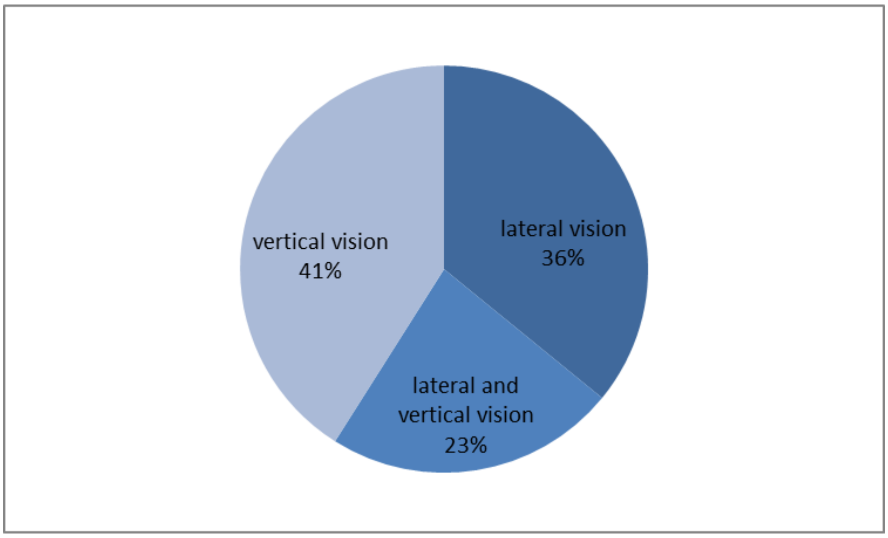

Figure 1. Chart presenting the kind of vision adopted to represent the mental maps.

From the results obtained by this classification, it is possible to observe that, regarding the representation capacity according to field of view, most of the students, 41% of total, elaborated their representations from a vertical perspective, as 36% elaborated their representations from a lateral view, and a third group of students (23%) represented the elements of the home-school route from lateral and vertical field of view.

5. Representation and orientation of elements present on mental map

Another classification carried out with the students´ drawings concerns the disposal and orientation of drawings and representation exclusively from the home-school route, or the representation of surroundings of the route. The drawings of the students were classified into three categories, from the simplest representations to the most complex ones, being the analyzed parameters described in the Frame 1:

Category	Description
Simple representations	They were included into this category the drawings that represented only the home-school route, without its surroundings or vicinity.
Intermediary representations	Into this category they were included the drawings that presented not only the home-school route, but also its surroundings, and though these elements were found disconnected or lacking any logical order.
Complex representations	Into this category they were included the drawings that, beyond represent the surroundings of home-school route, they also presented its elements aiming at a same side, having connection or logical order.

Frame 1. Description of categories of representation and orientation of elements present on mental map.

Figures 2, 3 and 4 show examples of mental maps categories.

This way, the drawing that presented few or no element topologically localized, as well as drawing, where they were the only represented the school and home, were considered as simple representations, from the total of drawings obtained on the practical activity, 33 drawings were included into this category.

The drawings that presented some elements topologically localized, but with no order or connection, as representations of lateral view oriented in different forms on the paper, were considered as an intermediary group of representations. From the total of mental maps analyzed on the practice, 28 representations were grouped into this category.

The representations that presented elements topologically oriented on the sheet of paper, such as vertical view, the representation not only of the traveled route between home and school, but also of the surroundings, were classified into a distinct group, namely complex representation. From the total of drawings obtained during the execution of this practice, 17 were grouped into this category.

To visualize better these results, the Figure 5 presents the percentage of analyzed drawings.

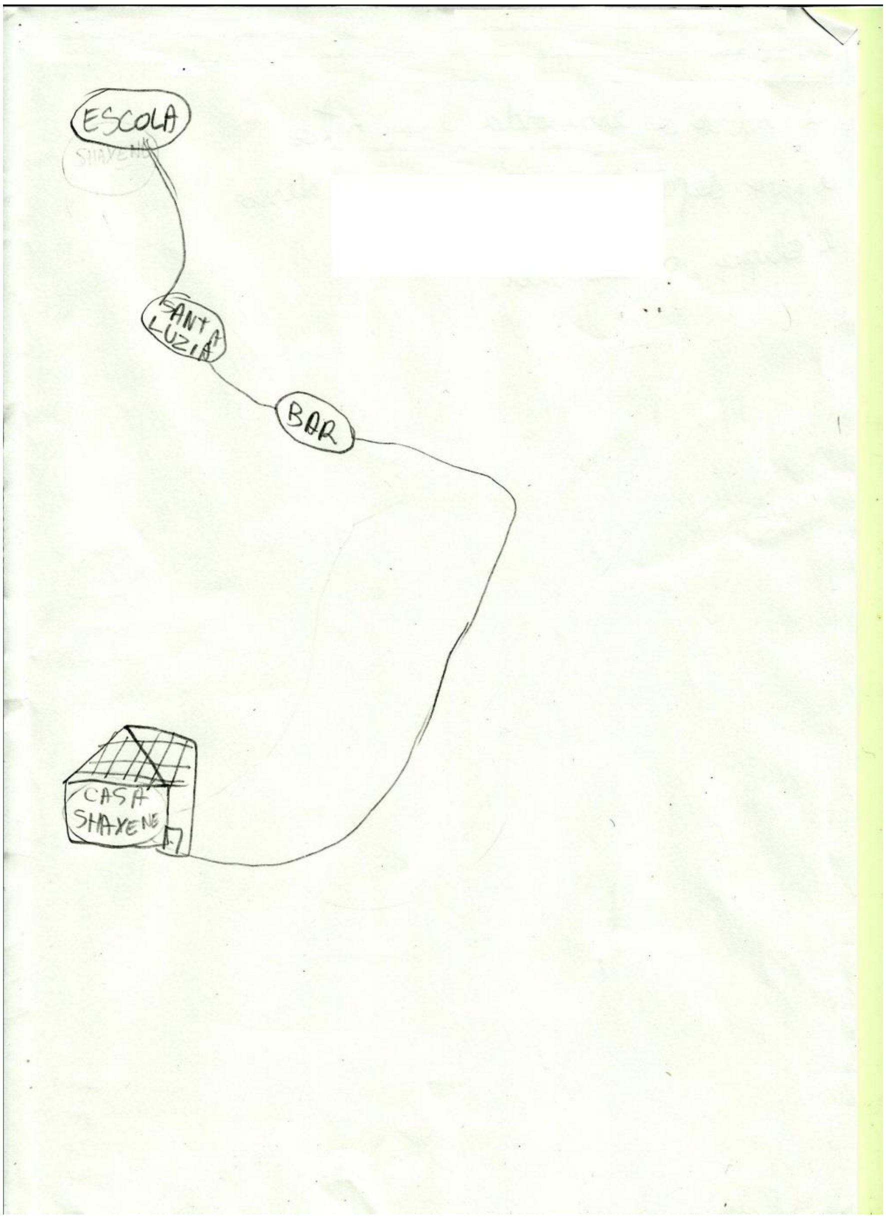

Figure 2. Simple representation example.

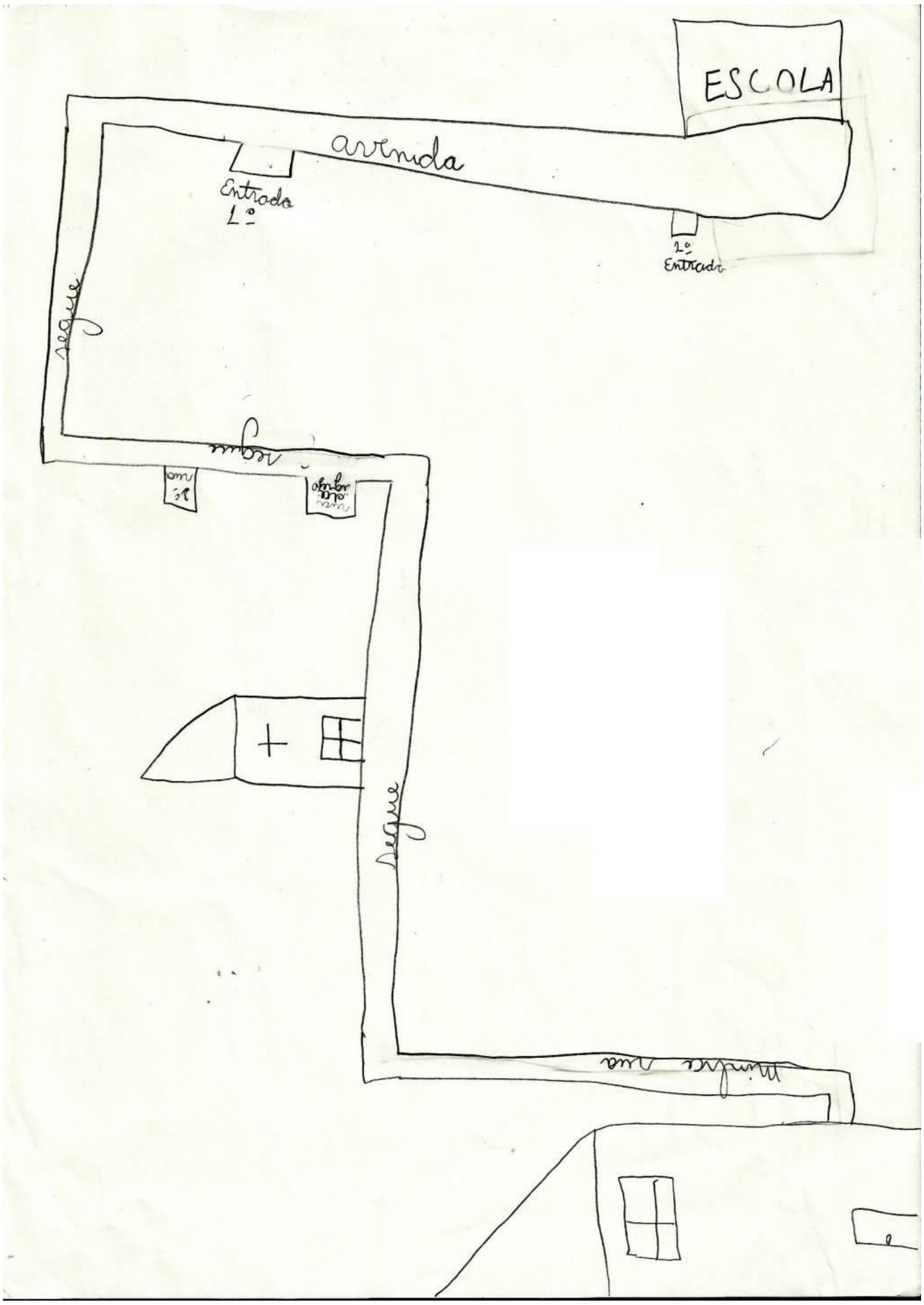

Figure 3. Intermediary representation example.

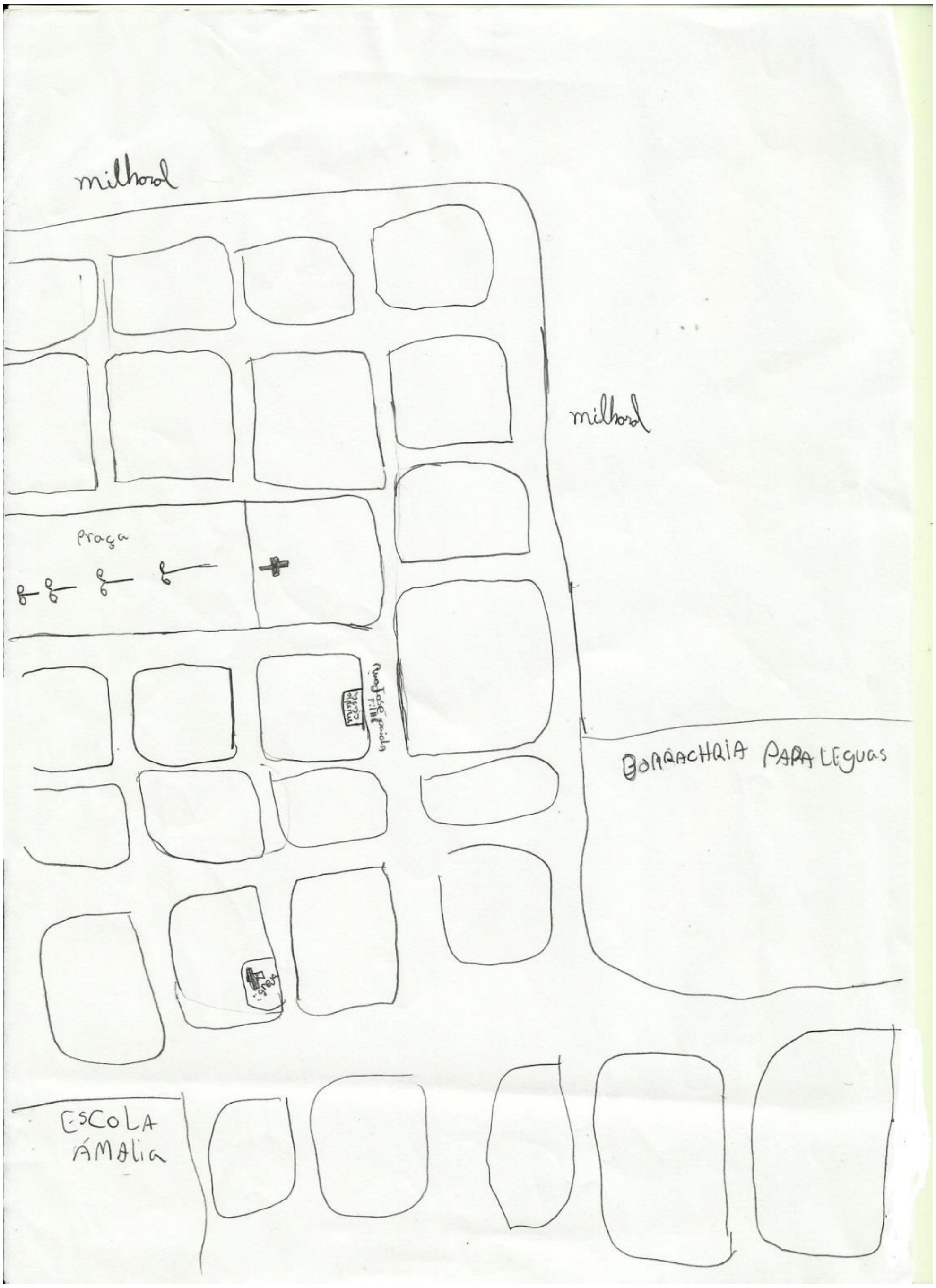

Figure 4. Complex representation example.

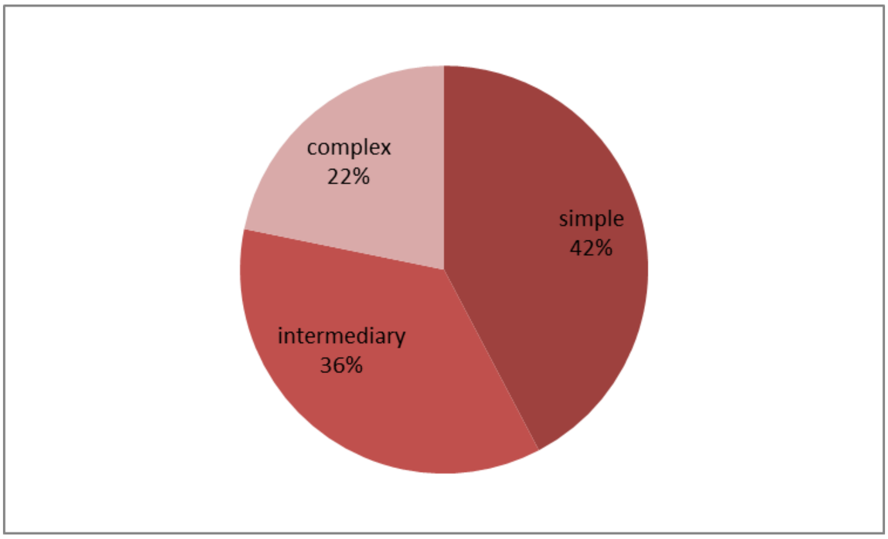

Figure 5. Chart presenting the representation and orientation of elements present on mental map results.

These results show that most of the students that participated in the practice were sorted into the group of simple representations, followed by the intermediary representations and complex representations. Beyond the analysis of the drawings, they were also analyzed the texts elaborated from observation of the mental maps.

6. Analyzes of texts

Regarding the texts elaborated to describe the elaborated representation they were analyzed and classified into three distinct groups of texts.

For the first group of texts, they were considered the most simplified descriptions of the drawings, detaching that such descriptions do not present any topological relation of laterality, as, for example, the indication to go right or left, or the distances or time taken by the route. From the total of the analyzed texts, they were observed 27 belonging to this group.

For the second group, they were used as criterion for grouping sometimes the presence of indicators of elementary topological relations, as right and left, or distance and number of quarters traveled, sometimes this kind of information was not presented, showing an intermediary level in written representation of the created drawing. 14 texts from the total analyzed were classified into this group.

The third group of texts presented, in elaborated drawing´s description, elementary topological relations, as right and left, the indication of distance or time taken on the route, showing that the student has a good written expression and comprehension of the drawn route. From the total of analyzed drawings from the execution of the practice, 37 were classified into this group.

Below, it´s presented a little board with a sample of text obtained from each group presented by the students who participated in the practice:

Group	Sample of text presented
They do not present in the text the elementary topological relations	"I go ahead, turn a block, go straight, turn the second block, turn the first block, turn the halfway and arrive"
Sometimes they present, sometimes they do not present elementary topological relations	"I go out of my house, turn, go straight, then turn left, go ahead and arrive to the school"
They present the elementary topological relations	"I turn left, go ahead, turn right, walk 4 blocks down, go straight, walk 2 blocks up, turn right and arrive to the school"

Frame 1. Sample of text obtained in the practice school.

Figure 6 presents the values in percentage of the different groups of texts elaborated based on the home-school route drawn by the students.

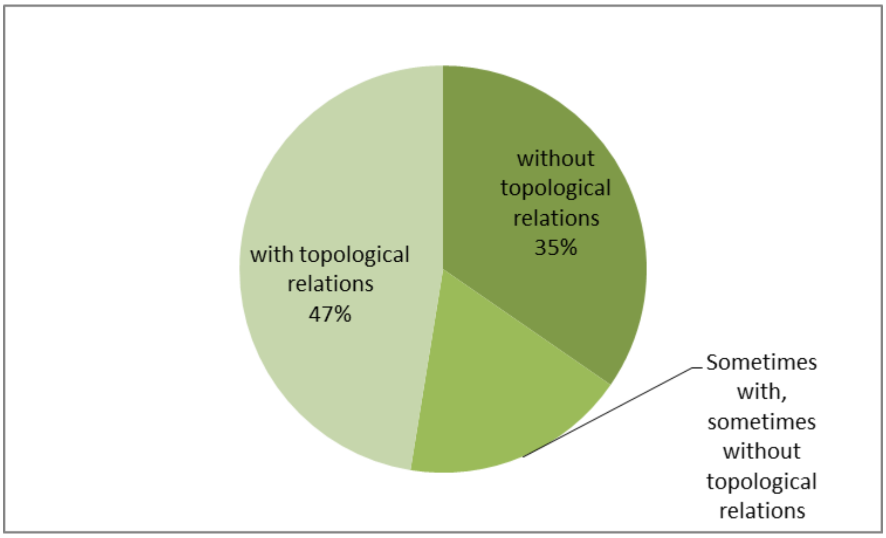

Figure 6. Chart presenting the analyses of texts.

The percentage obtained by the analysis of the texts elaborated by the students with the description of the traveled home-school route of each one showed that 47% of the texts presented elementary topological relations of laterality in its description, that 35% of the texts analyzed did not present any elementary topological relation in its description, and yet 18% sometimes presented topological relations, sometimes not, indicating that these learners are undergoing an intermediary stage of comprehension of these relations.

These values highlights that, when they express by a text, most of the students indicate in written form the elementary topological relations, followed by students who presented no topological relation in its description and, lastly, the students that sometimes presented, sometimes not, topological relations in their descriptive text.

7. Final Considerations

From the results obtained by the analysis of the mental maps and texts elaborated by the students during the practice, it is possible to make the following observations.

The results´ organization, in three different degrees of analysis of the texts and drawings, from the simplest to the most complex, in a line chart, shows the following panorama in Figure 7:

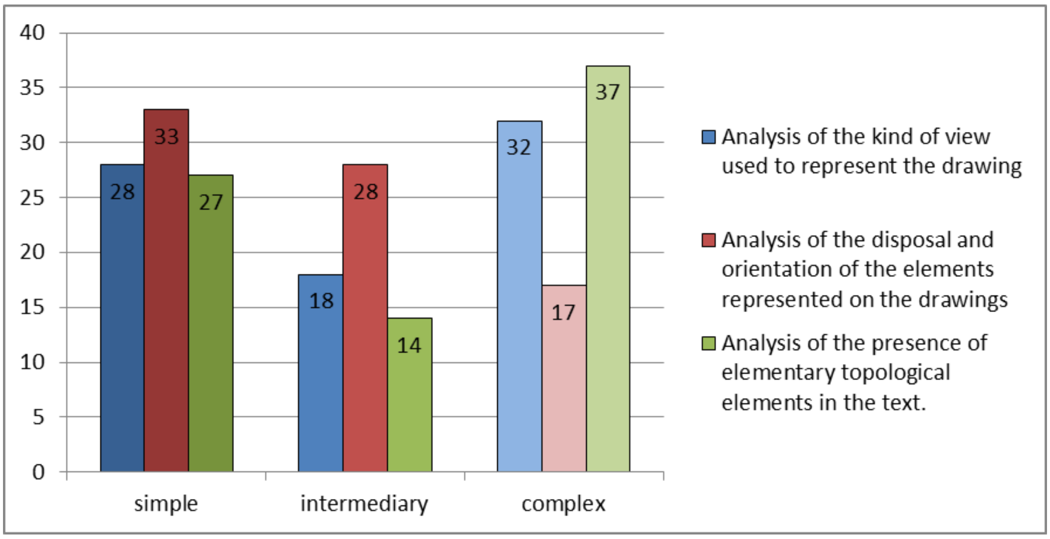

Figure 7. Chart presenting the final results of practice.

The observation of this chart shows that, for the three analyzes performed, there was a minor group for the students presented an intermediary performance on the spatial expression requested, whether in form of a mental map or text.

The analysis of the kind of vision presented for the drawings elaborated by the students shows most of them understand and can express by a mental map the idea a map is a spatial representation viewed from the top, and that it represents a certain portion of the space from a perspective different than the one we have when we look at a scenery on the ground.

Though many students have used in their drawing both elements with lateral and vertical vision, often depending on the element this student intends to represent, there is confusion in representation.

We can also verify that there is a confluence between the results obtained in the analysis of presence or absence of elementary topological representations in the texts elaborated and in the analysis of the kind of vision used to represent the mental maps, showing that in both of them most of the students presented a good performance, followed by the students that were classified as having simple representations and, lastly, by the intermediary students. This result indicates that the students who can represent the route sought from a vertical view, when they describe the route traveled, they indicate more clearly the elementary topological relations of laterality (as "to the right" or "to the left") of the elements observed in the text and on the map; as the students who cannot represent the vertical vision also cannot indicate the elementary topological relations in the text elaborated.

Regarding the analysis of the disposal and the order of orientation of the elements present on the mental maps, we can note, from the chart above, that the results mistune from the other analyzes.

Most of the students that attended the practice represented the elements oriented in varied positions on the paper and non-oriented to a same side, or else they represented only the route traveled, with no surrounding element, followed by representations were either oriented to a same side or presented elements surrounding the route and, lastly, the drawings presented both the elements oriented to a same side, and elements but the present on the traveled route.

From these results, they are adopted some strategies to develop a better spatial expression in the students regarding the drawing and the writing.

To develop better the representation and to treat the question of lateral and vertical vision on the students, they were executed activities of construction of a tridimensional model – a house made of paper – and it will be requested for the student to represent it from different perspectives (front, back and upon), then, gathering the models of the students onto a mockup, they will work the localization of the model in the whole, detaching and exercising the indication of its elementary topological relations.

Along the development of these activities, it will be requested for the students to elaborate constantly descriptive texts on the worked activities, for they can express especially the space realized in different forms.

Yet, it was expected the planning of these activities resulted positively to the teaching-learning process regarding the initial teaching of cartography as geographic language.

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References

Almeida, RD and Passini, EY; O espaço geográfico: Ensino e representação. 13rd edition. São Paulo: Contexto, 2004;

Brasil, MEC/SEF; Parametros Curriculares Nacionais: História e Geografia. Brasilia: MEC/SEF, 1997;

Castellar, S. and Vilhena, J; Ensino de Geografia. São Paulo: Cengage learning, 2010;

Kozel, S; Comunicando e representando: mapas como construções socioculturais in: Seeman, J (org.) A aventura cartográfica: perspectivas, pesquisas e reflexões sobre a cartografia humana. Fortaleza: Expressão gráfica e Editora, 2006, p.131-151;

Pontuschka, NN. et ali; Para ensinar e aprender geografia. 3rd edition. São Paulo: Cortez, 2009;

“Flying over Jurujuba” Scenarios and images of Jurujuba, Niterói, Brazil

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Abstract. The heron, the paraglider and the gas balloon are three symbolic elements frequently seen in the skies of the Jurujuba district, in the city of Niteroi, Brazil. They stimulate the knowledge and the record of places of reference and of emotions for its inhabitants. The proposal of the present work is to study the landscape of the Jurujuba district by mean of drawn images from an oblique perspective. These images are totally different from the horizontal perspectives daily perceived by the inhabitants. In the oblique ones we shall observe strategic points of reference which will facilitate our move, the same way as the heron, the paraglider and the gas balloon, in a harmonious and different overflight of the district. Jurujuba has deserved a special attention because it is a traditional fishermen district, well differentiated while inserted in the urban perimeter of Niteroi. In order to preserve its characteristics, the community needs to be oriented to avoid the loss of its identity due to the accelerated urban evolution of the municipality and to the present lack of perspectives of its artisanal fisheries and aquaculture activities, when the youngest generation does not see any future in them. In Jurujuba there is a clear need of restoring its history and of valuing its characteristics and the feeling of membership of its inhabitants. With this booklet, the authors expect that the children and teenagers, inhabitants of the district, will be encouraged to work with their schools and with their community in the registry of this history.

Keywords: Images, Jurujuba, history, community, Social Cartography, local identity.

1. Jurujuba: a fishermen district

> “The geographical space is the atmosphere: it is a subtle and diffuse element in which all aspects of the Earth

are immersed. Invisible but always present. Permanent and however changing. Imperceptible but taken by the wind out of its insignificance The light, crude or filtered, reaches us through the airspace, modifying the appearance of the land according to the time of the day and according to the season. The morning vapors slowly stay on the rivers and the prairies". (Dardel 2001. P.23).

Located at the south-west limit of the city of Niterói, Jurujuba is a traditional fishermen district. Strong in the 1960's, fisheries activities have suffered a continuous decline during the last decades. This was due to the strong decrease of the sardines catches in the Rio de Janeiro region which led to the closing of three canneries located in the district where hundreds of women (most of them wives of fishermen) used to work. Fishing boats aged during all this time without a sufficient fleet renewal. Also the fishermen went old and retired, without a sufficient renewal by the younger generation.

The positive aspect of closing the canneries was that it ended their pollution of the sea and the strong smell of fish meal which stank the air. Slowly a new activity was developed in the area: the farming of mussels, just in front of farmers' homes.

Finally, in the recent years, the sardine schools are back in the region of Rio de Janeiro, giving new hopes to fishermen. There is future for fisheries and fish farming in Jurujuba. Knowing well the district and its history helps the new generation to build this future.

For a better understanding of the district, giving value to its activities and to its people, the project developed the iconographic perception of its children. It encouraged them to know and to discover different points of view and different places and points of reference, through the story depicted and told. This led them to a re-reading of the story and to the creation of other stories, utilizing other referential places of the district.

The aerial view with oblique perspectives introduced in the children the knowledge of the land space seen from the air or from higher places such as the Pico fortress or the paragliding platform on the Viração hill.

The visual and projective perspectives allow the establishment of relationship among objects and the orientation relationship between the objects and their location on the maps. These concepts were developed during the apprenticeship of recognition and observation of the objects.

Using icons or known elements such as the paraglider, the heron or the gas balloon, it was possible to present to the children and students the history of the neighbourhood in an entertaining way, through an aerial view with drawings from several points of reference.

With pictures and with the preparation of puzzles it was possible to identify the places depicted and to locate them on the map of Jurujuba.

Meu bairro	**My Neighbourhood**
Cercado pela montanha e pelo mar Fica o bairro de Jurujuba Que desperta amor Em todo morador	Surrounded by the mountain and by the sea Is the District of Jurujuba Which awakens the love of all its inhabitants
Aqui tem muitas praias Todas muito belas Com destaque as de Eva e Adão Que estão sempre em nosso coração	Here you have many beaches All very beautiful With a special reference to Eva e Adão Which are always in our hearts
Jurujuba fica em um pedacinho Da cidade de Niterói E desperta nosso orgulho Pois é nosso porto seguro	Jurujuba stands in a small corner Of the city of Niterói And it awakens our pride As it is our secure harbour
Jorge Luiz turma 704 Colégio Estadual Fernando Magalhães	Jorge Luiz class 704 State College Fernando Magalhães

Figure 1. Poem of a high school student (in Portuguese and its translation into English).

Social cartography will be introduced with the location of places still not presented in the drawings. At this moment a new phase of the project is under development, but it is not described in the present document. Local place names also appear with much relevance on a map built by students from more advanced classes. With the aid of history and geography teachers of the State College Fernando Magalhães, they began a field and bibliographic research in order to define the histories of the sub-districts of Jurujuba in an oblique aerial view.

2. Drawing the map

It was through a field work done with the students of the 1st year of high school of the State College Fernando Magalhães that the research began. The students had a Google Earth image of their neighbourhood and a cut of a topographic map with a scale 1:50.000. They went out with their Geography teacher and also with some university students of the Universidade Federal Fluminense.

Figure 2. Fieldwork

Figure 3. Image of Google Earth.

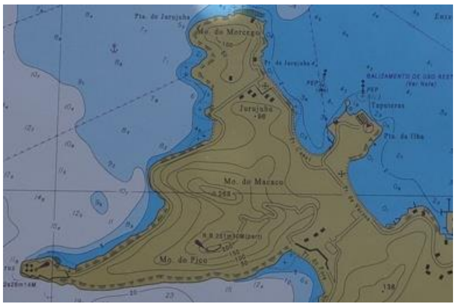


Figure 4. Nautical map of Jurujuba.

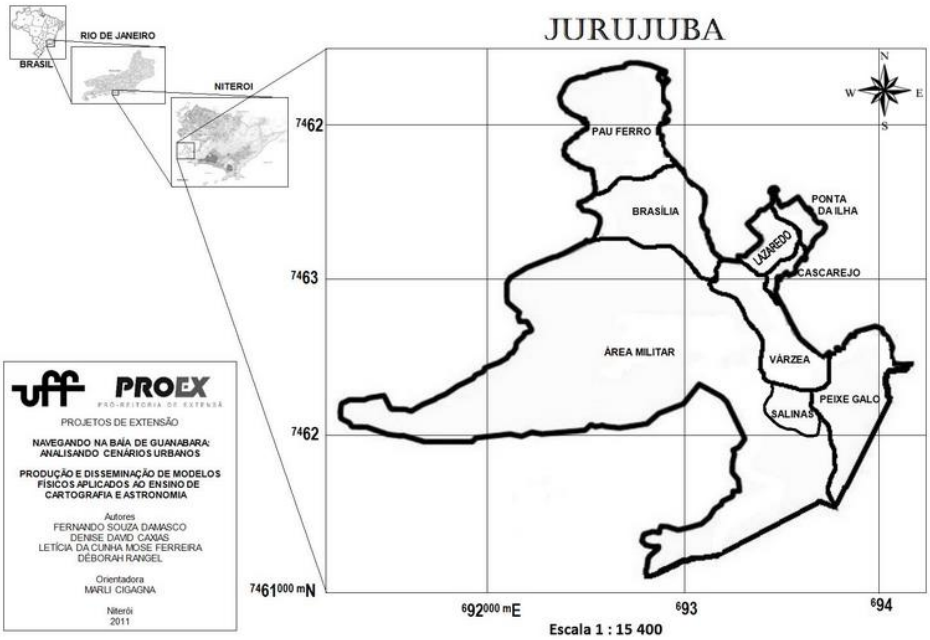


Figure 5. Sub-division of the district through participative communitarian cartography.

The main objective of this field work was to study local environmental questions, the location and the physical aspects of the district in which the school is located. The students were predominantly inhabitants of the neighbourhood and they began spontaneously to sub-divide the district according to their communities. This led to a work of social, participative and communitarian cartography.

The students were not only observers of the landscape but they also initiated a moment of reflection and of thought about the relationship between the components of the landscape and in the relationship of persons and places, in a perfect and harmonic symbiosis of relationship with the feeling of belonging. It was when the "district set" began to be seen as the neighbourhoods inside the district, their inhabitants, their location (hill, coastline, coastal plain), their activities, the access roads and the modalities of transport.

Figures 6 and 7. Discovering Jurujuba on the map and on the model.

3. Drawing the landscape seen from the sky

The essence of the work is a series of small drawings where the author registers the landscape of the district. These drawings were based on pictures taken from different angles and perspectives, giving always emphasis to images seen from above as an aerial photography.

Children normally see the landscape from an horizontal perspective, the images were worked in order to give them a point of view from above, as a flight of a heron or of a paraglider or a gas balloon, which are common elements in the skies of Jurujuba. Therefore these elements were considered the icons of the work.

Landscape is a space where people interact daily, a heterogeneous set of forms with multiple relationships between men and environment and among men.

The urban nucleus of Jurujuba is privileged for having this diversity of forms and relationships. We have the coastline forms, the relief forms (altitude of 203 meters), the shapes of the houses, the relationship of the inhabitants with the sea through fisheries activities and their relationship with nature. All these points were highlighted in the work and they enabled the creation of other drawings and of other stories. The work is therefore continuing.

According to (Santos, 1999), “Space is essential for the conditions that it offers to the production, to the movement, to the residence, for the communication, for the exercise of politics, for the exercise of beliefs, for leisure and as a condition of "living well"”.

The images are places of reference in Jurujuba and a child story was prepared in a booklet folded as an "origami", having on its back a map done by the high school students in former activities.

These images are important elements, leading to other activities to be developed with pupils of the primary school of the district, with the listing of other places of reference which are theirs. This type of activity was already begun with an itinerant exposition in schools, called "scenarios of Jurujuba", where the students identify other places of reference in the neighbourhood, explored by educational practices.

Another phase of the methodology was the work with puzzle images with big pictures of the district, 210 mm large and 297 mm long, cut in 9 pieces of same size, like postcards, in order to interpret them, to join them and to reconstruct the complete image.


Figures 8 and 9. Working with puzzle pictures.

The social cartography is developed in different parts of the activity, not only among the youngest pupils of the first years of the fundamental school but also among those of high school, giving them the opportunity to draw maps that really depict the identity of the neighbourhood, their sense of belonging and their pride. This work is also realized with adults with interviews in the community.

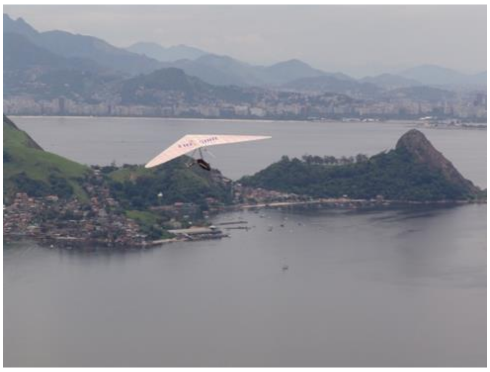
In a sense, this work is inspired by Humbolt. Actually, Humbolt brought a kind of art and of romantic aesthetics in his scientific work of describing Nature, while remaining objective. "Humbolt dominates the aridity of scientific descriptions to give a living impression of nature. It is not only sensorial and not only intellectual but a 'total impression', a wide pleasure, quiet and deep, which gives to the reader something similar to a pure vision of scenes and the communication of very high intuitions" (Ricotta, 2003).

4. The landscape seen by the heron, the paraglider and the gas balloon

When we talk about landscape, we have in mind what our eyes see and register. Our actors, the heron, the paraglider and the gas balloon are part of this landscape, but their point of view is different, as they perceive the landscape from a vertical and oblique perspective, with a panoramic outlook from a higher level than those which are more familiar to the inhabitants. They see the neighbourhood from a higher plan than a window from a house at the top of the hill, similar to the vertical vision commonly found in maps, aerial photos or satellite images.

The paraglider has his own track with a precise course, always based on the points of reference of the region. The heron knows well this place and it flies and glides while resting, but its perception of the landscape is to know the safe places, to search for food and for a place to shelter. The gas balloon flies according to the wind with no special fate and end up, who knows, in the sea very far from there.

These three elements are the main actors of the story that lead the reader to explore and to know better the district of Jurujuba. It intends to encourage children and students to re-cognize their neighbourhood through the reading of the landscape of their place. They also make them rewrite the story with other perceptions and details of this particular and enchanting community.

Figures 10 and 11. The oblique views of Jurujuba.

The landscape can be represented by different manners There are many ways to represent it. It is a mean to show us the way an observer has observed an object. We can be ourselves directly observers of a landscape or be observers of a representation of this landscape.

The objectives of working landscape with the local students were:

- to understand which are the landscape concepts of the students;
- to discuss different points of view and representations;
- to work out the different possibilities of observation and of representation of a landscape;
- to discuss about what is a beautiful landscape and what is a degraded landscape.

Basically, the contents of this work were about the concept of landscape, the concept of representation and the degradation of the landscape.

5. The drawing of the images

The drawings were done based on landscape as portrayed by Mateus Andrade Rodrigues (Lucas Honorato, Geography student from UFF, provided the layout of the booklet), student of the 2nd year of the State School Dr. Adino Xavier, who was very skilful to transform images with horizontal views into images with oblique views in order to provide a better interpretation of the places of reference of the district while giving to the reader the feeling of being flying over the region and having a panoramic view.

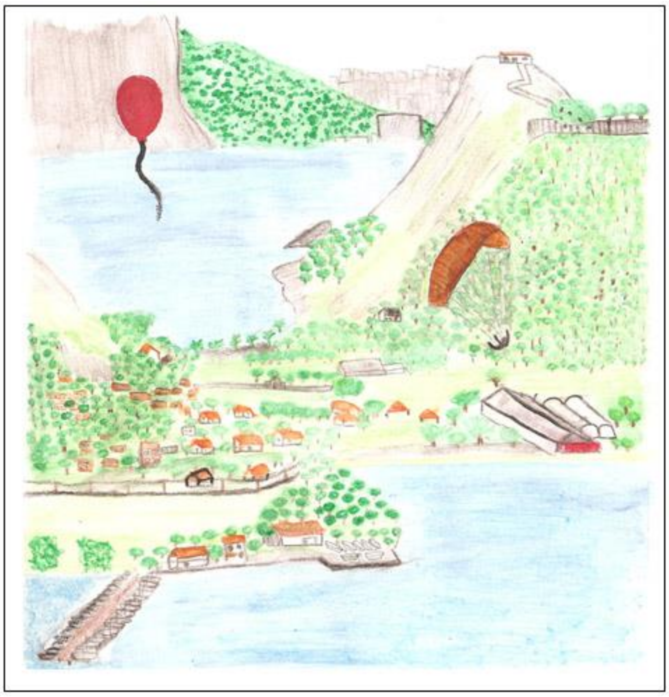


Figure 12. Jurujuba, drawn by Mateus Andrade Rodrigues.

The images of Google Earth were also used to spot the spatial location of the district, to interpret the image through specific criteria, to trace the courses and to establish the sequence of the story.

The Google Earth tool was also used to vision details of the image from a horizontal standpoint registering the landscape from the street. All this was associated to the patience and to the commitment of the amateur draftsman in performing the drawing, in order to allow other students, children and pupils, to see, to understand and to enjoy each part of the neighbourhood as if they were paragliders, herons or gas balloons.

After having traced the images of the most important and relevant places of the district, visible from a paraglider a heron or a gas balloon, a legend was created for each image telling a story as presented in figure 13.

6. Conclusion

The work done in Jurujuba is oriented toward the revitalization of the district and its whole community through auto-knowledge and auto-esteem. It is based on cartographic aspects developed jointly with the community, mainly with its children and teenagers from local schools. These cartographic aspects are eminently innovative as they take advantage of the local characteristics as well as the way these characteristics are perceived by the inhabitants themselves

The work is also fully in accordance with the concept of the “Brazilian Cultural Landscape” which has its roots in the Brazilian Constitution from 1988 itself. According to the Constitution, the cultural heritage is constituted by material and immaterial goods, taken individually or jointly, making reference to the identity, the action, the memory of the different groups which constitute the Brazilian society, in which we find scientific, artistic and technological creativity, ways of expression, ways to create, to do and to live, as well as works, objects, documents, edifications and other spaces dedicated to artistic and cultural manifestations. It also includes the urban sets and places with historical, landscape, artistic, archeological, paleontological, ecologic and scientific value.

Of course, a similar work can be realized in any other place, as for instance in fishermen communities along the Brazilian coastline or along Rivers as the São Francisco river in the Northeast of the country or the Ribeira valley, which group several towns along the Ribeira do Iguape river, on São Paulo coastline.

Similar experiences can also be replicated anywhere in the world, together with communities that identify themselves with the environment in which they live.

Cover Page -1 – FLYING OVER JURUJUBA

City Park, jumping with paraglider, we can observe Charitas beach and, further, the district of Jurujuba.

2 – Look at the Pico Fort and at the São Luis Fort! They are really high! Many years ago, they were used to defend the entry of the Guanabara bay. Today, we can visit them and learn about our history. The Varzea beach and the Salinas community are very close to the forts.

3 – Look! The Preventório Hill! How nice it is! How many houses... Many persons must leave there. It should be good to live at the top of the hill as you have a very good view of most of the city of Niterói.

4 – And what about those points on the water? These are the mussels farms where shellfish farmers grow the mussels we eat.

5 – What a big fish! This is the Quai beach. It is where the fishermen arrive with their boats fully loaded with fish. Every 29th June is the Sankt Peter day and the fishing boats depart from this quay for a maritime procession. Guess why it is called the Quay beach!

6 – This is the Church Sankt Peter of Jurujuba. It was a former wooden chapel rebuilt in 1947 with stones, lime and whale oil.

7 – Wow! The Santa Cruz Fortress! With its thick walls and plenty of old canons, always caring the entry of the Guanabara bay. At its side we have the Macaco hill and, further, the beaches of São Francisco and Charitas.

How beautiful is our neighbourhood!

Figure 13. Development of the story.

References

Almeida, R. D.(2001) “Do Desenho ao Mapa. Iniciação Cartográfica na Escola”. São Paulo: Contexto.

Dardel, E. (2011) Translation: Rolzer, W. “O Homem e a Terra: Natureza da Realidade Geográfica”. São Paulo: Perspectiva.

Landim, P. C. (2004) “Desenho de Paisagem Urbana: As cidades do Interior Paulista”. São Paulo: Editora UNESP.

Ricotta L. (2003) “Natureza, Ciência e Estética em Alexander von Humbolt”. MUAD, Rio de Janeiro.

Santos, M. (1999) “A Natureza do Espaço: Espaço e Tempo: Razão Emoção”. São Paulo: Hucitec.

Venturi, L. A. B. (2005) Organizador. “Praticando a Geografia: Técnicas de Campo e Laboratório”. São Paulo: Oficina de Textos.

Navigating With Tactile Maps

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Abstract. This paper reports results of a study, which investigated the tasks, strategies, and abilities associated with navigational map use of travelers who are blind or low vision. Recognizing that navigation is a complex task (Lobben 2004 & 2007, Wobers & Hegarty 2010), the overall goal was to understand how performance on potential sub-tasks of navigation affects navigation success. Because prior research has shown that travelers who are blind or low vision are able to learn a route or the travel environment more successfully when using a map, we chose to keep the map as part of the research question and experimental design. We hypothesized that a person who combines and updates their mental map created from in-lab pre-field map recreation exercise with the mental map created from physically interacting with their environment may be a more effective navigator.

Keywords: Tactile Maps, Navigation, Map Use

1. Introduction

Travel is an essential human activity. Travel activities differ, though, and these differences are based on more than discrete trip objectives. Consider the mode of transportation, human sensory input channels, and the type of travel aid (i.e. GPS, in-car navigation system, maps, wandering) as only three noteworthy differences. In this research we focus specifically on navigational map use, as maps often play an integral role in navigation. While this activity is one in which nearly everyone engages, abilities, tasks, and strategies associated with map navigation differ between people (Lobben 2004) and between populations.

Navigation maps serve as important aids to a person who needs to travel through a real-world environment. Such maps are vital because nearly everyone needs to travel to some extent and “the most significant handicap produced by visual impairment is the limits imposed on the ability to travel independently” (Golledge 1986). For those who live “without the gift of vision, mobility has to be gained through training, patience, courage, and hard-earned personal experience [but] the visually impaired person who wants to live an active life...has no choice" (Passini & Proulx 1988). Travelers who are blind or low vision who navigate through the environment, face experiences that travelers who are sighted do not. For example, forming a cognitive map of an area is significantly more time consuming for map users who are blind or low vision than for map users who are sighted (Spencer et al. 1992, Ungar et al. 1996 & 1997). The tactile map may provide an essential layout or reference point to which map users may register landmarks (which are recognized through kinesthetic, auditory, tactile, or olfactory cues) encountered during environmental exploration. Researchers have discovered that the task of traveling through and learning an environment may be completed much more efficiently and easily if the traveler who is blind or low vision has the aid of a map before and during the task (Golledge 1986. Passini & Proulx 1988, Spencer et al. 1992, Ungar et al. 1996 & 1997, Espinosa & Ochaíta 1998, Blades et al. 2000).

While tactile maps are an integral part of the process, the activity of navigational map use involves many tasks, not all of which seem directly map-related (Lobben 2004). Another important part of the process entails a person's ability to interact with the environment. When travelers who are blind or low vision traverse a planned route, they may use two maps, the tangible and the mental. The mental map is one that they develop, update, remember, and use (i.e. recall information) during the navigation process. In studies that focus on wayfinding without a map, researchers have discovered that the extent to which a person can create an effective and operational mental map will influence their route learning and wayfinding success (Klatzky et al. 1990, Loomis et al. 1993, Blades et al. 2002).

2. Methods

Both in-laboratory and in-field delivered instruments were used and all testing was conducted individually with participants who are blind or low vision. This investigation focused on one primary research question: What is the relationship between specific navigational map use sub-tasks and overall navigation success by travelers who are blind or low vision?

Following the approach of Jacobson et al. (1998), a mix of in-laboratory and in-field delivered tasks were employed. Testing took place in both a research lab as well as in the local environment. Each participant was tested individually. A single testing session lasted approximately three hours. The test session began with in-lab testing during which the participant completed three spatial abilities and map use tasks (discussed below and summarized in Table 1). Following completion of those tasks, the participant completed a series of in-field navigational tactile map tasks. Finally, the participant completed sense of direction and confidence surveys as well as a final in-lab task. Informed consent was obtained from each participant following protocol approved by the campus institutional review board.

2.1. Experiment Tasks

Tasks One, Two and Three were completed as a series in a laboratory prior to field testing. Tasks One and Two were both rotation tasks. Task One, a traditional geometric rotation test (*Figure 1*), was modeled from the Kit of Factor-Referenced Tests, while Task Two, a map rotation test (*Figure 2*), was adapted from a similar study with participants who were sighted (Lobben 2007). Two rotation tasks were included for two reasons. First, the traditional geometric test (and similar versions) has been used in map use-related studies in the past (Nadolne & Stringer 2001, Bell & Saucier 2004, Zhou & Zhang 2007, Melsom 2009), but not in studies involving participants who are blind or low vision. We were interested in determining whether general geometric rotation plays a role in navigation success for this participant group. Second, previous research showed that in-lab map rotation tests do not predict navigation success, but do predict the extent to which a participant rotates their map during the process of navigating (Lobben 2007). We wanted to determine whether the same relationship is evident with participants who are blind or low vision.

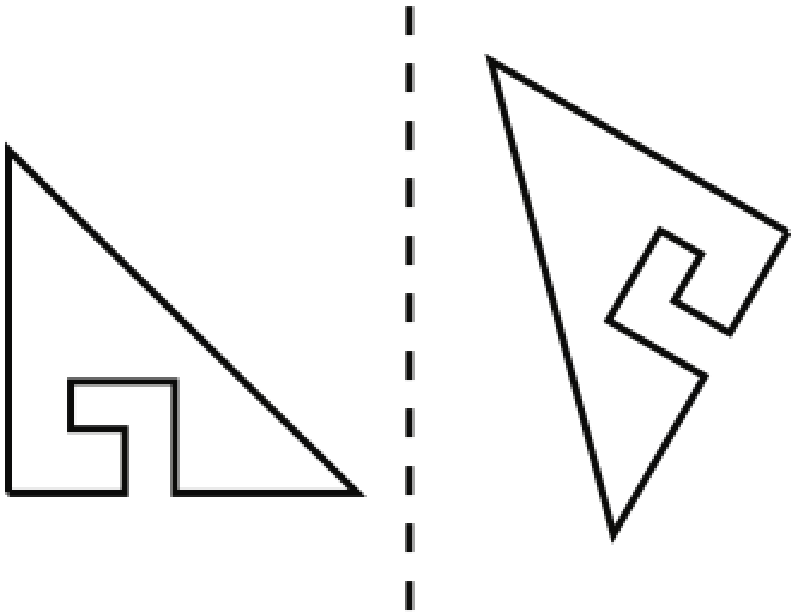

Figure 1. Example of Geometric Rotation Task

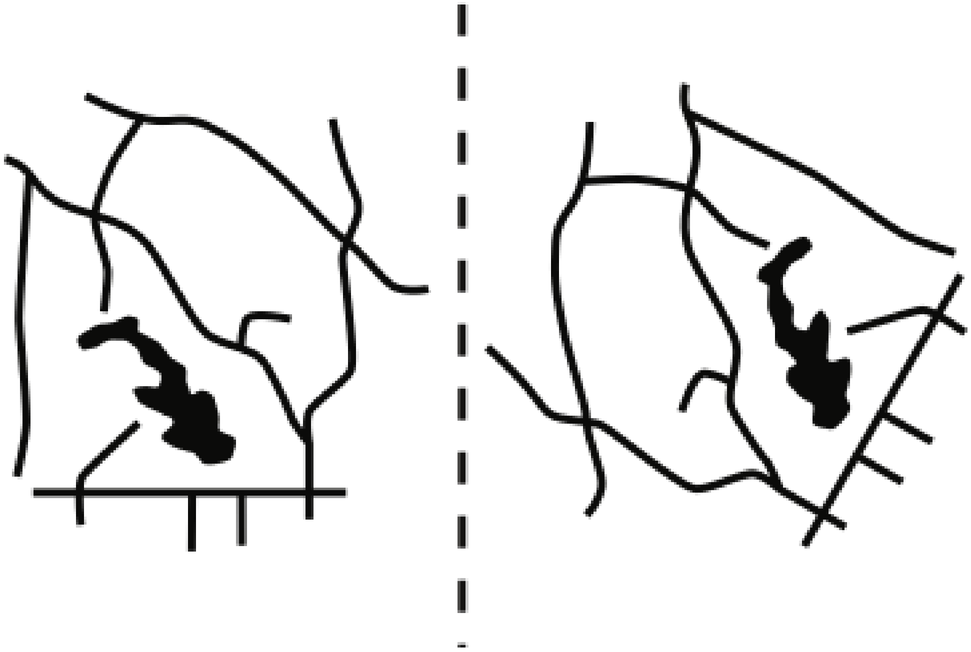

Figure 2. Example of Map Rotation Task

Task Three was a survey map recreation instrument patterned after the task used by Ochaíta and Huertas (1993) and Jacobson et al. (1998). It was designed to measure participants' survey memory. For the current research, the participant was given a map legend and asked to study it until familiar with the map symbols. Following the legend study, the participant was presented with a gridded street map, about four blocks by about five blocks in extent, printed on an 11"x17" piece of microcapsule paper (*Figure 3*). Each participant was given five minutes to study the map. Following the study period, the participant was given another five minutes to re-create the map using magnetized symbols exactly like the symbols encountered on the map. Study and re-creation timing was determined through pilot testing.

Task Four and Task Five were completed during field testing, following the first three in-laboratory tasks. After completing all of the laboratory tasks, the participant was taken outside and guided to the area represented by the tactile map they studied in the laboratory. Similar to a study conducted by Zimmerman (1990) in which participants were let to a location in the environment, oriented, and asked to navigate to a given landmark, Task Four required the participant to plan and follow four routes (shown in *Figure 4*). Tactile stars represent start and end locations for a single route; the participant was asked to navigate between stars, passing a specific landmark on each route (i.e. a large parking lot or an overpass). This landmark was used

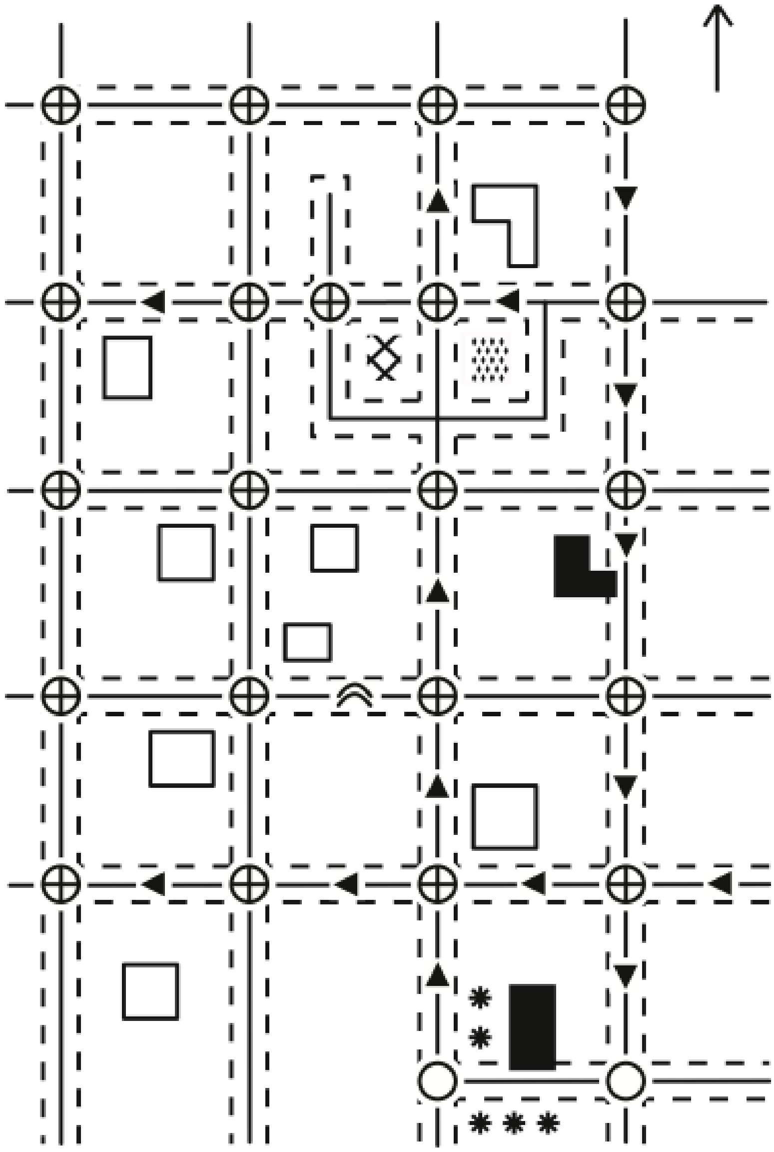

Figure 3. Map Used in Task 3, Map Recreation

to ensure that each participant followed the same route. The participant was then given time to determine the route, including the action points (turning points, for example). All map consultation was timed, including initial route planning. At prescribed locations during route-rollowing, the participant completed a field task during each of the four routes. Task Five was a self-location estimate. Following a method used by previous research (Lobben 2007), for this task, the participant was stopped along the routes, given the tactile map, and asked to identify the current location on the map and egocentric orientation in the environment.

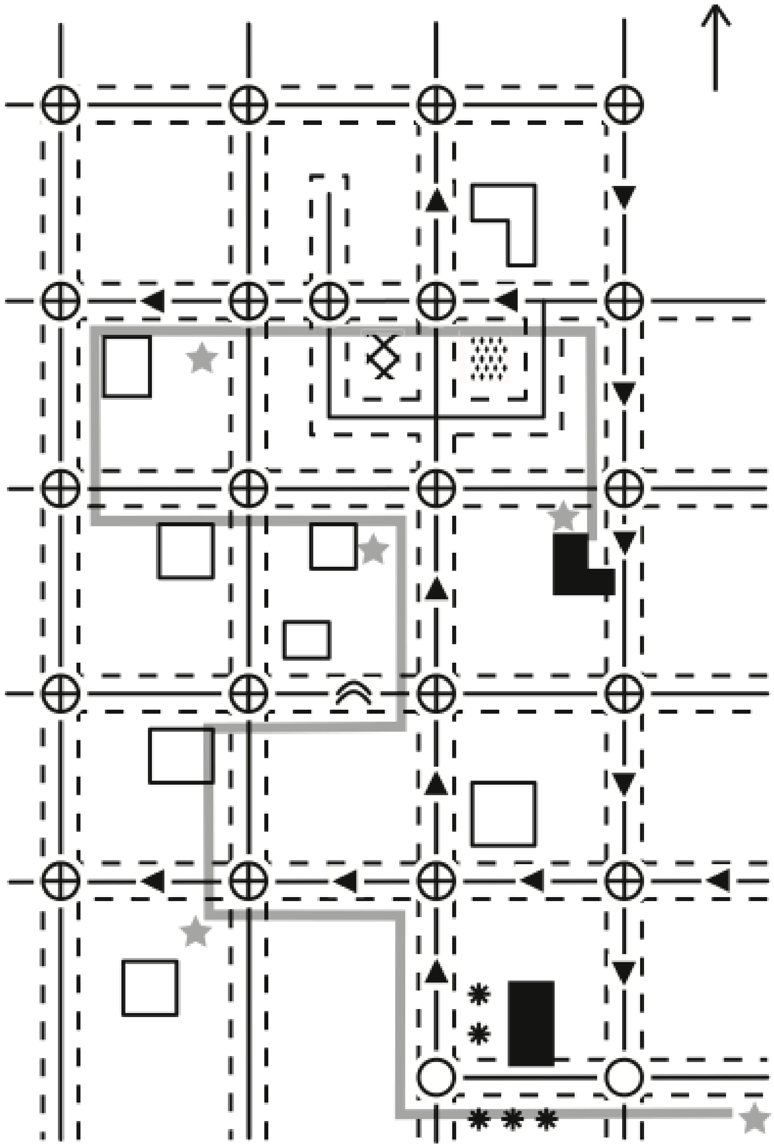

Figure 4. Map Used in Field Exercise, Routes Highlighted

Task Six, Task Seven, and Task Eight were completed in the laboratory following the completion of the in-field tasks above. Task Six asked the participant to again re-create the map using the same protocol as with Task Three. The final two tasks were both surveys. Task Seven (*Table 1*) was an eighteen-question Sense of Direction survey – SOD. This Sense of Direction

Survey was adapted from previous research by Hegarty et al. (2002) who created the self-report measure for participants who are sighted.

I am very good at giving directions	1 2 3 4 5 6 7
It is important to find new routes in the environment	1 2 3 4 5 6 7
I am confident in my ability to use maps	1 2 3 4 5 6 7
I am very good at judging distances	1 2 3 4 5 6 7
My sense of direction is very poor	1 2 3 4 5 6 7
I think of my environment in cardinal directions	1 2 3 4 5 6 7
I am not very good at judging time	1 2 3 4 5 6 7
I have trouble understanding directions	1 2 3 4 5 6 7
I do not enjoy using maps	1 2 3 4 5 6 7
I often take shortcuts	1 2 3 4 5 6 7
I do not confuse left and right much	1 2 3 4 5 6 7
I am very good at reading maps	1 2 3 4 5 6 7
I remember details when traveling in a new area	1 2 3 4 5 6 7
I do not enjoy giving directions	1 2 3 4 5 6 7
I usually remember a route after traveling it only once	1 2 3 4 5 6 7
I do not worry much about getting lost	1 2 3 4 5 6 7
I do not have a good mental map of my environment	1 2 3 4 5 6 7
I have a lot of experience using maps	1 2 3 4 5 6 7

Table 1. Sense of Direction scale

Each participant also completed a confidence survey, Task Eight (*Table 2*). This survey was also adapted from an existing instrument created and used by Blades et al. (2002). The original Blades et al. (2002) version included a 5-scale Likert structure. For consistency with the Sense of Direction survey, the original 5-scale format was changed to a 7-scale format.

Rate your confidence in traveling in different contexts:	
at home	1 2 3 4 5 6 7
local streets	1 2 3 4 5 6 7
busy roads	1 2 3 4 5 6 7
crossing at traffic signals	1 2 3 4 5 6 7
crossing without signals	1 2 3 4 5 6 7
new environments	1 2 3 4 5 6 7
when making detours around hazards	1 2 3 4 5 6 7
when exploring away from known route	1 2 3 4 5 6 7

Table 2. Confidence Survey

2.2. Participant Demographics

Seventeen participants who are blind or low vision were recruited from the local school for the blind, the university, and from the community, yielding sixteen usable results. Participant demographics, based on self-report, included five males and eleven females, ranging in age from thirteen to sixty; fourteen were blind and two were low vision; eleven were dog-guide and five were white cane users.

2.3. Analysis

Participant performance was calculated in one of two ways depending on the specific task. Tasks One, Two, Four, and Five were scored based on participant response time while Tasks Three, Seven, and Eight were scored based on participant answer choice. Task Four served as the dependent variable in the analysis. This variable represented overall navigation performance as determined by the total time spent consulting the map, an approach used and validated in past research (Marston et al., 2006; Lobben, 2007). All other Tasks described above functioned as independent variables.

Analyses included Akaike Information Criterion – AIC, Akaike Information Criterion correction – AICc, multiple regression, and post-hoc correction for low N. AIC (Akaike information criterion) is not used for hypothesis testing, but rather provides a goodness-of-fit of possible models using all of the variables included in the AIC calculation (in this case, the dependent and all independent variables). Final model choice is usually based on the model represented by the lowest AIC (as was done in this case). A stepAIC was run in R. Following the AIC analysis, AICc was calculated. The AICc is used as a correction for analyses run with a relatively low N and is calculated based on original AIC, n, and k (number of parameters). The final stage of the analysis applied the Pratt equation to calculate a corrected squared-multiple R. This post-hoc calculation is made to correct potential bias due to the relatively low number of individual observations (Yin & Fan 2001).

3. Results

The results from the stepAIC revealed that the optimal model with the lowest AIC included four independent variables: Task One (geometric rotation), Task Five (self-location), Task Six (post-field map recreation), Task Seven (Sense of Direction scale). Following, the AICc analysis identified the same independent variables, though their values differed slightly from the original AIC variables. Using these results, a multiple regression was run using the four independent variables from the AIC/AICc results. Because this model (*Table 3*) was run using the AIC-selected variables, the result is an overall significant model, individually significant independent variables, and a strong main effect.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.990[a]	.979	.972	4.116

a. Predictors: (Constant), selfloc_tota, sod_total, a_total, geom_total

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8900.598	4	2225.149	131.355	.000[a]
	Residual	186.340	11	16.940		
	Total	9086.937	15			

a. Predictors: (Constant), selfloc_tota, sod_total, a_total, geom_total
b. Dependent Variable: time_total

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	316.315	28.813		10.978	.000
	a_total	-.626	.136	-.294	-4.587	.001
	geom_total	.165	.044	.404	3.794	.003
	sod_total	-3.450	.336	-1.181	-10.269	.000
	selfloc_tota	1.889	.173	.591	10.917	.000

a. Dependent Variable: time_total

Table 3. Multiple Regression Output

4. Discussion

The primary research question queried the relationship between specific navigational map use sub-tasks and overall navigation success by travelers who are blind or low vision. The analysis associated with this question involved the establishment and use of overall navigation success as the dependent variable and sub-tasks as independent variables. The final regression model, which was developed through a multistep process including AIC, AICc, regression, and R^2 correction, revealed only four subtasks as predictors for navigation *success*. So, while all of the in-laboratory and in-field delivered tasks may be related in some way to navigational map use, not all of these relationships are significant for navigation success.

The significance of the four variables is not entirely surprising. After all, as mentioned above, these variables were included in the testing and analysis because three of them were shown in previous research to be associated with environmental mapping and navigation success. First, Task Five, a self-location task, requires the participant to interact with the map and the environment, together, more than any other task used in this research. Previous research by Lobben (2007) also included self-location task in the test battery. The self-location task was administered in the same way for both the current and previous research. In both studies the self-location task was a strong predictor of overall navigation performance. The current research demonstrated that self-location was a significant variable in the multiple regression model. This task captures a person's ability to relate the map to where they are in the environment and identify the direction they are facing, which requires a person to relate both themselves and the map to the environment, making self-location an ego- as well as allocentric task. A traveler who can demonstrate this ability effectively and efficiently may be aware of their map/environment position continuously during the navigation activity as well as maintain a sense of direction. Both of these abilities contribute to successful navigational map use.

Second, Task Six, post-field map recreation, represents a person's acquired survey knowledge of the environment (i.e. top-down configurational environmental knowledge), from both the map as well as from active physical travel. Each participant completed this task twice, before and after navigating with the map, but only the post-field variable was significant in the regression model. The meaningfulness of this variable is not surprising either. A post-field recreation reveals the extent to which each participant encoded the actual environment while engaging in the navigational map use task. In other words, Task Six may reveal the extent to which a person attended to the details of the environment, rather than simply attending to the geometry of the space (i.e. counting intersections as a strategy for orientation for example).

Third, Task Seven, the Sense of Direction scale, reveals how well a person feels they can perform a navigation or environmental spatial ability task. Our results indicate that this self-report survey provides a significant and meaningful predictor of overall navigation performance. While our adapted version of the original Sense of Direction survey was used with a different population, blind or low vision travelers, the self-reporting mechanism may function similarly to the original developed by Hegarty et al. (2002). In the original format, Hegarty et al. (2002), suggest that the success of the survey may be due to the fact that people truthfully and accurately self-report their environmental spatial abilities. Since wayfinding and navigation are fundamental activities that most everyone engages in everyday, people are likely keenly aware of how well (or how poorly) they perform these complex environmental tasks. Hegarty et al. (2002) demonstrated that the survey provides a prediction of environmental spatial abilities. While the original Sense of Direction survey was designed for and deployed with travelers who are sighted (Hegarty et al. 2002), and ours was adapted and deployed with travelers who are blind or low vision, enough similarity between the two instruments remains to consider them equivalent. The augmented survey designed and administered in this research was regressed against overall navigation performance. Results reveal a significant relationship with reasonably strong overall main effects in the model. Again, while slightly different from the Hegarty et al. (2002) self-report survey and while administered to different populations, the general outcomes from the respective field studies are similar.

Fourth, Task One, is a general geometric rotation task. Mental rotation has received considerable attention in spatial research. Interestingly though, previously reported research (with participants who were sighted) revealed no significant relationship between rotation and navigation, but did find significant relationship between an in-lab rotation task and physical map rotation during navigation (Lobben 2007). Our results show no significant relationship between in-lab map rotation and in-field physical map rotation. In fact, none of the participants in this study rotated their maps during the field navigation exercise.

5. Conclusion

These results demonstrate what past and present researchers continue to observe – not all seemingly ‘map-related’ tasks are significantly related to actual in-field map-use activities. As an issue of ecological validity, it may be patently incorrect to assume that a lab-delivered task, just because it seems to be map- and/or navigation-related, is necessarily a meaningful task that people use during real-world navigational map use. Many tasks were administered in the current research and only four of these tasks/variables were shown to be significantly related to actual in-field recorded performance of navigational map use. But, even though nearly everyone engages in the act of navigation, making it a familiar activity, researchers cannot simply relegate the validation of their research instruments to sensibility and rationalization (Cronbach 1957). Field validation may be essential for making claims of prediction.

Also, these results support the assertion made by Jacobson et al. (1998) that a mix of in-laboratory and in-field delivered tasks may be an experimentally valid approach in this sort of research, where ecological validity is paramount. The significant variables included in the post-AICc developed regression model include both lab-delivered (map rotation, sense of direction survey, and map reconstruction) and field-delivered (self-location) instruments.

Of the battery of tasks administered, significant predictors of navigation success include: map reconstruction, self-location, sense of direction, and mental geometric rotation. From a theoretical standpoint, the relationship between these sub-tasks and navigational map use performance allows us to understand some of the underpinnings of the very dynamic task of environmental navigation. We can begin to see that while many tasks may seem to be related to tactile map navigation, not all really are – or at least are not statistically significant. Three of the tasks that were shown to be significant contributors to navigation performance included: map reconstruction, self-location, geometric rotation requires a person to be able to fluidly transform a perspective and make judgments about positioning of the object. While these three tasks may seem to be dissimilar, when considered collectively, we can see some common grounds – perspective taking and representational space. Whether directly map related (as with the map reconstruction and self location tasks) or non-map related, the ability to dynamically transform space and perspective, regardless of the type of object, seems to play a significant role in tactile map navigation performance.

References

Bell, S and D Saucier. (2004). Relationship among Environmental Pointing Accuracy, Mental Rotation, Sex, and Hormones. *Environment and Behavior*. 36(2): 251-265

Blades, M, S Ungar, and C Spencer. (2000). Map Use by Adults with Visual Impairments. *Professional Geographer*. 51: 539-553.

Blades, M, Y Lippa, R Golledge, R. Jacobson, and R Kitchin. (2002). The Effect of Spatial Abilities on Visually Impaired Peoples' Wayfinding Abilities. *Journal of Visual Impairment and Blindness*. June. 407-419.

Cronbach, LJ. (1957). The two disciplines of scientific psychology. *American Psychologist*. 12(11): 671-684.

Espinosa, MA and E Ochaíta. (1998). Using Tactile Maps to Improve the Practical Spatial Knowledge of Adults Who Are Blind. *Journal of Visual Impairment & Blindness*. May: 338-345.

Golledge, RG. (1986). Sensitivity to Perspective Structure While Walking Without Vision. *Perception*. 15: 173-188.

Hegarty, M, A Richardson, D Montello, K Lovelace, and I Subbiah. (2002). Development of a self-report measure of environmental spatial ability. *Intelligence*. 30: 425-447.

Jacobson, D, R Kitchin, T Gärling, R Golledge, and M Blades. (1998). Learning a Complex Urban Route Without Sight: Comparing Naturalistic Versus Laboratory Measures. Presented at Mind III: The annual Conference of the Cognitive Science Society of Ireland. University College Dublin, Ireland. August 17-19.

Klatzky, RL, JM Loomis, RG Golledge, JF Cicinelli, S Doherty, and JW Pellegrino. (1990). Acquisition of route and survey knowledge in the absence of vision. *Journal of Motor Behavior*. 22: 19–43.

Lobben, A. 2007. Navigational Map Reading: Predicting Performance and Identifying Relative Influence of Map-Related Abilities. *Annals of the Association of American Geographers*. 97(1):64-85.

Lobben, A. 2004. Tasks, Strategies and Cognitive Processes Associated with Navigational Map Reading: A Review Perspective. *The Professional Geographer* 56(2): 270-281.

Loomis J, R Klatzky, R Golledge, J Cicinelli, J Pellegrino, and P Fry. (1993). Nonvisual Navigation by Blind and Sighted: Assessment of Path Integratio Ability. *Journal of Experimental Psychology: General*. 122(1): 73-91.

Marston, J, J Loomis, R Klatzky, R Golledge, and E Smith. (2006). Evaluation of Spatial Displays for Navigation Without Sight. ACM Transactions on Applied Perception. 3(2): 110-124.

Melsom, A-K M. 2009. Individual differences in spatial abilities: Evidence for different strategies in an indoor navigation task. Master's Thesis, University of Tromsø.

Nadolne, M and A Stringer. (2001). Ecologic validity in neuropsychological assessment: Prediction of wayfinding. *Journal of the International Neuropsychological Society*. 7(6): 675-682.

Ochaíta, E and JA Huertas. (1993). Spatial representation by persons who are blind: A study of the effects of learning and development. *Journal of Visual Impairment and Blindness*. 87: 37-41.

Passini, R and G Proulx. (1988). Wayfinding Without Vision: an experiment with congenitally totally blind people. *Environment and Behavior*. 20(2): 227-252.

Spencer, C, K Morsley, S Ungar, E Pike, and M Blades. (1992). Developing the Blind Child's Cognition of the Environment: the Role of Direct and Map-given Experience. *Geoforum*. 23: 191-197

Ungar, S, M Blades, and C Spencer. (1996). The Ability of Visually Impaired Children to Locate Themselves on a Tactile Map. *Journal of Visual Impairment & Blindness*. Nov-Dec: 526-535

Ungar, S, M Blades, and C Spencer. (1997). Strategies for Knowledge Acquisition from Cartographic Maps by Blind and Visually Impaired Adults. *The Cartographic Journal*. 34(2): 93-110.

Wolbers, T and M Hegarty. (2010). What determines our navigational abilities? *Trends in Cognitive Science*. 14(3): 138-145.

Yin, P and X Fan (2001). Estimating R^2 shrinkage in multiple regression: A comparison of analytical methods. *The Journal of Experimental Education*. 69: 203-224.

Zhou, R and K Zhang. (2007). Impact of Mental Rotation Strategy on Absolute Direction Judgments: Supplementing Conventional Measures with Eye Movement Data. *Lecture Notes In Computer Science Proceedings of the 12th international conference on Human-computer interaction: intelligent multimodal interaction environments*. Beijing, China.

Zimmerman, GJ. (1990). Effects of Microcomputer and Tactile Aid Simulations of the Spatial Ability of Blind Individuals. *Journal of Visual Impairment and Blindness*. 84(10): 541-547.

The contribution of the Tactile Cartography for Teacher's Training in Brazil

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Abstract. Cartographic representations constitute an indispensable content for the study of Geography aimed at the formation of citizenship. The amount of literature on Cartography teaching in the classrooms is noticeable; however, little has been discussed about teaching this discipline in the graduation courses. Cartography in Geography teaching is important to help in the analysis and in the development of observation, perception and space representation abilities. Analyzing the workshops on Tactile Cartography, it was possible to observe the difficulty of the teachers to dominate cartographic-related contents. Focus will be given to experiences from courses delivered in 2012, a partnership between the University of Sao Paulo (USP), Sao Paulo State University (UNESP) and the Sao Paulo State Secretary of Education; in which, when challenged to elaborate a tactile map, the teachers who attended the courses expressed difficulties in reading the information communicated by the printed map to be adapted, mainly in what concerns the aspects of graphic semiology. This led us to perform a theoretical review of the cartographic communication principles and t conclude that the tactile cartography broadens the possibilities of application of practical activities with maps in the classroom, involving all students, and becomes a support content for the geography teachers, independently of the reality lived.

Keywords: Geography teaching, school cartography, teacher's formation

1. Introduction

The cartographic representations constitute an indispensable content for the study of Geography focused on the formation of citizenship. The amount of literature on Cartography teaching in the classrooms, mainly since the 1990s, is noticeable, concerning elementary, middle and high school. The fact is that little has been discussed about teaching this discipline in the graduation courses, mainly the ones aimed at the formation of teachers, beyond methodologies and techniques, focused in the formative quality to ensure that this professional can have intellectual autonomy to conduct this thematic in the daily practice.

The result of this lack of concern with the graduation courses destined to form Geography teachers is the difficulty that these teachers present when trying to develop the contents related to cartography, which are required today by the Brazilian school syllabus.

This study aims to emphasize the urgency of courses for teachers after graduation (in Brazil, known as continuing education or capacitation), covering the different areas of knowledge to deal with spatiality in its multiple dimensions and representations.

Cartography, either as discipline or research area, is a *social constructor* (Almeida 2010); therefore it is subjected to and reflects society changes. In this sense, the contextualization about Geography teaching in Brazil is necessary to instrumentalize the approaches and the actions in the Teacher's Formation Courses.

According to Salichtchev (1988) Cartography can be seen as "a science which portraits and investigates the spatial distribution of the natural and cultural phenomena, their relations and changes over time, through cartographic representations - – model of symbol image which reproduces this or that aspect of reality in a graphical and generalized way". This is the art, the method and technique of representing geographic spaces, either form direct or indirect observation, and its products (maps, letter or plant) are used in the daily life since pre-historical times (Castrogiovanni 2010).

Thus, Cartography, defined by the International Cartographic Association (ICA) as the set of studies and scientific, artistic and technical operations based on the results of direct observations or analysis of documentation for the elaboration and preparation of letters, plans and other forms of expression as their utilization , articulates the natural and social sciences and reflects different historical moments, increasingly approaching Geography, mainly for the importance in teaching and research. The role of the cartographer or the teacher is extremely relevant for the social construction of the map. This approximation brings several obstacles to the teachers, which will be discussed in this study.

The school cartography is in the interface of Cartography, Education and Geography; therefore, the cartographic concepts are present in the syllabus and should be included in the disciplines destined to the formation of the teachers.

It was only in the last two decades that the need to compensate the failures of the graduation course became a concern in Brazil. In this stage, palliative measures have been discussed to help the teachers in formation and also those who had graduated a long time ago and have to work with the new thematic and the new technology which are present in the classroom nowadays.

According to Oliveira (2010), Geography was distant from the Brazilian population, mainly concerning cartographic representations. The objective of the Geography taught in the 19th century and in part of the 20th was to meet the capitalist and bourgeois needs to know the territory and its wealth. The most important was the memorization of names and places, not the comprehension of their complexity.

"In what concerns the political and economic changes and reorientations which occurred in the Brazilian space, they motivated the insertion of Geography as a school discipline in the syllabus of secondary education in 1837, with the creation of 'Colégio Pedro II', aiming to help the national bourgeoisie to attend university level courses existing in that time" (Oliveira 2010).

Most publications on Geography teaching in Brazil focused on the nomenclature of events and there was a strong disconnection between the contents approached and the cartography-related elements. The information concerning spatial representation were seen as content, rather than methodology, a means to study the geographic space (Oliveira 2010)

It was only in 1913, that the book *Geographia do Brasil* by Carlos Miguel Delgado de Carvalho dared to use maps, due to the outcome of the republican movement and the liberalism in Brazil. Even so, the use of maps was very restricted due to the high cost of the publication of images in textbooks.

The 1980s marks a methodological rupture in the configuration of the school geographic knowledge, which started to be more critically approached, which was reflected in the cartographic representations of the social context lived in that time.

The teaching of Geography - and consequently Cartography – at the Brazilian school has experienced advances and setbacks. With the concern to escape from traditionalism, themes related to Physical Geography and cartographic principles were minimized in the syllabus; and topics related to human geography and the debate over social contradictions were prioritized.

Simielli (1996) developed a series of studies in the late 1980s and throughout the 1990s about the importance of the cartographic alphabetization for students of the initial grades, with the concern to form conscious and critical map readers, able to represent the geographic space and become map makers.

The publication of the National Curriculum Parameters by the Brazilian Ministry of Education broadens the debate on cartographic alphabetization and cartography teaching in general in the basic schools. After the publication of this document and the due to the falling costs of color publication, the textbooks started to use more maps in their editions.

However, in many publications, the maps are set as illustrations, without any concern with scale, correct legend or even orientation. In addition, the Geography courses destined to form teachers do not follow these changes and the professionals many times do not have conditions to evaluate the maps in the textbooks. Even though these problems seem to have been overcome, they still affect the education in Brazil.

2. The Tactile Cartography course allied to the Geography teacher's formation

2.1. The importance of cartographic learning

The work of the geography teacher is complex, as it needs to transcend the reading of the geographic space, reading the reality of the students and their knowledge about this space. Considering this reality, the teacher will be able to, more confidently, propose challenging problems which are part of the students' lives and which are many times put aside due to the use of passive methods proposed by the teacher.

For the teacher to have a good performance it is important that he/she dominates the geographic content to be taught; however, knowledge about the area of learning psychology, social psychology, history of education, history of geography as a discipline and about languages and methods to be used in the classroom is also necessary, as the model that defined the good teacher only judging the academic knowledge is obsolete; today other competences are necessary for the satisfactory development of the pedagogic practice. Among the geographic types of knowledge that the teacher needs to dominate, are the ones related to the development of cartographic activities in the classroom.

Cartography in Geography teaching is fundamental to help in the analysis and in the development of the abilities of observation, perception and representation of the space. And here is the importance of handling, reproducing, interpreting and constructing maps.

The access to communication in its broadest sense means access to the knowledge; and the map as a means of communication allow the access to spatial knowledge from the surroundings to the limits of a country or the world.

Almeida R. D. (2001) makes an important remark:

[...] the individuals who cannot use a map are prevented from thinking about the aspects of the territory that are not registered in their memory. They are limited to the registration of images of the living space, which prevent them to perform the elementary operation of situating unknown localities (Almeida 2010).

Didactic resources as maquettes (models), games and tactile maps help in the process of learning graphic representations, as they allow the children to get in contact with generalization, symbology, point of view and map proportion in a ludic way, deconstructing their elements and understanding the thematic presented.

2.2. Tactile Cartography course

The tactile Cartography, a branch of Cartography which approaches the perception, the elaboration and the use of maps, can be defined as the science, the art and the technique of transcending the visual information in a way that the result is a document that can be used by all the individuals, including visually impaired people.

The tactile maps are cartographic representations in relief, elaborated from visual information. In these maps it is possible to reproduce the symbolic system of the visual map through the tactile language, provided the particular characteristics of the touch are considered. The tactile graphic representations can be used as didactic resources in the classroom or to help in the locomotion of visually impaired people (in buildings and public places, urban centers, etc.).

Considering the need to work the aspects of inclusion of impaired students in regular schools with the teachers in activity, the authors o this article have been offering tactile cartography courses. The objective is to spread information about the importance of the tactile didactic material in supporting the teaching/learning processes and the importance of new technologies applied to the educational processes of visually and hearing impaired people and present some topics related to cartographic concepts and the production of tactile graphic representations, broadening the discussion about the application of materials in the classroom.

However; delivering training courses for Geography teachers, we could observe that these professionals present theoretical deficiencies concerning Cartography. They also presented serious difficulties in the development of methodologies for fundamental and middle school students about the teaching "of" and "with" maps.

Due to the specificities of the tactile maps, their construction and use can be seen as interesting didactic resources for Geography teaching. To construct a tactile map it is necessary to understand the meaning of each symbol and also the nature of the representation in order to be able to choose the best form, texture and height to be used in the tactile version.

Among the experiences with courses and workshops for teachers, an event held in 2012 stands out; a partnership between the University of Sao Paulo (USP), Sao Paulo State University (UNESP) and the Sao Paulo State Secretary of Education. It consisted in a 16-hour course for teachers coordinators of the pedagogic nuclei of Sao Paulo State. These teachers are responsible for the planning meetings and for training geography teachers throughout the 645 municipalities of the state.

The course counted with the participation of ninety teachers divided into two groups and approached the basic principles of Cartography, specificities of tactile cartography, techniques for the construction of tactile maps and the importance of the inclusion of impaired students in the regular basic education.

When challenged to elaborate a tactile map, the teachers who attended the courses expressed difficulties in reading the information communicated by the printed map to be adapted, mainly in what concerns the aspects of graphic semiology.

This led us to perform a theoretical review of the cartographic communication principles, using as methodology the process of reflection necessary for the elaboration of a tactile map; i.e., the printed map needed to be "deconstructed", analyzed and mainly understood so that the desired information was communicated in an efficient way in the new map.

3. Conclusion

Today, the images and the maps play a relevant role and are present in all the areas, in the workplace and in leisure, in people's daily lives, in formal and informal education. Thus, School Cartography is fundamental, preparing children and young people to use the cartographic language.

The Tactile School Cartography brings countless possibilities of application in education and in the daily life of impaired and non-impaired students. Thus, it contributes for the visually impaired students to have the same opportunities as the individuals who are able to see.

The utilization of tactile graphic representations in regular classes is beneficial for all the individuals. The “seers” are able to understand better the tridimensional representation and the visually impaired students feel totally included.

These innovating alternatives broaden the comprehension of the graphic and cartographic languages, facilitating the learning process.

The inclusion of the impaired student in the regular classroom in Brazil requires a theoretical and methodological rethinking by the teachers, in this case, geography teachers, who widely use maps. The study of ways to adapt the visual language to the tactile version is fundamental.

To work with tactile maps the Geography teacher needs to relearn the cartography studied in the graduation course, giving a new meaning to the graphic representations of the geographic space.

Thus, the tactile cartography broadens the possibilities to apply the practical activities using maps in the classroom, and becomes a support for the geography teacher, independently of the reality lived.

These innovating alternatives certainly broaden the comprehension of the cartographic and graphic languages, facilitating the learning process and the teachers’ work as well.

References

Albuquerque, M. A. M. de. (2009). A autoria de livro didático de geografia em Pernambuco no século XIX: uma relação entre a legislação e a elaboração, Terra Livre, 2 (31): 163-171

Almeida, R. D. de. (2010). Cartografia escolar. 2ªed. São Paulo: Contexto.

Oliveira, A. G. de. (2010). A Cartografia e o Ensino de Geografia no Brasil: uma olhar histórico e metodológico a partir do mapa (1913-1982), João Pessoa: [s.n.].

Carmo, W. R. do. (2010). Cartografia Tátil Escolar: experiências com a construção de materiais didáticos e com a formação continuada de professores, São Paulo. Dissertação (Mestrado em Geografia Física). DG, FFLCH, Universidade de São Paulo - Brasil.

Castrogiovanni. A. (2009) Ensino de Geografia: práticas e textualizações no cotidiano. 7ª ed. Porto Alegre: Mediação.

Salichtchev, K. A. (1988). Algumas reflexões sobre o objeto e o método da cartografia depois da Sexta Conferencia Cartográfica Internacional. Seleção de textos: cartografia temática, n.18, p. 17-23.

Sena, C. C. R. G. de. (2009). Cartografia Tátil no Ensino de Geografia: uma proposta metodológica de desenvolvimento de recursos didáticos adaptados a pessoas com deficiência visual, São Paulo. Tese (Doutorado em Geografia Física). DG, FFLCH, Universidade de São Paulo - Brasil.

Simielli, M. E. R. (1996). Cartografia e Ensino, São Paulo. Tese (Livre Docência). DG, FFLCH, Universidade de São Paulo - Brasil.

Vlach, Vania Rubia Farias, (1988), A propósito do ensino de Geografia: em questão, o nacionalismo patriótico, São Paulo. Dissertação (Mestrado em Geografia), Universidade de São Paulo - Brasil.

The Challenges of Testing Spatial Thinking Skills with Participants who are Blind or Partially Sighted

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Abstract. Spatial thinking skills are critical in geographic education for understanding and conceptualizing complex geographic problems. Testing spatial thinking skills on participants who are blind or partially sighted contributes to a better understanding of accessible cartography, tactile map production, and cognitive representations of space. These opportunities are met with equally significant challenges ranging from the transference of visualizations to tactile mediums to the embedded cartographic biases in experimental stimuli. This paper explores the challenges of spatial thinking field testing with participants who are blind or partially sighted, critically evaluates our experimental design, and offers suggestions for improvements in future experiments.

Keywords: Spatial Thinking, Tactile Maps, Accessible Cartography

4. Introduction

This paper focuses on the unique challenges in field testing spatial thinking skills with participants who are blind or partially sighted. Over the past 5 years, the Spatial and Map Cognition Research Lab (SMCRL) at the University of Oregon has worked on numerous projects contributing to a growing body of knowledge about maps and graphics for users who are blind or partially sighted. This work includes the development of a tactile map editing software (TAME), tactile symbology for navigation maps, and a tactile atlas of United States demographics. This experience facilitates recent investigations of spatial thinking skills with those who are blind or partially sighted.

Spatial thinking skills are critical in geographic education for understanding and conceptualizing complex geographic problems. The NRC report *Learning to Think Spatially* argues:

> "Spatial thinking is a collection of cognitive skills. The skills consist of declarative and perceptual forms of knowledge and some cognitive operations that can be used to transform, combine, or otherwise operate this knowledge. The key to spatial thinking is a constructive amalgam of three elements: concepts of space, tools of representation, and process of reasoning. It is the concept of space that makes spatial thinking a distinctive form of thinking" (2006: 12).

Addressing these challenges requires developing new methods and improving techniques to broaden social understanding of key geographical patterns and processes (NRC 2010). Enhancing essential spatial thinking skills by expanding the structure and functions of geographical conceptualizations, representations, and technologies into accessible mediums for citizens who are blind or partially sighted is of critical importance.

The primary research question of this project is: How are individual lower level spatial thinking skills linked together to understand the complex task of region identification? This question stems from a proposed spatial thinking framework — a synthesis of the three established spatial thinking models (Gould 1996, Golledge et al. 2008, Gershmel & Gershmel 2007) — to situate space, time, and attribute constructs in an organizational ontology. The spatial thinking framework we have designed facilitates hypotheses for empirical behavior field testing. Situating out hypothesis in this organizational framework, we theorize discrete skills are cognitively assembled into complex groupings and combinations to complete specific spatial tasks.

Working within this framework, individual spatial thinking skills can be specifically targeted in training protocols to improve overall performance for the higher order complex task. For example, we hypothesize region identification as a high level skill achieved through the assemblage of the lower level skills of proximity (the relative closeness of objects), boundary (delineations between different objects), clustering (the gatherings of objects based on location and attribute across the stimuli), and classification (the grouping of objects according to a common relation or attribute). If region identification is poor, we can focus on individual skills hypothesized as necessary for identifying regionality. If region identification performance is good, we can explore discrete performance on each of the individual skills to understand how the larger task is cognitively assembled. In this paper, we discuss experimental design with participants who are blind or partially sighted utilizing the spatial thinking framework, the unique challenges of field testing with this population, the results of this experiment, and considerations on how to improve similar experiments moving forward.

5. Experimental Design

Behavioral testing and data for this experiment were collected in July, 2012 at the National Federation of the Blind (NFB) conference in Dallas, Texas and the American Council of the Blind (ACB) conference in Louisville, Kentucky. Over the two conferences, we collected data from 41 participants who are blind. The experimental design consists of four discrete sections. The first section is a demographic questionnaire in which participants respond to questions about age, onset of blindness, education, mobility device, and familiarity with maps and navigational devices. Following demographics, a pre-test of 60 tactile graphics is administered. The pre-test asks participants to complete timed and evaluated spatial thinking tasks. The pre-test consists of 60 tactile graphics falling into one of three contexts (geographic, chemistry, or no-context) and one of four spatial thinking skills (boundary, classification, proximity, clustering). During each test, the participant is shown five consecutive graphics from one of the twelve combinations of the task and context—geographic proximity, chemistry boundary, or no-context clustering for example (*Figure 1)*.

Each set of graphics has the participant complete a task utilizing a specific spatial thinking skill. For example, in geographic proximity, we asked participants to locate the two islands closest to each other and thus most likely to have similar environments. For chemistry boundary, participants determined whether the oxygen and hydrogen symbols have mixed or if there was a clear delineation between the two. By breaking the four spatial thinking skills into three separate graphical contexts, we are able to test whether spatial thinking ability is generalizable across disciplines.

Following the pre-test, participants engage in a region identification exercise allowing untimed exploration of the concepts introduced in the pre-test. Finally a post-test, equivalent to the pre-test, is administered. The pre and post-test both have a defined sequence in which interaction with the graphics follows a predetermined script to ensure cross participant continuity.

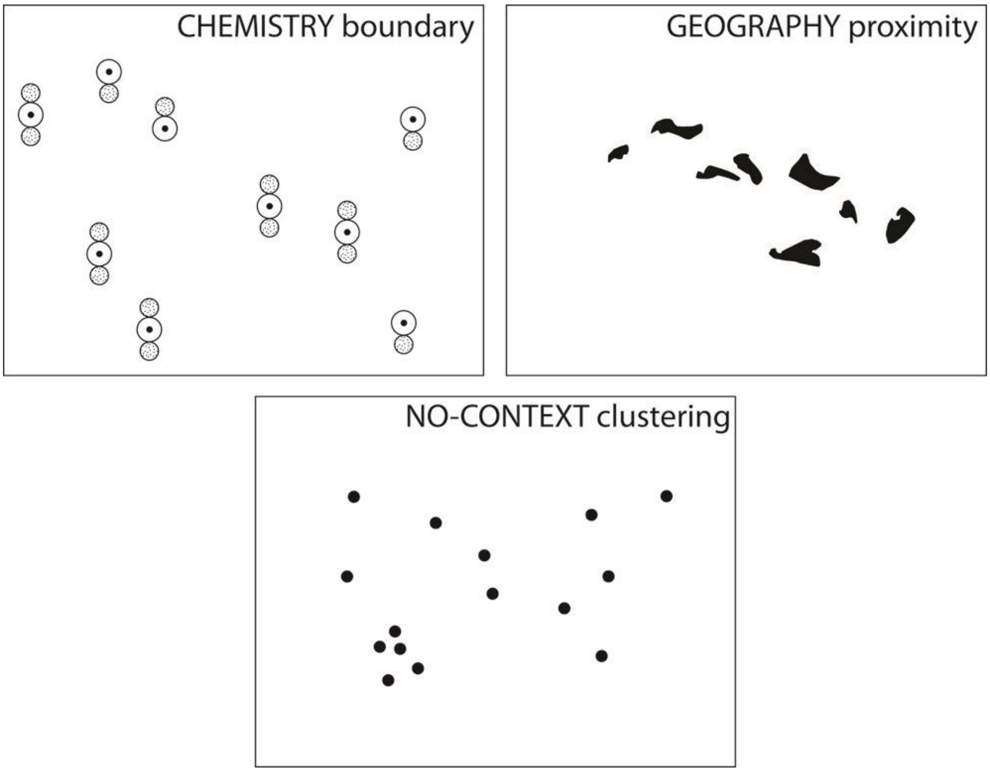

Figure 1. Tactile graphics of the spatial thinking skill classification contextualized in a chemistry, geography, and no-context representation.

The primary data collected for this paper are the accuracy and response times of individual spatial thinking skills. The individual performance variance in the experimental interactions illustrate one of the key challenges in accessible cartography production—how to make quality maps for people with the highest navigational challenges. As Lobben and Lawrence argue, "the technical factors that are relatively straightforward in the production of visual input maps present sometime difficult hurdles for the creation of tactile maps" (2012: 96). What seems basic in visual map and graphic production —the density of objects, the orientation of the page, or the scale of symbology— are considerably more complex and inconsistently transferred to tactile mediums. Research has shown that properly designed tactile maps are linked to quality of life by increasing environmental knowledge, spatial mobility, vocational opportunity, and social independence (Aldrich et al. 2002). The significant obstacles hindering the widespread implementation of effective tactile maps includes the standardization of production methods (Sheppard and Aldrich 2001, Rowell and Ungar 2003, Lobben 2005), intuitive design (Lawrence and Lobben 2011), and the dissemination of research to the public (Miele & Marston 2005, Lobben & Lawrence 2012). Engaging in behavioral testing with participants who are blind or partially sighted significantly contributes to an understanding of accessible cartography in two distinct ways. First, experimental testing reveals linkages of how those lacking discernible visual experiences of space transfer spatial knowledge from graphic to cognitive representation. Secondly, insight into these linkages leads directly to improved production methodologies, formal standardization, and comprehensive implementation of accessible tactile graphics and maps.

In addition to the clear social importance of accessible cartography research, testing with participants who are blind or partially sighted extends the temporal scale of task reaction time to the stimuli. Whereas the determination of the two closest objects on visual stimuli may take sighted participants fractions of a second, the same task on a tactile graphic with participants who are blind can take significantly longer. The extended task completion time in this experimental design extends the range of outputs and facilitates a broader understanding of the cognitive assemblage of individual spatial thinking skills to solve complex problems.

6. Results

Initially, we calculate the mean and variability of response times for each of the 24 measured tasks — four spatial thinking skills across three contexts from both the pre and post-test.

Analysis (*Figure 2)* shows spatial thinking skills perform consistently across the three graphical contexts for the skills of clustering and proximity. Boundary and classification, especially in the context of geography and chemistry, both take longer to complete and have higher degrees of variability between participants. In our proposed spatial thinking framework, we hypothesize certain spatial thinking skills are higher order and build upon previous, less complex skills (*Figure 3)*.

Region identification is conceptualized as a high level skill achieved through the assemblage of proximity, boundary, clustering, and classification. We consider the skill of boundary identification and proximity of objects as 1st order, or relatively simple, spatial thinking skills. Classification of objects based on attributes is a more complicated 2nd order skill requiring 1st order building blocks. The clustering of objects into homogenous groups based on spatial location or similar attributes is an increasingly complicated 3rd order spatial thinking skill requiring multiple lower order building blocks.

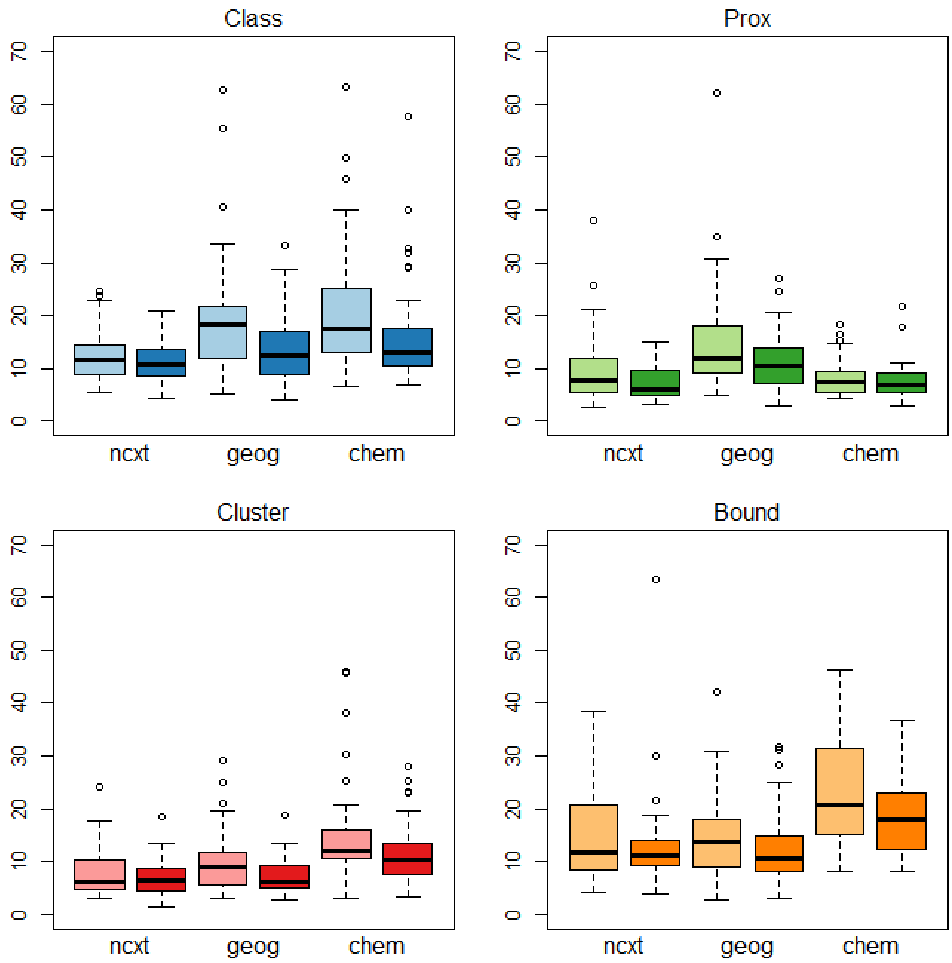

Figure 2. Box plots of each of the four spatial thinking skills. Each plot has the three contexts with the pre-test light and the post-test dark.

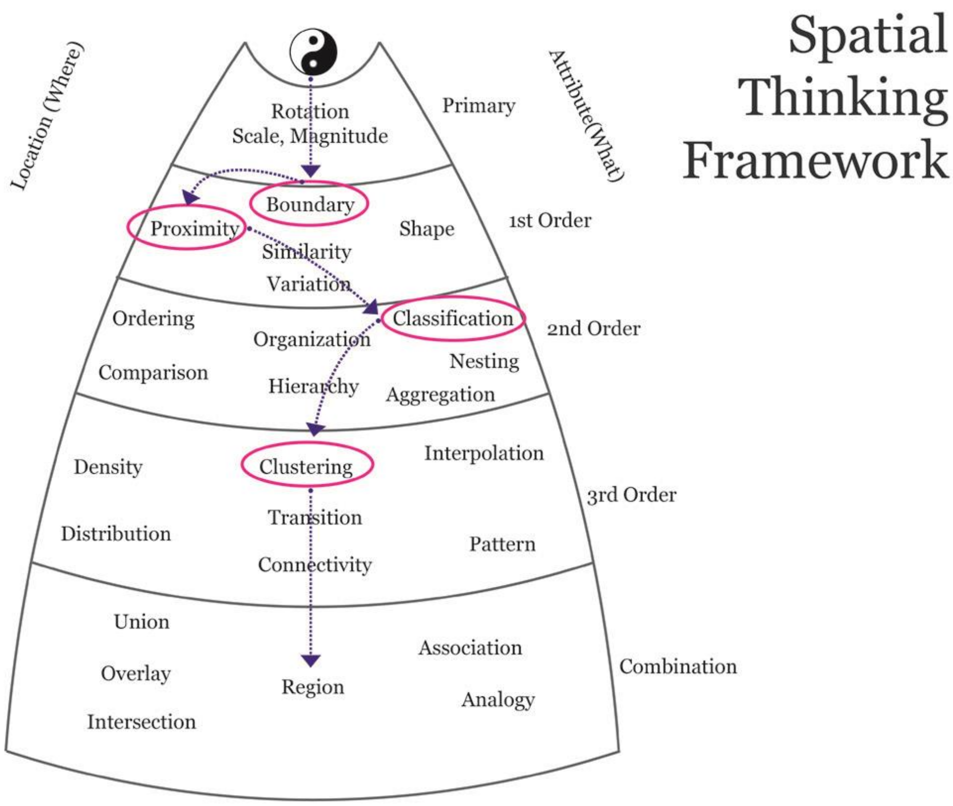

Figure 3. Spatial thinking framework with hypothesized linkage between perceptual moment (top) and region identification.

Research has shown the time and ability of participants who are blind to search and perceive a tactile graphic is highly variable (Picard et al. 2010) and, contrary to popular belief, it is unclear whether or not blindness heightens tactile acuity (Norman & Bartholomew 2011). To effectively focus on spatial thinking skills, we have to minimize the effects of tactile search in data analysis. As Postma et al. (2007) notes, tactile search strategies vary greatly depending on age of onset, education, vocational training, and support. To account for differing individual strategies, we first remove the initial observation from each task, controlling for the participant‘s initial tactile search. We then subtract the final observation in each set from the remaining three, standardizing the tactile search for each participant. Finally, we merge all the data points for an adjusted response time for each of the four spatial thinking skills and perform a factor analysis. Removing the tactile search, the task of proximity (determining which two objects are closest together) takes an average of .578 seconds while the task of clustering (finding the largest bunch of objects in a single variable graphic) takes an average of .948 seconds. The task of boundary (determining if two sets of objects were separated or mixed together across the extent of the graphic) takes an average of 1.948 seconds. The task of classification (determining how many different classifications of data exist within a graphic) takes an average of 1.975 seconds *(Table 1)*.

Spatial Thinking Skill	Adjusted Time (ms)	Group
Proximity	578.97	1
Cluster	942.17	2
Boundary	1948.88	3
Classification	1975.35	3

Table 1. Adjusted time and factor analysis for each of the four spatial thinking skills.

We hypothesized proximity and boundary would have similar response times and form the group in the factor analysis, classification would take slightly longer and be in a second group, and cluster would take the longest and be in a third group situating organizationally as visualized in *Figure 3*. Contrasting expected results versus actual results *(Figure 4)* clearly shows where task performance diverges from our hypothesized organization of spatial thinking skills and linkages.

In addition to response times, task accuracy is calculated. We created an index of task difficulty by calculating the mean response time across all participants multiplied by the percent correct. In this index, values below 1.0 indicate acceptable task difficulty and values above 1.0 indicate unacceptable.

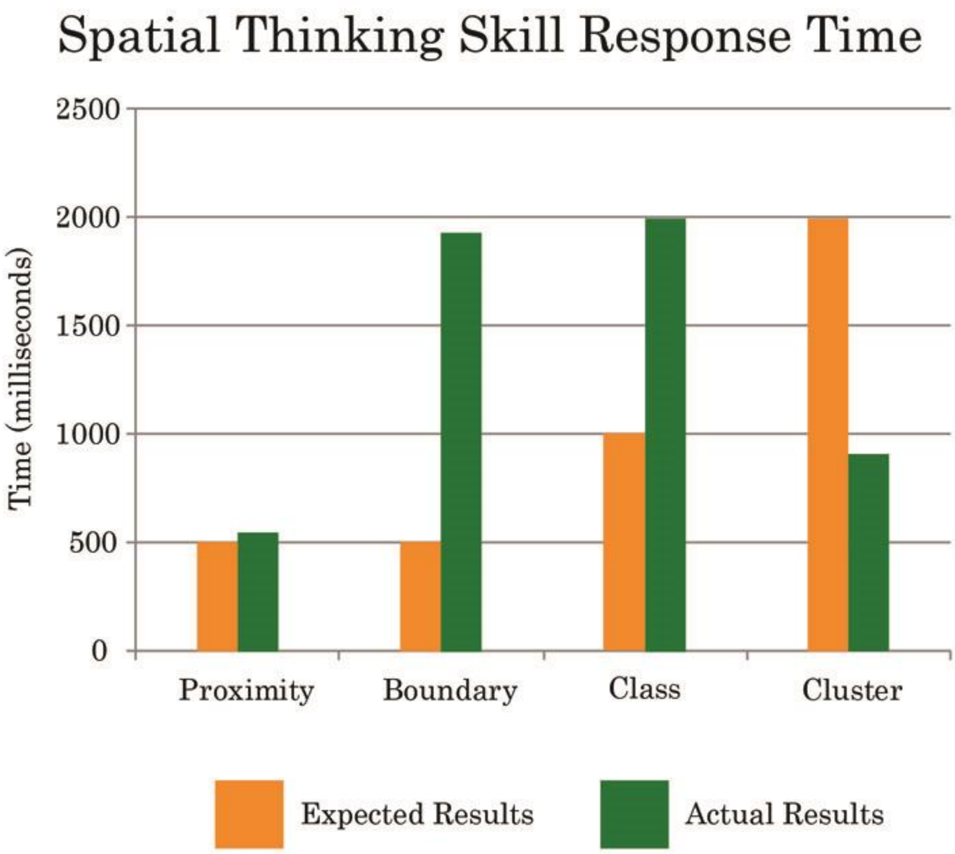

Figure 4. Expected versus actual adjusted response time for the four spatial thinking tasks.

The task difficulty ranking reveals the tasks of boundary and classification are of an unacceptable difficulty resulting in poor performance. Additionally, this index clearly indicates that the chemistry and geographic contexts are both more difficult than graphics with no context. One possible explanation is that situating spatial thinking processes in discipline specific context adds additional complexity to the skill itself. Alternatively, the difficulty index (*Table 2)* could also indicate that contextualized tactile representations distract substantially from the spatial thinking skills themselves and appends unnecessary intricacy to the experimental design.

Task	Average Time	% Incorrect	Difficulty	
Context				
No Context	10.3075	0.0575	0.6947	Acceptable Difficulty
Chemistry	15.05	0.165	3.11915	
Geography	12.805	0.105	1.43535	
Spatial Task				Unacceptable Difficulty
Proximity	9.736666667	0.03666667	0.396833	
Boundary	16.22666667	0.24333333	4.373333	
Classification	15.59333333	0.09333333	1.532033	
Clustering	9.326666667	0.06333333	0.696733	

Table 2. Task difficulty index. Using a simple metric, we determine tasks in purple represent an acceptable tactile design and those in orange unacceptable.

Studies have suggested that the ability of a blind participant to tactilely perceive stimuli is significantly increased with basic geometric shapes stripped of complex contextual implications (Picard et al. 2010, Heller 1989, Miller 1975). The difficulty index illustrates that only the single variable (proximity and clustering) no-context graphics meet our expected task difficulty. In light of this, we accept that contextualization of spatial thinking skills in tactile graphic design adds unnecessary complexity and produces preventable uncertainty in the results. The divergence of the measured results from the expectations and findings from the difficulty index lead us to critically reflect upon the experimental design of tactile spatial thinking tests. Issues ranging from stimuli complexity to participant anxiety must be carefully considered in future experimental designs to yield results capable of answering the fundamental research question.

7. Discussion

The uncertainty in the results from this experimental design necessitates that we reevaluate the graphical stimuli production and experimental protocol. Research has shown the transference of graphics from visual to tactile mediums accounts for the lower perceptual resolution of touch by increasing generalization, simplification, and symbolization (Jacobson 1998). That which is lost in translation between mediums indicates that highly complicated and contextualized graphical depictions may be inappropriate for behavioral testing on spatial thinking skills. Appropriate graphics for discrete spatial thinking skills could be stripped of superfluous contextualization and strive to be as stripped down as possible *(Figure 5).* Additionally, as cartographers, our visualizations of spatial constructs are heavily influenced by the history of map design and discipline of geography. As a result, stimuli design may be unintentionally biased towards academic training and the representation of a spatial construct may not reflect a generalizable depiction. In the seemingly straightforward material production of behavioral stimuli, we assume the visual cartographic representations of spatial thinking constructs will uniformly transfer to a tactile medium for a group of blind or partially sighted participants with limited exposure to quality maps and radically varied perceptions of space.

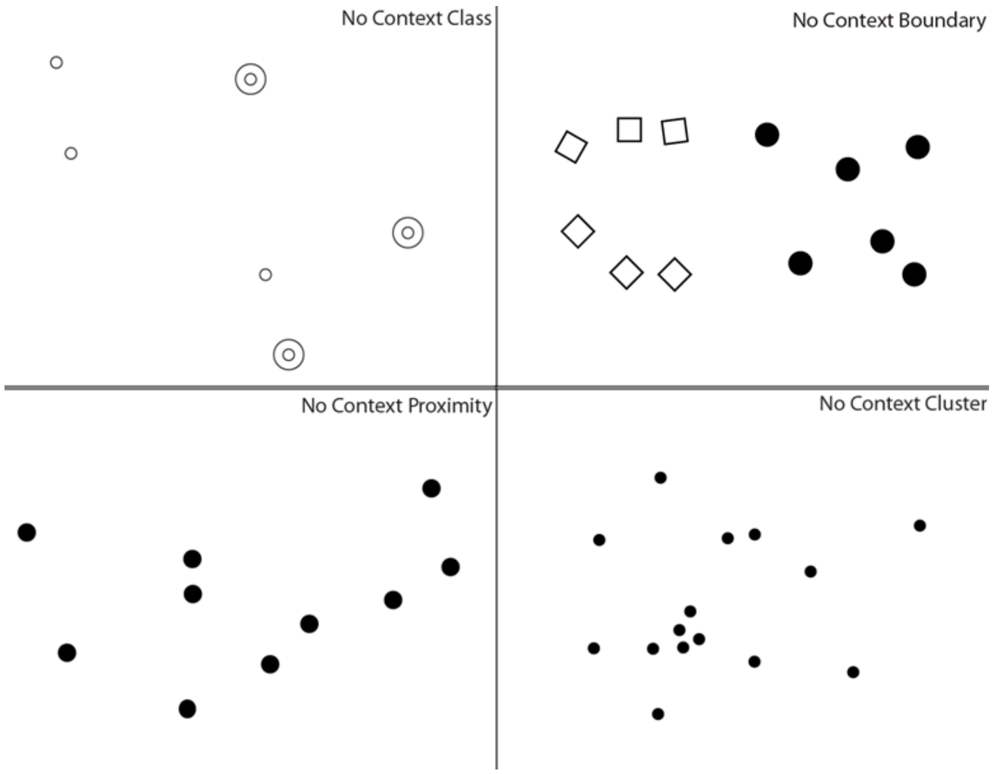

Figure 5. No-context representations of the four spatial constructs hypothesized as building blocks for region identification.

When we look at the stimuli for this experiment in relation to the results, we begin to question if the geographically biased representation of boundary, for example, is fitting of a generalizable representation of boundaries. We expected boundary to be grouped with proximity as a 1st order skill. Instead, results indicate boundary as a high level 3rd order skill building on lower level constructs. Conceptualizations of boundaries are highly variable depending on discipline (Lamont & Molnar 2002). Even within the discipline of geography, conceptualizations of boundaries range from physical inscriptions on the landscape to fluid socially constructed markers. In this experiment, participants are asked to determine if there is an invisible delineation between two sets of homogenous groups or if the groups are mixed across the stimuli. While this is a perfectly acceptable geographic interpretation of the spatial construct of boundary, it may be far from the general consensus. Though we determine this task to be one of boundary identification, it may in fact be one of pattern recognition or spatial organization to the participant. Our experience as academic cartographers may, counter-intuitively, make our representations of spatial constructs more abstract than those of the public. This disparity between conceptualizations of constructs is increasingly compounded when sighted cartographers are designing maps and graphics for participants who are blind or partially sighted.

This experiment, loaded with our own geographic and cartographic biases of what graphically constitutes a boundary is epistemologically restricting. Research in cognitive spatial thinking processes with participants who are blind or partially sighted compels us to rethink graphical representations of constructs and to develop more flexible experimental designs. The primary concern of the initial designs should be to strip away individual biases in representation of concepts. Behavioral experiments produce generalizable statistics from the intimate configurations and personal perceptions of objects across the stimuli. Top-down approaches to stimuli design limit our understanding of how spatial thinking skills are cognitively linked and assembled across different populations. When testing with populations that are blind or partially sighted, it is important to remember added contextualization and discipline influenced graphical representations of spatial constructs limits the amount of meaningful insight that may be gained. Tactile stimuli design, especially when influenced by conviction and the privilege of sight, must embrace flexible approaches.

8. Conclusion

The linkages between complex higher level tasks and the lower level building blocks are theorized in the spatial thinking framework, generating a series of testable hypotheses to shed light on how spatial thinking performance is an operational assemblage of individual spatial thinking constructs. In this experiment, we attempted to draw out performance on discrete spatial thinking graphics linking together to form region identification. The response times, groupings, and accuracy of the results did not meet our expectations leading us to question both the original hypothesis and the experimental design itself. Through a difficulty index, we reveal the limitations of our experimental design and the consequences of cartographically framed representations of spatial thinking constructs for participants who are blind or partially sighted. To counter this effect, we encourage critical refection on design of tactile representations for spatial constructs. Additionally, we conclude that contextualization of graphics adds an unnecessary difficulty and complexity to already complicated spatial thinking task. Cartographers need to recognize that which is commonplace in visual representations can be exceedingly demanding in a tactile format. Understanding spatial thinking skills and cognitive representations of spatial stimuli with participants who are blind or partially sighted demands flexible methodologies, careful design, and critical reflections on what is lost between mediums.

References

Aldrich, Frances K., and Linda Sheppard. 2001. "Tactile Graphics in School Education: Perspectives from Pupils." *British Journal of Visual Impairment* 19(2): 69–73.

Gersmehl, Philip J., and Carol A. Gersmehl. 2007. "Spatial Thinking by Young Children: Neurologic Evidence for Early Development and Educability." *Journal of Geography* 106(5): 181–191.

Golledge, Reginald, Meredith Marsh, and Sarah Battersby. 2008. "A Conceptual Framework for Facilitating Geospatial Thinking." *Annals of the Association of American Geographers* 98(2): 285–308.

Gould, Peter. 1991. "Dynamic Structures of Geographic Space." *Collapsing Space and Time: Geographic Aspects of Communication and Information*: 3–30.

Heller, Morton A. 1989. "Tactile Memory in Sighted and Blind Observers: The Influence of Orientation and Rate of Presentation." *Perception* 18(1): 121–133.

Heller, Morton A., Jeffrey A. Calcaterra, Lynnetta L. Burson, and Lisa A. Tyler. 1996. "Tactual Picture Identification by Blind and Sighted People: Effects of Providing Categorical Information." *Perception & Psychophysics* 58(2): 310–323.

Jacobson, R. Dan. 1998. "Navigating Maps with Little or No Sight: An Audio-tactile Approach." In *Proceedings of the Workshop on Content Visualization and Intermedia Representations*.

Kennedy, John M., Paul Gabias, and Morton A. Heller. 1992. "Space, Haptics and the Blind." *Geoforum* 23(2): 175–189.

Lamont, M., and V. Molnar. 2002. "The Study of Boundaries in the Social Sciences." *Annual Review of Sociology* 28: 167–195.

Lawrence, Megan M., and Amy K. Lobben. 2011. “The Design of Tactile Thematic Symbols.” *Journal of Visual Impairment & Blindness* 105(10): 681–691.

Lobben, Amy, and Megan Lawrence. 2012. “The Use of Environmental Features on Tactile Maps by Navigators Who Are Blind.” *The Professional Geographer* 64(1): 95–108.

Miele, Joshua A., and James R. Marston. 2005. “Tactile Map Automated Production (TMAP): Project Update and Research Summary.” In *Proceedings CSUN*.

Millar, Susanna. 1975. “Visual Experience or Translation Rules? Drawing the Human Figure by Blind and Sighted Children.” *Perception* 4(4): 363–371.

National Research Concil. 2006. *Learning to Think Spatially: GIS as a Support System in the K-12 Curriculum*. The National Academies Press Washington, DC.

National Research Concil. 2010. *Understanding the Changing Planet: Strategic Directions for the Geographical Sciences*. The National Academies Press Washington, DC.

Norman, J. Farley, and Ashley N. Bartholomew. 2011. “Blindness Enhances Tactile Acuity and Haptic 3-D Shape Discrimination.” *Attention, Perception, & Psychophysics* 73(7): 2323–2331.

Picard, Delphine, Samuel Lebaz, Christophe Jouffrais, and Catherine Monnier. 2010. “Haptic Recognition of Two-dimensional Raised-line Patterns by Early-blind, Late-blind, and Blindfolded Sighted Adults.” *Perception* 39(2): 224-235.

Postma, Albert, Sander Zuidhoek, Matthijs L. Noordzij, and Astrid ML Kappers. 2007. “Differences Between Early Blind, Late Blind and Blindfolded Sighted People in Haptic Spatial Configuration Learning and Resulting Memory Traces.” *Perception* 36(8): 1253–1265.

Rowell, Jonathan, and Simon Ungar. 2003. “The World of Touch: An International Survey of Tactile Maps. Part 1: Production.” *British Journal of Visual Impairment* 21(3): 98–104.

Sheppard, Linda, and Frances K. Aldrich. 2001. “Tactile Graphics in School Education: Perspectives from Teachers.” *British Journal of Visual Impairment* 19(3): 93–97.

The Impact of Indonesian Policy on the Use of High Resolution Imagery for Updating National Geospatial Information

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Abstract. There are some positive impacts of Indonesian policies related to geospatial information. This article describes two policies: Act no 4/2011 concerning geospatial information and Presidential Order no. 6/2012 concerning the uses, distribution of high remotely sensed imageries. Act no 4/2011 didn't mention directly to remote sensing role for revising geospatial information but in fact Presidential Order no. 6/2012 mentioned explicitly to use ortho-rectified image for the purposes of national program done by all governmental agencies. Policy of uses, control quality, processing and distribution of high resolution of satellite data. The main positive impact is an updated national geospatial information that will also affect to a better national development planning. The indirect impact of those two policies will improve skilled and educated users in the field of remote sensing and cartography.

Keywords: remote sensing policy, geospatial information, cartographic education and training.

1. Introduction

Remote sensing and cartography have important contributions for the effort of accelerating the geospatial data and information. Remote sensing can play important roles in the context of renewing and revising the available data and accelerating the data of areas where have outdated information or no geospatial data at all. Remote sensing images having georeferenced mode are very potential to replace old and outdated cartographic information. While geospatial data can be well presented and fulfilling the criteria needs according to cartography guidelines. By having Indonesian Geospatial Information Act no. 4/ 2011, Indonesian people have been more guaranteed in accessing geospatial data (GD). This Act is forcing to the Government to continuously prepare and serve geospatial data and information, both basic geospatial information (bGI) and thematic geospatial information (tGI) inexpensively and easily to be used by public. The Government concerns itself to use geospatial information (GI) in the context of supporting the national development program. At least, the acquisition of an accurate and responsible GIS cannot compete with much more demand of GI continuously from various levels of planning. In other word, it is not easy to compete with the high and fast information demands. Therefore, to fulfill the need, it is obligatory to do 'break-through' effort, including the technological selection, and to formulate a policy for the acceleration of geospatial availabilities.

This paper generally describes the impact of Indonesian policy on the use of high resolution imageries for updating base geospatial information, including national base map (topographic map). Remote sensing and cartographic roles in the development of geospatial information will also influence positively to the national development planning. Using ortho-rectified image for the whole Indonesian territory will affect to the needs of education and training for remote sensing and cartography.

To support such policy it needs focused and dedicated activities for speeding up geospatial information. Research, education and training, and socialization in cartography can be conducted for the purpose of supporting policy in accelerating geospatial information.

Any effort of acquisition of geospatial data and information is basically required for existing development. Whether or not giving benefits directly for particular sector, updated geospatial data and information are definitely required. For the quick response like natural disaster, a special treatment in collecting new GI must be provided by the government (Martha, 2011).

Even though all sectorial mapping activities to be referred to bGI, in practical work, development has to be completed without waiting for the availability of geospatial data (bGI). Therefore, there are duties and services of the government to provide proper geospatial data and information. Planning and executing national development (physical planning) requested some particular requirements (Martha, 2011).

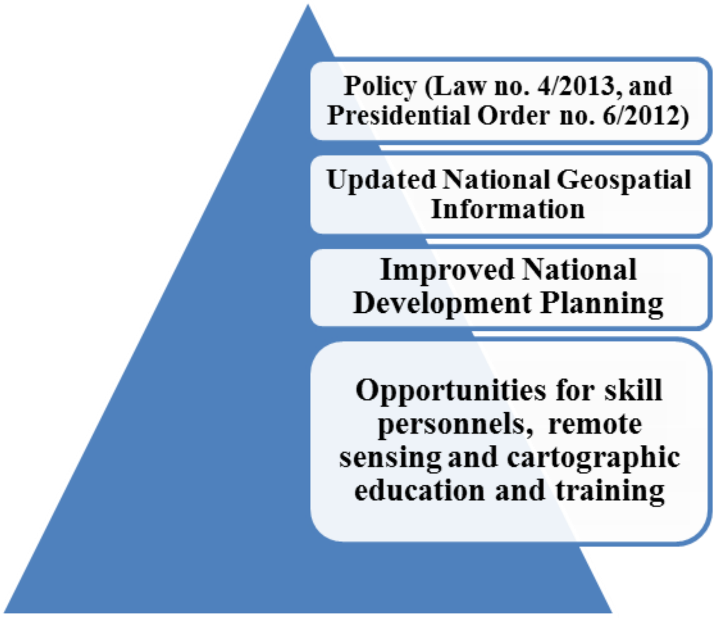

Figure 1. The impact of policy to Remote Sensing and Cartographic Education and Training

Due to the high needs of preparing geospatial data and information, it is required to have a special policy to support in accelerating the GI acquisition. Remote sensing is an effective tool for assisting the acceleration of GI, and cartography as a tool in performing and visualizing such GI data and information.

As an effort for accelerating policy, it must be not obeying the basic principle of academic truth and can be scientifically responsible. Thus, the role of policies on remote sensing as main input media will generate new geospatial data and information and capable of providing reliable geospatial data and information for natural resource management and regional development planning. The policies will affect to updated geospatial information nationally. By results of revised geospatial data and information will contribute for local, regional and national planning stages, and the process of development. Finally, the impact will be opportunities for educating and training human resources in remote sensing and cartography (*Figure 1*).

2. Remote Sensing in updating geospatial data and information

As a comparison with other country, remote sensing in Japan has an important role for maintaining Digital Basic Map. Since 2009, the Javanese national mapping authority, the Geographic Survey Institute or Geospatial Research Institute (GSI) has started to develop “Digital Japan Basic Map” which is nation’s new basic map and will replace 1:25000-scale topographic maps. As mentioned in *Figure 2*, Digital Japan Basic Map consists of three components; map information, digital ortho images and geographic names (Tachibana 2009).

Map Information Digital Ortho Image Geographic Names

Figure 2. Digital Japan Basic Map through the Internet (Tachibana 2009).

Map information is actually digital data including topography, vegetation and others physical data that can be integrated with other additional geospatial information for the benefits for public administration. The Indonesian mapping authority should learn from Japanese and other country experiences and policy to provide the latest geospatial information in constant way without getting problems with paper map stock.

Digital ortho images are very effective information sources for public administration purposes, they need to be developed first. Providing the update geospatial information for the whole territory of Indonesia is really not cheap but it seems no other way for serving public, as what has been done by US and Japanese Mapping Authority. The Geospatial Survey Institute (GSI) of Japan for instance, develops digital ortho images from aerial photographs taken by digital aerial camera. To make easy for preparing digital ortho images, they had applied aerial photographs as only one of reference data for updating 1:25000-scale topographic maps, digital aerial camera, GPS and digital photogrammetric system.

The geographical name dataset is important geospatial information element to be prepared in relation to map updating. Without accurate toponym or geographic names, a map can’t be called as a proper map. This dataset will be used to identify geographic features both for humans and computers.

Additionally, geographic identifiers are to be used for integrating or sharing geospatial information among different geospatial information databases.

3. Policy for revising geospatial information

There are two types of policies, first, Law or Act (GI Act) and second, Presidential Instruction (Order).

3.1. Policy / Act No. 4/ 2011 - Geospatial Information

This policy has related to the problem of education and training. Besides remote sensing, cartography assists in presenting geospatial data visualization into map. It can also be involved in policy supports for updating and visualizing bGI and tGI.

Article 35 GI Act no. 4/2011 mentioned that presentation of geospatial data can be done in the forms of coordinated tables, printed map both in the form of map sheets and the book of Atlas; digital maps, interactive maps, including those can be accessed through information and communication technology; multi-media maps, globes, or maps with 3D model. More descriptions can be read in article 36: GI presentation as stated in article 35 (except coordinated tables) must use the scale determined based on the level of accuracies on data sources and the purpose of the GI uses.

Even though standard of map presentation is not explicitly in the GI Act, it doesn't mean that standard is not important. Basically by applying standard, GI becomes 'tight' with guidance as reference. Cartographic principles will automatically function to protect how GI can be feasible to be presented and ready to read by map readers or users. To make it possible, all cartographic data within GI will be feasibly evaluated based on particular scale. Cartographic presentations of several products like printed maps, digital map, interactive map, multimedia, globe and 3D maps. Those products require mapping guideline (article 35 and 36).

Geospatial information content has to be well presented and visualized properly on the map and atlas with acceptable accuracy according the level of uses. For technical and engineering purposes, of course, such map must have high accuracy. It means that the role of cartography is very relevant to present and represent of geospatial data and information assisted by the art of visualization. This may be problem when the interpretation of GI Act no. 4/2011 with no explicitly stated the presentation standard. Imagine, how problem will arise, when there is no printed map having a standard of representation, while private individual (based on the Act) is possible to publish maps. There will be serious problem due to complicated spatial information affected by various themes and scales used.

Atlases consist of maps with various themes; scale must be standardized suitable for paper size of the publication. Information display should be readable enough for the users. For School Atlas, the problems of contents must also be solved separately, there some curricula involvement and other cartographic considerations. All kinds of home work will challenge us and many opportunities are broadly opened for the development of cartography.

Digital maps are basically the same as printed maps, when visualization process of geospatial data becomes information (maps), they should follow the standard cartographic rules. Map scales on topographic and thematic maps will indicate the level of geospatial information. Bigger computer roles in processing data mean less human intervention of cartographic skills. Other words, IT software will free generate any products. Nonstandard GI product may be resulted from the operational procedures without referring to cartographic standards.

Inter-active maps can be accessed through information and communication technology. They are basically pictures of geospatial information through the mode of display simplification. In this map, GI will be communicated with the users inter-actively. The involvement of other expertise like graphic designer, information technologist is needed. However, for visualizing the substance of geospatial information should be better consulted with cartographers. Geospatial data generalization having its own principles requires cartographic rules and inputs from cartographic experts. This means that interactive maps basically have a goal for communication media among users, with user-friendly mode for the benefit of human life.

Useful information using multi-media map will benefit users. By socializing cartographic products, for instance through activity like customer gathering, it will affect and improve the number of map users, and also as promoting in map sales and geospatial data services. Once again, the involvement of experts in media, press, journalism, IT etc., is needed. To maintain the information accuracy and proper map visualization, cartographic skilled personnel will involve in the process of multi-media map making. Many experiences in making multimedia maps can qualitatively initiate in performing standard and feasible visualization.

Globes and maps with 3D information are often applied as teaching aids to describe geography for the students. There is still no standard rule in Indonesia as guidance for private companies to produce this globe and 3D maps. The 3D model can be made with embossed papers and printed in particular printing machine. Local companies need to have such guideline to produce globes and 3D maps for having a proper information and useful tool for elementary to high school students.

3.2. Presidential Order No. 6/2012

This Presidential Order no. 6/2012 concerning uses, control quality, processing and distribution of high resolution satellite data, indicated the government understands that high resolution satellite imageries with radiometric and geometric correction (ortho-rectified image), has similar use and provide benefits more compare to topographic maps. Even, this can be said that the role of ortho rectified image has 'over' that of topographic map itself. The reason is that instead of waiting for the larger scale of topographic map with no time guarantee when to be published. Based on the Act no. 4/2011 concerning Geospatial Information, any thematic maps cannot be published since tGI has to depend on bGI reference.

Compare to those two legislature products, there is a regulation gap (because there is no Government Regulation to be as 'bridge'; the word 'remote sensing' is not explicitly mentioned in UU no. 4/2011, while in Presidential Order no. 6/2012, did not only mention the word of remote sensing but the uses and benefit of imagery). In our regulation system, from the highest to the lowest rank of regulation is started from Constitution, Law/National Act, Government Regulation and finally to Presidential Decree or Presidential Order. For the purpose of updating geospatial information, this Presidential Order is a new breakthrough for national mapping, and will impact positively to the education and training in the field of geography and cartography.

Presidential Order no. 6/2012 stated:

"in order to highly resolution satellite data be optimally used and the national budget can be efficiently saved and to avoid the duplication of budget allocation for procurement of high cost of high resolution satellite imagery".

This consideration gives meaning that within Presidential Order is only meant to improve efficiency in budget use and avoid duplication in procurement of high resolution satellite images. The use of satellite data itself is not part of such important considerant. Therefore, there is no *scientific background* to support this very important role of satellite imagery in development planning.

The content of this Presidential Order is aimed to all Ministry, National Army commander, National Police, all Heads of Non-Departmental Agencies, all Governors and all Regent/Mayors.

First:

Order for using ortho-rectified high resolution satellite imagery to be prepared by Board of Geospatial Information (BIG) for less than 4m resolution; and to be prepared by National Institute of Aeronautics and Space (LAPAN) for 4 m resolution.

Ortho image in this Presidential Order has a meaning *'cartographic view'* or to be ready for applying radiometric and geometric corrected satellite imageries to the purpose of sectorial development program conducted by other government institutions. In the implementation of Presidential Order, between BIG and LAPAN has to have the same perceptions for operation. LAPAN and BIG should have a good cooperation to support this Presidential Order. They just follow the Order to prepare ortho-rectified image. LAPAN cannot think that more practical if radiometric and geometric corrections are processed by LAPAN. BIG will consider that a geometric activity is its own competency, supported by the majority of skilled personnel having geodesy qualification.

Second:

Order to convey plan of high resolution satellite imagery data needs to conduct program and activity for the next fiscal year to BIG through coordination meeting.

Presidential Order consists of instruction that benefits the duty of BIG, because there will be one gate in using high resolution satellite imagery. To make BIG more powerful, also LAPAN, additional roles and supports are required from Ministry of Research and Technology.

Third:

Order for:

1. Head of LAPAN

a. Prepare high resolution satellite data with Government License;

b. Improve capacity and operation of high resolution satellite data acquisition;

c. Prepare and produce high resolution satellite data/ images as ruled by existing regulation;

d. Process image of high resolution satellite data with spectral and radiometric correction;

e. Generate metadata of high resolution satellite data based on Indonesian National Standard (SNI);

f. Conduct archiving high resolution satellite data; and

g. Together with Head of BIG conducts quality control for high resolution satellite data.

2. Head of BIG

   a. Improve capacity and processing system of high resolution satellite data for national survey and mapping purposes;

   b. Generate ortho-rectified image (high resolution satellite data) for surveys and mapping based on processing result like spectral and radiometric correction done by LAPAN;

   c. Conduct archiving and securing high resolution ortho-satellite imagery;

   d. Distribute high resolution ortho-satellite imagery through National Spatial Data Infrastructure; and

   e. Together with Head of LAPAN conducts quality control for high resolution satellite data.

Based on the Order no. 3, there is no instructions for both BIG and LAPAN to conduct geometric correction for high resolution satellite imagery (ortho image). This possibly needs to have correction in original text of the Order. It is important for both BIG and LAPAN have duties in quality control. The problem is how to do such control, because the two institutions have each own authority.

BIG will improve in using satellite image for national mapping/ geospatial information (Point 2a), and this will motivate BIG to do research on Digital Elevation Model (DEM) to generate topographic maps through ortho-rectified image (Point 2b).

4. Conclusion

a) The fast acquisition of geospatial data and information (GI) using satellite imagery can assist in revising the national geospatial information. Remote sensing and cartography education will also play important roles to support the updating works of geospatial data and information.

b) Although a standard of GI presentation is not explicitly stated in GI Act no. 4/2011 it doesn’t mean that the visualization can be done freely without cartographic principles. All GI products such as printed maps, atlas books, digital maps, interactive maps, multimedia maps, globes and 3D model maps are required to follow the procedures of visualization.

c) Two policies, like Act no. 4/2011 and Presidential Order no. 6/2012 will provide the opportunities to accelerate readiness, cheap and accessible GI availability then it will support the acceleration of national development.

d) The policy of the application of remotely sensed data in Indonesia will affect the needs of skilled personnel; and giving more opportunity for remote sensing and cartographic education and training development in Indonesia.

References

Martha, S. , Poniman, A., and Matindas, R.W. (2009). *Some cartographic roles for multi-hazard mapping in Indonesia*, Join Symposium of ICA Working Group on CEWaCM and JBGIS GI4DM: Cartography and Geoinformatics for Early Warning and Emergency Management: Towards Better Solution, Prague, Czech Republic, January 19-22, 2009.

Martha, S., Kertopermono, A.P., and Karsidi, A. (2011). Remote Sensing and Cartographic Supports in Accelerating Geospatial Data and Information in Indonesia, *InterCarto-InterGIS17: Interdisciplinary Conference on Sustainable Development of Territories: GIS Theory and Practice*, Sanur Paradise Plaza Hotel, Bali, December 18-19, 2011.

Republic of Indonesia. (2011). *Indonesian Act no. 4 /2011* concerning Geospatial Information, Jakarta, 21 April 2011.

Republic of Indonesia. (2012). *Presidential Order no. 6 /2012* concerning uses, control quality, processing and distribution of high resolution of satellite data, Jakarta, 8 Mei 2012.

Tachibana, Y. (2009). *New NSDI and National Mapping Policy of Japan*, Eighteenth United Nations Regional Cartographic Conference for Asia and the Pacific, Bangkok, 26-29 October 2009.

Chernoff Faces as an alternative method of representation in schools: Austrian-Hungarian survey

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Abstract. During 2008 and 2009 was developed an international project on the possible use of Chernoff faces in School Cartography, with the participation of Argentine and Hungarian researchers, organizing a survey that finished with positive results, but also with some questions without a clear answer. This situation motivated Hungarian colleagues to organize a new project together with Austrian specialists in 2010 and 2011. The results of the Austrian survey were compared with the results obtained by Argentine and Hungarian pupils in 2009, finding answers to the previous contradictory results. A new Hungarian questionnaire was applied in grades 5 to7 of two Elementary Schools in Budapest, studying how younger children read the data represented using Chernoff faces and pictograms modified according to the Chernoff principle. This Hungarian survey determined the grade of acceptance between the younger pupils, as well as the grade of practical usability of these alternative methods in School Cartography.

Keywords: Cartography for children, Chernoff faces, School, survey

1. Introduction

1.1. What are the Chernoff faces?

This method for data representation was created by Hermann Chernoff (Professor Emeritus of Applied Mathematics, Department of Statistics at Harvard University) in 1973 (Figure 1). The essence of his method is the use of the features of a human face to represent different variables (Chernoff 1973). According his article up to 18 themes or variables can be represented using a face. During a theoretical research made in 2008 (Reyes 2009) participant researchers concluded that at same time six (6) variables can be represented with a Chernoff face in interest of a faster and easier reading of data (e.g. represented on a map).

From 1977 the Chernoff faces began to be introduced to cartography abroad. The first and more famous (today considered a classic) example is the map entitled “Life in Los Angeles, 1970”, designed by Eugene Turner and drafted by Richard Doss from the Geography Department at the California State University in 1977 (Figure 1). Turner wrote about this map: “It is probably one of the most interesting maps I've created because the expressions evoke an emotional association with the data. Some people don't like that.” (Turner 2004).

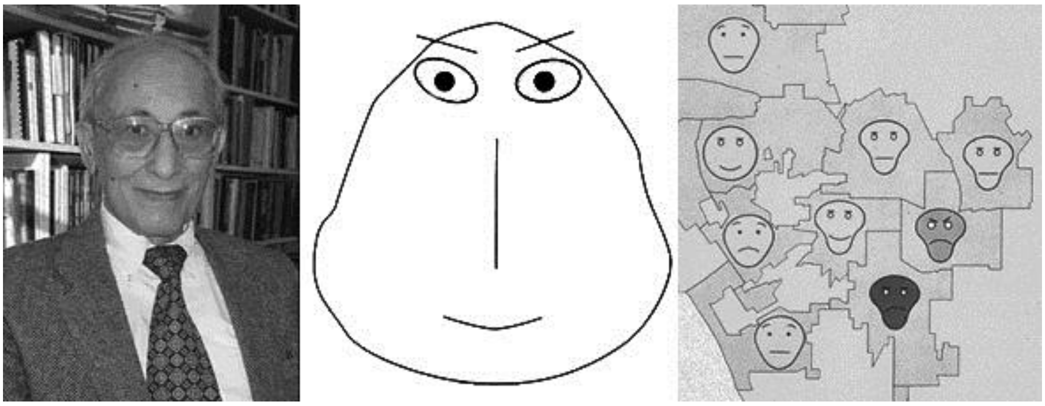


Figure 1. Herman Chernoff (2008), the first face from 1973 and a fragment of the first thematic map (Turner 1977)

1.2. Hungarian-Argentine research project (2008-2009)

The Chernoff faces were not created for the data representation on maps. By this reason, the characteristics of this method need to be adapted to the cartographic requirements before using it on a map and in specific in School Cartography.

In 2008 Argentine and Hungarian researchers began a two years project entitled “The possible uses of the Chernoff faces for data visualisation in School Cartography”. During the first year was followed the theoretical research (Reyes 2009) to draft and to exchange principles and general lines to follow during a school survey, which was made in the second year (Reyes et al. 2010).

In this survey, 818 pupils from 8 schools of the province of Buenos Aires and 1038 pupils from 12 schools in three Hungarian provinces (all of them from 12 to 15 years old) answered a questionnaire designed according to the specific characteristics of each educational system between March and June of 2009 (Juliarena, Garra, Rey et al. 2009). The questionnaire was formed by four questions to examine four aspects of the use of Chernoff faces:

- Use of “traditional” Chernoff faces
- Use of Chernoff faces applying cartographic principles
- Applying the Chernoff principle on pictograms
- Drawing of thematic data by pupils on an outline map using Chernoff faces

The results of the Argentine-Hungarian survey can be read on the Table number 1 in the point 3.2 (Results of survey in Austria) of the present paper, comparing them with the results obtained in the Austrian survey in 2011. Apart from the positive results explained in earlier papers (Reyes 2010), some contradictory and unexpected experiences were noted when the Argentine and Hungarian results were compared:

- Question applying the Chernoff principle on pictograms: the Hungarian pupils’ obtained the best result between the four questions of the questionnaire, while it was the second worse result in the Argentine questionnaire.
- Reading of data represented by changing only the shape of a face (“traditional” Chernoff face) did not provoke more significant difficulties than if the representation is made changing the size and the fill (applying cartographic principles).

On other hand, the survey was made for older (13-14 years old) pupils, but one of the conclusions of the previous theoretical research was that use of the faces can be more successfully for children in early grades of Elementary Schools, an idea that was reaffirmed by some of the opinions written by the Hungarian pupils to comment their own answers.

In interest of giving answer to all those questions that remained open, colleagues from the Department of Cartography and Geoinformatics at Eötvös Loránd University (Budapest) decided to follow the research in a new international project with the participation of the Research Group on Cartography at the Institute of Cartography and Geoinformatics of the Vienna University of Technology.

2. Organization of the Austrian-Hungarian research project

In 2010 both institutions began a project entitled “Further research and survey related to the theoretical and practical results of previous international projects about the possible cartographic uses of the Chernoff faces”, financed by the bilateral agreement for research between Austria and Hungary. This research project presented different characteristics in relation to the Argentine-Hungarian one:

- The theoretical research was planned according to the results obtained during the Argentine-Hungarian project and it was focused to the optimization of the method for School Cartography.
- Both research teams organized a survey in their respective countries in 2011, which were planned to complete each other and not to compare their results.
- Austrian colleagues organized a survey similar to the Argentine-Hungarian one, and compared their results with the results obtained in 2009, finding answers to clarify the previous contradictory results.
- Hungarian colleagues organized a new survey for pupils in earlier grades (grades 5 to 6) in two selected Elementary Schools in Budapest. This test filled the gap left during the 2009 survey, studying how younger children can read the data represented using the method and the grade of acceptance between them.

Reading the last two characteristics it can be deduced that the present project was divided into two subprojects with results separated from each other, but completing each other and the previous Argentine-Hungarian project at same time.

3. Austrian research subproject

3.1. Design of the questionnaire in Austria

After the study of the results obtained in the theoretical research and common arrangements, Austrian colleagues followed similar principles to design their own questionnaire, that is to use similar solutions than in the Argentine-Hungarian project (the same number and content of questions, colour, symbols, paper size, pupils with similar cartographic knowledge), in interest of facilitating the comparison of results in both surveys.

The questionnaire was formed by four questions and it was printed in black and white and A5 format. Considering the specific characteristics of the Austrian educational system, the questionnaire was designed for pupils of grades 3 and 4 (13–14 years old) in Austrian Secondary Schools (AHS, allgemeinbildende höhere Schule – academic secondary school and HS, Hauptschule – general secondary school) with some experience using maps and school atlases.

The questions were penned as follows:

1) Question using "traditional" Chernoff faces (only the shape of a face can be changed to represent data and all the faces are unfilled): The selected data were the "Tourism in Austrian provinces" to compare the number of tourists, the overnight stays of domestic and foreign guests and the length of stay. There were two simple and one more difficult question (Figure 2).

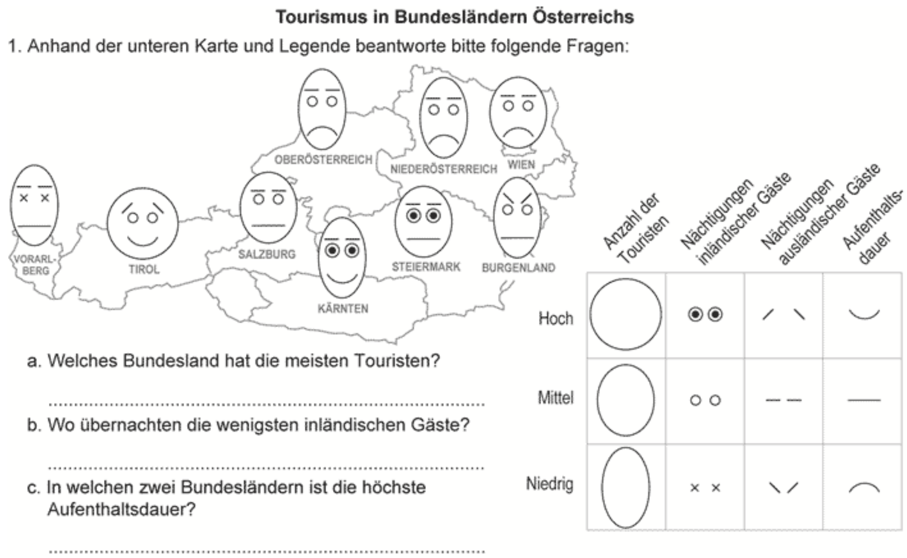


Figure 2. Question using "traditional" Chernoff faces

2) Question with Chernoff faces applying cartographic principles (size of the face varied according to the represented data): The theme was the agriculture in the Alpine countries and the number of farm animals in Austria (Figure 3).

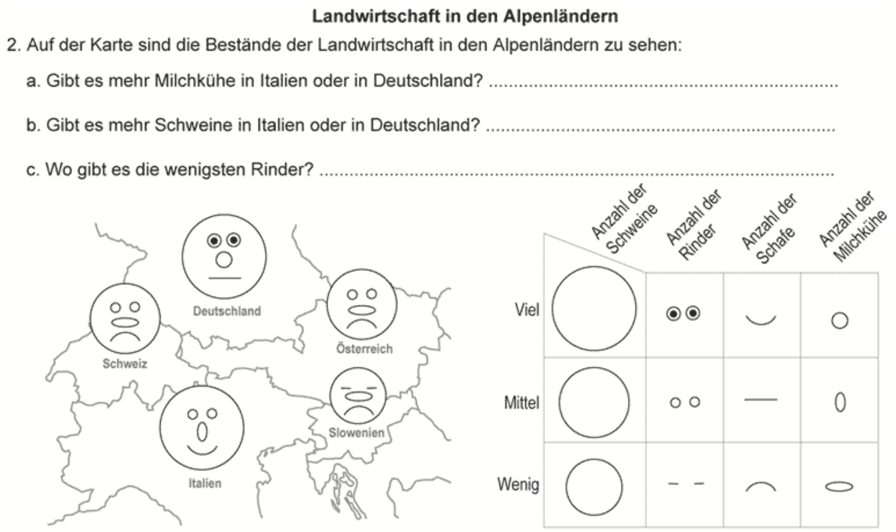


Figure 3. Question with Chernoff faces applying cartographic principles

3) Question applying the Chernoff principle on pictograms: In Austria the same pictogram (a tree) was chosen, changing similar parameters: leafage, trunk, etc. like in Hungary and Argentina (Figure 4). The topic was the data about forestry in some neighbouring countries (growth of the forest area, the proportion of forests and the gross value added of forestry).

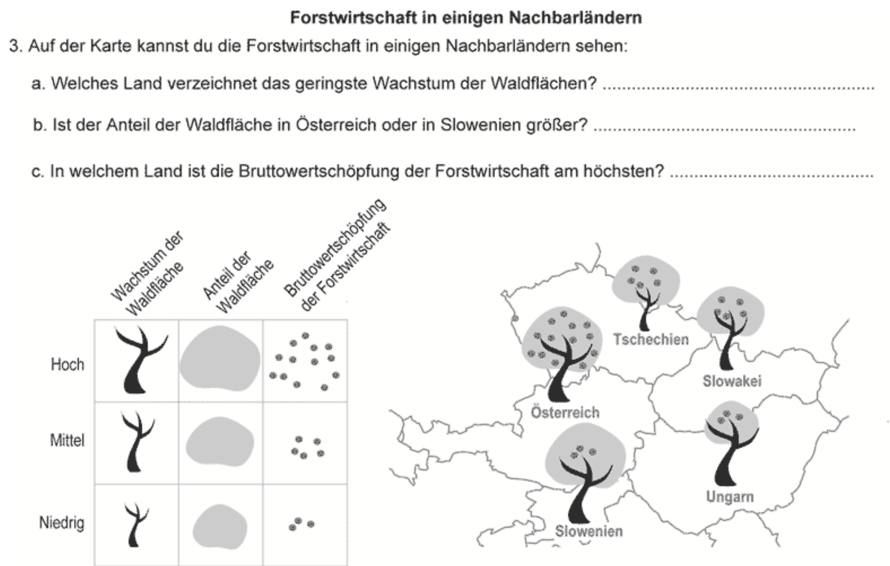
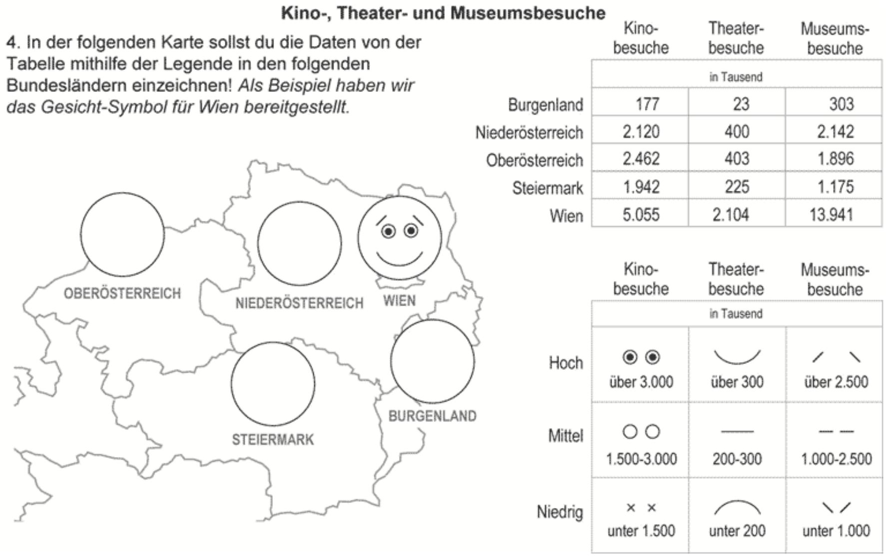


Figure 4. Question applying the Chernoff principle on pictograms

4) Question to draw thematic data on an outline map using Chernoff faces (Figure 5): In the last part the pupils have to draw their own Chernoff map with a table containing basic data and a legend. Data were about the cinema, theatre and museum visits in some Austrian counties. The shape of the face was given, pupils had only to draw the eyes, lips and eyebrows on the outline map.



	Kino-besuche	Theater-besuche	Museums-besuche
	in Tausend		
Burgenland	177	23	303
Niederösterreich	2.120	400	2.142
Oberösterreich	2.462	403	1.896
Steiermark	1.942	225	1.175
Wien	5.055	2.104	13.941

	Kino-besuche	Theater-besuche	Museums-besuche
	in Tausend		
Hoch	über 3.000	über 300	über 2.500
Mittel	1.500-3.000	200-300	1.000-2.500
Niedrig	unter 1.500	unter 200	unter 1.000

Figure 5. Question to draw thematic data on an outline map using Chernoff faces

3.2. Results of the survey in Austria

The questionnaire in Austria was applied between March and June 2011 and 11 schools from eight Austrian Federal States participated, the majority of the answers arriving from Lower Austria (Niederösterreich). A total of 1793 pupils answered the questions of the test, and the majority of participants were 13 years old (42,7%, 766 pupils) and 14 years old (33,5%, 601 pupils). From them 52,5% were girls (942 pupils) and 46,3% (830 pupils) were boys.

The Austrian results were proportionally better than in Hungary or in Argentina (Table 1). The number of correct answers is also interesting because in Austria the understanding and using of Chernoff faces on maps were the best (more than 80% of pupils answered the first, second and fourth questions correctly). But they gave the least right answers about this principle on pictograms (only 74% of the pupils), while this was the best result in the Hungarian survey with 87% of the pupils.

MAIN RESULTS OF THE SURVEY									
QUESTION-NAIRE	ARGENTINA (2009)			HUNGARY (2009)			AUSTRIA (2011)		
	Correct answers	Answers with one or more errors	No answer	Correct answers	Answers with one or more errors	No answer	Correct answers	Answers with one or more errors	No answer
Question using "traditional" Chernoff faces	493	313	12	828	207	3	1584	209	0
Question with Chernoff faces applying cartographic principles	285	527	6	665	367	6	1514	273	6
Question applying the Chernoff principle on pictograms	294	520	4	908	123	7	1329	461	3
Question to draw thematic data on an outline map using Chernoff faces	540	257	21	798	211	29	1474	297	22

Table 1. Comparison of results obtained in Austria in 2011 with the results of Argentina and Hungary in 2009

In Figure 6 can be compared the results obtained in the three surveys. Based on these statistics can be determined that the Austrian results confirmed the results obtained in Hungary during the school survey in 2008.

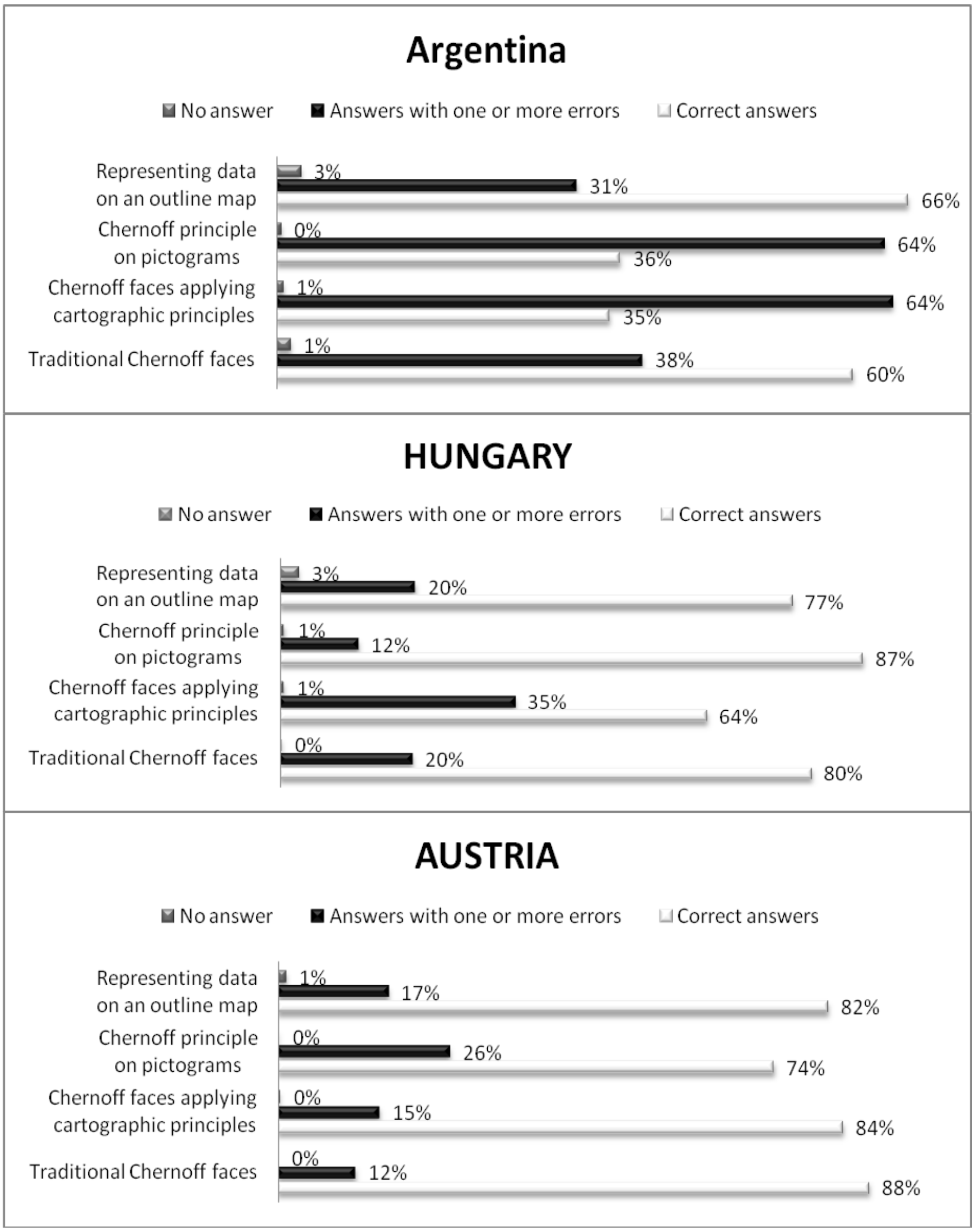


Figure 6. Diagram comparing the percentage of correct and incorrect answers by questions in the Argentine, Hungarian and Austrian survey

Other of the most interesting results was the comments and feedbacks of the pupils in the Austrian survey. A total of 1208 pupils (67,4%) wrote their opinions, which researchers categorized as positive, negative or neutral (Figure 7).

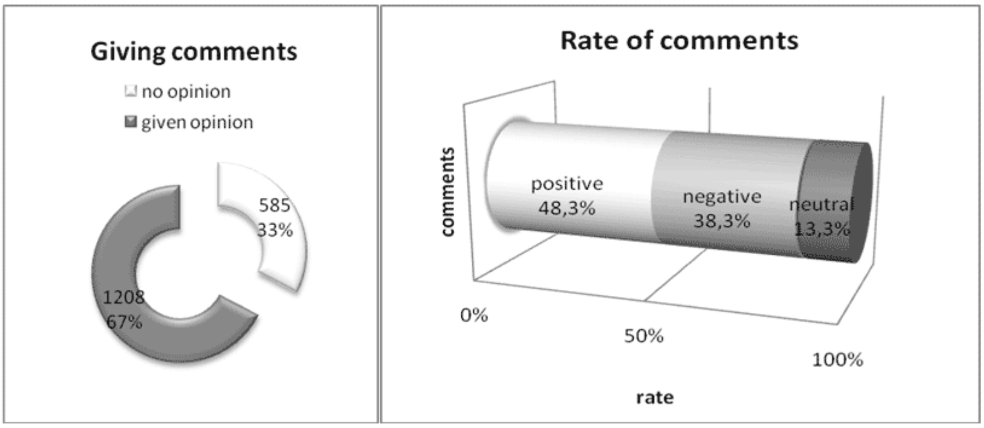


Figure 7. Proportion of positive, negative and neutral comments during the Austrian survey

4. Hungarian research subproject

4.1. Design of the questionnaire in Hungary

The new questionnaire was designed considering the specific characteristics of the Hungarian educational system: in Elementary Schools pupils began to learn some basic map concepts (mainly related to orientation and sketches of their classroom and immediate environment) from grade 3, but they learn more detailed these concepts in grade 5. The situation with the school atlases is similar: they begin to use “My First Atlas” from grade 3, but the use of maps and school atlas became more systematic from grade 5. The final decision was to apply the questionnaire for pupils in grades 5 to 6, when they have at least a minimal experience using maps and school atlases in the classroom.

The new questionnaire was planned to complete the results obtained in 2009, giving answer to a main question: Will the pupils select the alternative methods of representation (in this specific case the Chernoff faces and the pictograms designed according to the Chernoff principle) if they have the same information represented using traditional methods of thematic representation?

TASKS	QUESTIONS	METHOD OF REPRESENTATION
First task	Which is the region of the country with the highest number of Secondary Schools?	Traditional method: Simplified bar graph
	Where is the number of elementary schools lower: in Central Transdanubia or North Hungary?	Alternative method: Pictogram made according to the Chernoff principle
Second task	Which is the region of the country with the highest number of pupils in elementary schools?	Two traditional methods applied together: - Choroplets (hatching) - Proportional circles (change of size and fill)
	Where is the number of Secondary School pupils lower: in West Transdanubia or Northern Alföld (Great Hungarian Plain)?	Alternative method: Chernoff faces

Table 2. Description of the Hungarian questionnaire

The Hungarian questionnaire was designed with two tasks including two-two questions and two thematic maps by task: one map made with a traditional method of representation and a second map using an alternative method of representation. The content of this test is described in Table 2, and the questionnaire (which because of financial limitations was printed in a black and white A5 format) is presented in Figure 8. Based on our theoretical research and practical experiences during the previous survey, we decided to ask not about provinces (19 plus Budapest), but regions of Hungary (only seven). The same data were represented in two maps: the first one using a traditional method of representation (A map) and the second one made using a Chernoff pictogram or Chernoff faces (B map). Pupils had to answer the questions specifying which of both maps they used to give the answer (A, B or both). Intentionally, researchers planned questions with easy answers (demanding only basic knowledge about map reading from the pupils), because our main aim was to determine which method of representation they prefer to answer the question.

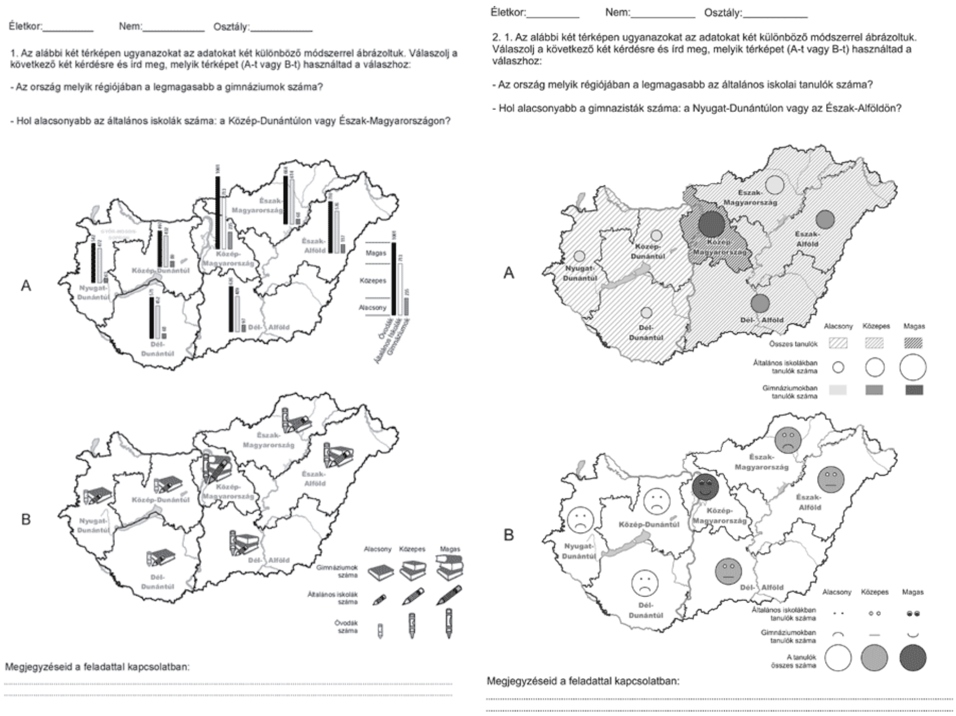


Figure 8. Questions and maps in the Hungarian questionnaire

4.2. Organization and results of the survey in Hungary

Two elementary schools (both placed in Budapest) were selected to participate in the survey. The participation was anonymous, not only for the pupils, but also for the schools. School no. 1 is a small institution in the 2nd district that can be considered an “average” elementary school. School no. 2 is a nationally recognized, “elite” institution, with a 100 years long high level tradition in all the fields of education and its’ pupils have won multiple national and international competitions.

The survey was applied between April and May 2011, counting with the participation of 106 pupils (52 from School no.1 and 54 from School no. 2), and from them 55 were girls (52%) and 51 boys (48%).

The general results of the survey are presented in Table 3, using percentages to present how many pupils selected the traditional or alternative method of representation to answer a question. Together with the general results presented in the table, specialists also calculated the partial results by each question and by schools, which are presented by different diagrams on the website of the project (http://cartography.tuwien.ac.at/chernoff/).

Based on these diagrams we can have more genuine background information about the results of the survey.

In both tasks the number of correct answers surpassed considerably the incorrect ones: summing up both schools the 1st task was answered correctly by 97% and 81% of the pupils, while the 2nd task was answered without any mistake by 98% and 87% of the pupils.

SELECTION OF THE METHOD OF REPRESENTATION IN BOTH SCHOOLS								
	First task				**Second task**			
	1st question		**2nd question**		**1st question**		**2nd question**	
	T.M.	A.M.	T.M.	A.M.	T.M.	A.M.	T.M.	A.M.
All the answers	78 (74%)	25 (24%)	82 (77%)	21 (20%)	56 (53%)	44 (42%)	54 (51%)	47 (44%)
Difference	53 (50%)		61 (57%)		12 (11%)		7 (7%)	
Only correct answers	75 (73%)	25 (24%)	63 (73%)	20 (23%)	54 (52%)	44 (42%)	46 (49%)	44 (47%)
Difference	50 (49%)		43 (50%)		10 (10%)		2 (2%)	
T.M. – *Traditional method of thematic representation* A.M. – *Alternative method of thematic representation*								

Table 3. Comparison of results obtained in both Hungarian schools, considering the total of answers and only correct answers separately

Analysing the results of both schools can be affirmed that in the 1st task the largest number of pupils selected convincingly the traditional method of representation, in this case a stylized bar chart, because this diagram let them read quicker and clearer the differences between the represented data. In the 2nd task the results varied and the number of pupils selecting the traditional or alternative method was relatively the same. In this case more children were more perceptive to the message transmitted by the Chernoff faces, which let them recognize quicker and easier the differences of the represented data than using the two combined traditional methods in the other map.

Interesting results were obtained when researchers examined the answers given by each school separately (Figure 9):

- Task 1: In school no. 1 the number of pupils that selected the pictogram map surpassed 2,1 and 2,3 times the number of pupils that chose the same map in school no. 2.
- Task 2: In school no. 2 the number of pupils that selected the Chernoff faces was larger than the number of pupils that chose this method in school no. 1.

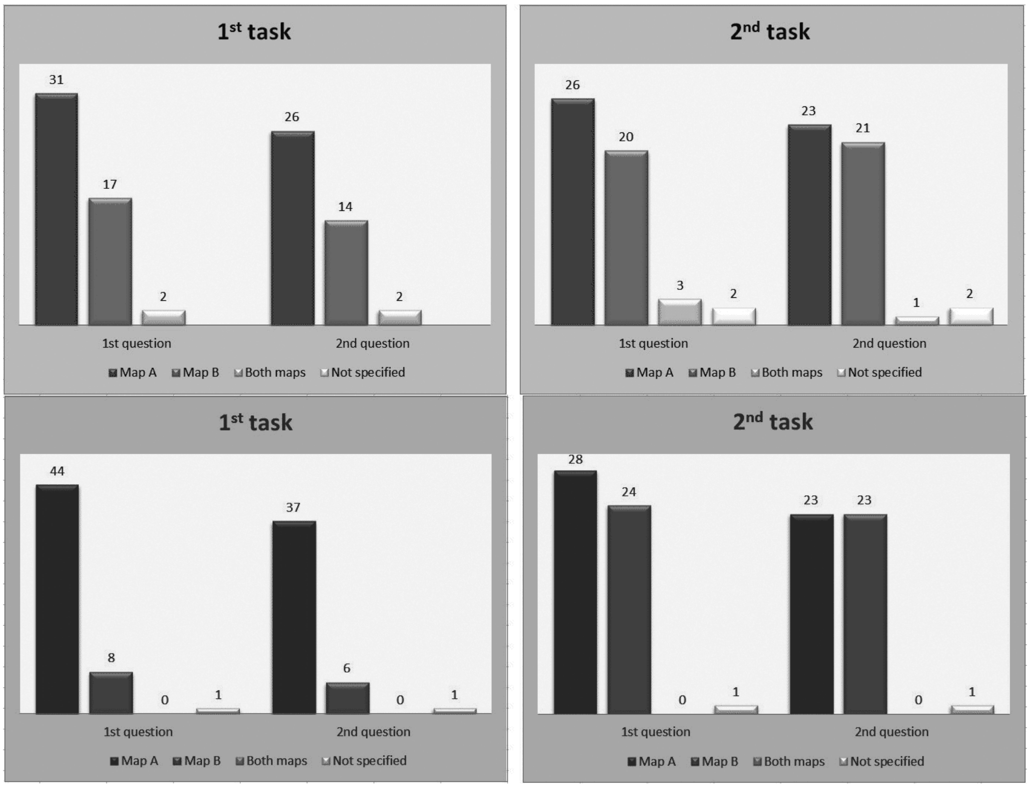


Figure 9. Results represented by schools (Hungarian survey): The two diagrams on the top represent the results obtained in school 1, and the two diagrams on the bottom correspond to school 2 (diagrams were made using only the correct answers)

5. Conclusion

Both research teams worked out suggestions related to the possible use of Chernoff faces in School Cartography that can be applied in a more general context. Resuming our proposals we can affirm that:

- The alternative methods of representation (in this specific case the Chernoff faces and pictograms made following the Chernoff principle) cannot and should not substitute the role of traditional methods of representation in thematic cartography, but they can also play a significant role in the spreading of map use (reading) for those children and young people, who by different reasons do not dispose of the knowledge and practice needed to use the traditional methods of representation without any kind of difficulty.

- Chernoff faces can be used in atlases and maps made for children in lower grades of elementary schools. An essential condition for their successful use is that that the planning and making of faces should fulfil the cartographic principles followed by the traditional cartography along centuries, and they should convey a clear and understandable psychological message, making adequate use of the feature salience and natural correspondence (Nelson 1997–2007).
- Chernoff pictograms are recommended to be used in school atlases for older students, or in atlases working out specific themes for the general public, because their graphic design can wake up better the attention of users with less knowledge and practice using maps.

The final results of our project can be accessed on the project website (http://cartography.tuwien.ac.at/chernoff/), including also more detailed information: questionnaires, results in tables, etc.

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References

Chernoff, H (1973) The use of faces to represent points in k-dimensional space graphically. Journal of the American Statistical Association, 68, pp. 361-367

Juliarena C, Garra A M, Rey C A et al. (2009) Posible uso de las fases de Chernoff para la visualización de datos en la cartografía escolar. Boletin del CAC 53(45), 2009/1, pp. 42-51

Nelson E S (2000) The Impact of Bivariate Symbol Design on Task Perfomance in a Map Setting. Cartographica 37(4), pp. 61-78

Nelson E S (2007) The Face Symbol: Research Issues and Cartographic Potential. Cartographica 42(1), pp. 53-64

Nelson E S et al. (1997) Visual Search Processes and the Multivariate Point Symbol. Cartographica 34(4), pp. 19-33

Reyes J J (2009) Ideas for the use of Chernoff faces in school cartography. The World's geo-spatial solutions [CD] Proceedings of 24th ICC ICA: Santiago de Chile.

Reyes J J et al. (2010) Chernoff survey in Argentine and Hungarian schools. Proceedings of the Third International Conference on Cartography and GIS [CD]: Nessebar.

Turner E (2004) Gene's Map Gallery [Online] Available at: http://www.csun.edu/~hfgeg005/eturner/gallery/gallery.htm Accessed 9 June 2012

The evolution of cartographic visualization in the Digital Era

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Abstract. The development of the digital production techniques were rapidly improved around 1980-1990 due to the requirements of desktop publishing. Both hardware and software components were essential in the development of the technology, but the first milestone of this process was the release of personal computers. In the cartographic visualization, the GIS technologies were invented in the 1970s. However, for a very long time the development focused on the input part and on the analysis. The need for real map production features (to produce paper maps which conform to cartographic traditions) in GIS software environment was raised after most of the paper maps were converted into digital ones. On the other hand, the non-GIS based map production could easily use the development of the DTP technologies about ten years earlier. The DTP features supported all those necessary visualization features that were widely used in traditional cartography.

Keywords: DTP, cartographic visualization, digital cartography, GIS

1. Introduction

To create maps and other cartographic products using digital methods we should have knowledge not only on cartography, but the knowledge of several computer programs (including operation system, file management, printing) and their relevance for our work. The technology of “analogue” cartographic production (including map printing) was developed in the 20th century. The production of colour maps became widely used when the offset printing replaced the other printing techniques (like lithography) after the beginning of the 20th century. The colour printing technology was continuously improved, although theoretically it remained the same until the digital methods were invented. This new technology very soon influenced the visualization of printed maps especially in the beginning, when the digital technology had some weaknesses.

2. Early computer maps

Computers became important devices since the 1960s, when more and more researchers had access to information technology on different levels. Computers at that time were very expensive devices: only large companies or state authorities (including research and higher education institutions) could access them.

One of the main weaknesses concerning the cartographic visualization was the lack of good computer (graphic) screens. The very early screens were alphanumeric; they could show only characters, and graphics were not possible at all.

GIS was initiated in 1960s, when the governmental level statistics in United States claimed a tool for analysing and visualizing the statistical data. US Census is one of the best known examples of the early use of information technology methods in statistics.

William Garrison was a recognized geographer at the University of Washington, when he came up with an idea to make use of statistics and computers to study and better understand and represent statistical problems. Waldo Tobler, a student of William Garrison invented a model called Map In – Map Out (MIMO) in 1959, which would apply computers to cartography. This model was the basis for GIS and contained all the basic features of GIS software (like geocoding, data acquisition, data analysis) available and in use today.

The Canada Geographic Information System was developed in the 1960s. Roger Tomlinson worked at an aerial survey company in Ottawa, focusing on producing large-scale photogrammetric and geophysical maps. The cooperation between IBM offices and Tomlinson brought the geographic knowledge to the table as IBM brought computer programming and data management. This was the first idea to convert the national land management to an IT driven environment.

The most famous institute of the early GIS was the Harvard Laboratories, which was founded in 1964 by Howard Fisher in Harvard University. The close relationship to the best known information technology institutes (MIT, Yale) inspired the research, but in the first years architecture, urban development and resource management were more important than the geography based research. Their famous application was the SYMAP (Synagraphic Mapping System) in 1965, which was a set of different modules for analysis and manipulation of data for production of choropleth or isoline maps. Fisher called this application as a mathematical cartography, but the term automated cartography was much better accepted in the International Cartographic Conferences.

Due to the very limited visualization functionality of computer screens, the main output devices were computer printers. In the 1960s and 1970s, there was not too much focus on output devices in informatics. At that time, line printers and matrix printers were nearly the only opportunities to make output from digitally stored data. These devices were produced to print text (characters) based on simulating the well-known “output device”, the typewriter using impact printing. However, these devices were driven by the computer at a much larger speed than any human could do. What was much more important in the cartographic point of view is the print size. In the industrial and scientific environment, where financial resources were available, such kind of large format line matrix printers and (later) dot matrix printers were used. This large output size (wider than the 80 columns of an A4 sheet) became available in the 1970s. The SYMAP technology was used only in research institutes, where line printers were available. This printing technology has never been used together with personal computers, although the technology was long time used in business environment. Finally, the large speed laser printing replaced the old technology. Dot matrix printers were developed around 1970. The very first printers used 5*7 dot matrix to form the characters; later the 9*9 dot matrix became standard. In the 1970s and 1980s, dot matrix impact printers were generally considered the best combination of expense and versatility, and until the 1990s, they were by far the most common form of printers used with personal computers.

Line printer maps were not comparable to professional cartographic products made by traditional map production techniques, but due to the complexity and time consuming of the map production process even the low quality digital maps were useful. The automatic production of statistical maps showed also the potential of the GIS, but it was evident that such maps would not replace the professional looking maps, created by traditional map production techniques (Figure 1).

The very first special output device used in cartography was the pen plotter. Compared to nowadays printers, pen plotters were very slow and cumbersome to use. Users constantly had to worry about a pen running out of ink. If one pen ran dry at the end of a plot, the entire plot had to be re-done, which was very time consuming. Plotters could only draw lines; they could not reproduce raster or photographic images (areas could be filled only with hatching). Despite these limitations, the high resolution and colour capability made the pen plotter the colour hardcopy output device of choice until the late 1980s, especially in technical drawings and CAD graphics, which consisted of simple lines like cadastral maps. Only the inkjet technology has made pen plotters obsolete.

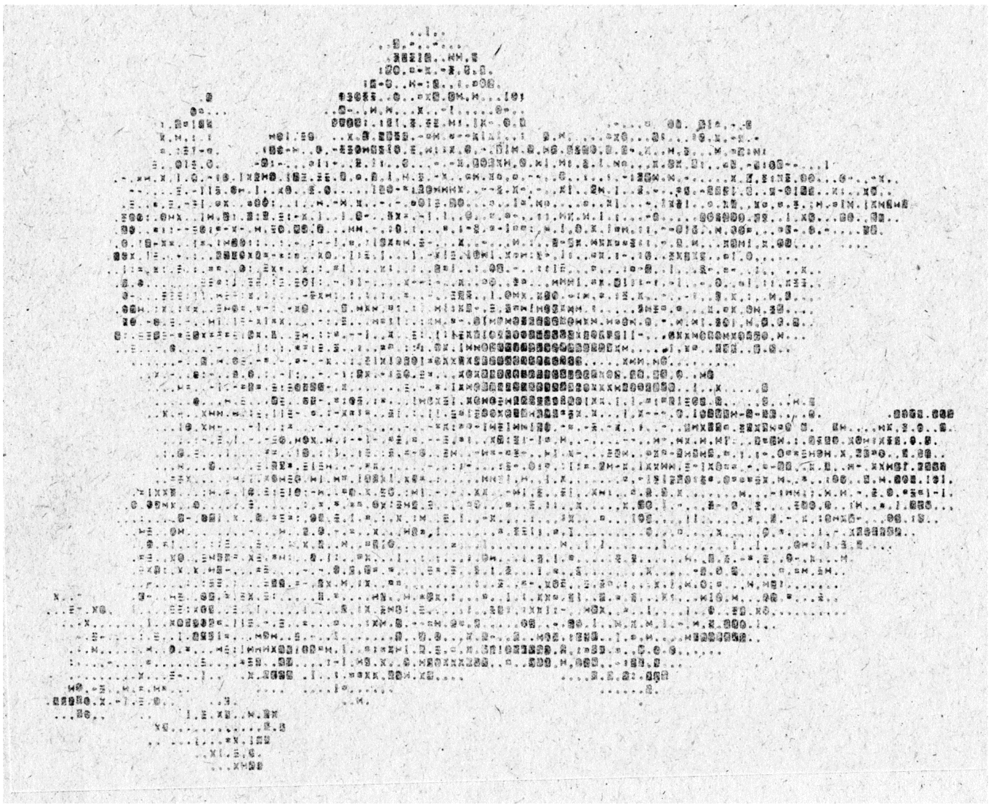

Figure 1. Experimental choropleth map of a Hungarian county, created by the COMAPO software on ICT 1905 mainframe computer (1972)

In drum technology, the papers were fixed and a pen was moved in a single axis track, and the paper itself moved on a cylindrical drum to add the other axis or dimension. Where the paper was fixed on a flat surface and the pens were moved to draw the image was called a flatbed plotter. This type of plotters regularly can use several different colour pens to draw with.

CalComp was incorporated in 1958. This was one of the first companies in the United States to market peripheral products designed specifically to work with computers. CalComp's appearance coincided with the first wave of acceptance of computers by such mainstream businesses as banks and insurance companies. In 1959, the company developed the world's first drum plotter, but few expected the instrument to grow into CalComp's strongest product line.

The HP 7470 model was a small low-cost desktop pen plotter created by Hewlett Packard in the 1980s. It used a revolutionary "grit wheel" design, which moved the paper held in place by a wheel with embedded grit and a pinch roller. The HP 7470 had originally only two pens, one on either side. It was much less expensive than the previous flatbed design, which was very heavy but had four pens. The HP 7475 used a rotating carousel with six pens. This design was also scaled up for very large pen plotters (Figure 2).

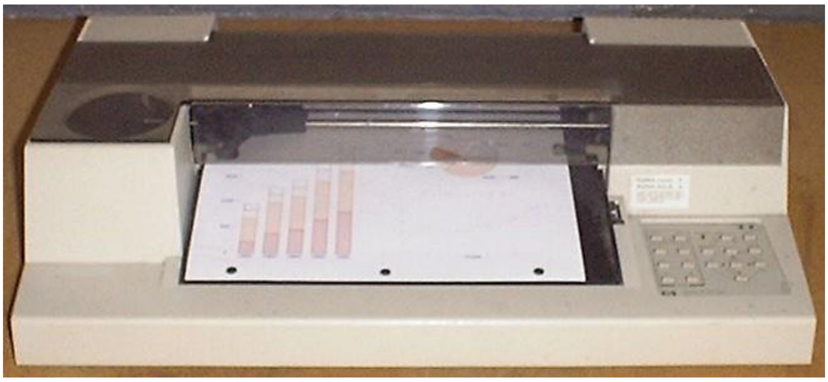

Figure 2. HP7475A plotter

When the personal computers became affordable, having larger storage capacity, and GIS software were used more frequently, cadastral maps were the first map types in state cartography to process digitally. Cadastral maps were ideal concerning the digital processing: they used only straight lines, practically no map symbols, no (or very few) areas to fill, and they used only limited colours. Another advantage of cadastral maps was that these maps were not regularly copied. Normally, there was only one hand drawn copy which was updated.

3. The Desktop Publishing

Although the development of GIS was vital for the conversion of cartography to digital, one aspect of this process (the output side) is regularly neglected or not mentioned at all. The opportunity of the automation of the whole map production process became possible with the development of desktop publishing (DTP) in the personal computer era. The main aim of the DTP is to manage different text (rich formatted text, tables) and graphic information (illustrations, equations, photos) of a page in a computer environment as it is usually necessary when producing books, magazines or any other publication (especially where we have lot of different typefaces in various sizes). Such computer programmes were available for about a decade before the personal computers were released, but these systems were so costly that only very large international publishing companies were able to afford them (mostly in North America, Japan and Western Europe).

DTP was the individual alternative of the traditional, professional publishing and printing industry. DTP replaced the first part of the very expensive infrastructure of the printing industry making it a really personal activity: having a personal computer and a suitable DTP software, one was able to design any product on the screen. The most important development of DTP was the invention of the technical part of the process: laser printers were used for proofing and image setters (laser plotters) for the production of printing films. Image setters were very expensive, but when the technology became available around 1985, it was easily available as an affordable service (like the photocopy machines). The most significant advantage of DTP was the integration of the typographic and graphic knowledge of publishing in software which gave the user enough freedom in the design.

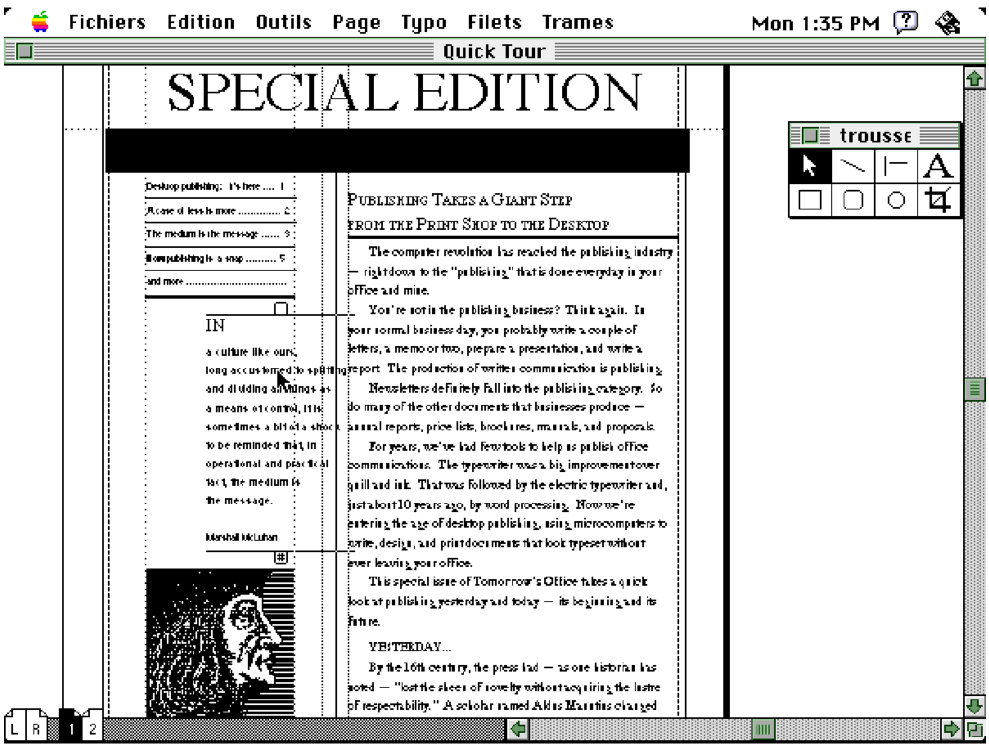

Figure 3. Aldus Pagemaker 1.0 screenshot (Mac version), source: http://www.makingpages.org/pagemaker/history/

The first DTP software on personal computers was the Aldus PageMaker (released in July 1985 for Apple-McIntosh computers and in 1986 for IBM PCs). The first black and white personal laser printers (HP Laserjet, Apple

LaserWriter) were also launched at that time (1984-1985). Although these early laser printers were quite expensive for home users and had only relatively low resolution (300 dpi), due to the special invention, the Postscript language, the laser printers were essential to use as a proofing device before we started the printing process in a print shop. Other software products were also very important, like vector graphics and image manipulation software, because the DTP offered the integration of different page elements. However, the manipulation was possible only in the original software component (Figure 3).

Postscript is a page description language (developed by Adobe, which was established in 1982); it was the first widely available product that allowed for control over a large number of fonts and graphical objects. The main advantage of Postscript is the device-independency and that Postscript is not related to any concrete operation system. Postscript devices (laser printers, image setters) have a raster image processor (RIP), which performs the instructions of the Postscript file, so the quality of the printed output depends on the resolution of the output device. RIPs were built-in in the output devices, which increased the price and prevented home users from affording a Postscript device. Postscript was treated as a professional application, and Adobe earned considerable amount of money on licensing Postscript language for printer manufacturers.

Other important feature of the Postscript language, especially concerning the desktop publishing, is the handling of typefaces as vector structures, so the characters are scalable and rotatable. Practically, users can manage all kinds of graphic manipulation. Previously, all industrial DTP systems, different operation systems used raster fonts, which gave very limited options: only few fonts could be used and only some predefined sizes were allowed to use. In a later period, more features of raster fonts were added, but the printing time of these extra elements was very long.

What DTP requested for a computer based system was also useful for map production. The technological part of map production was a very complicated process: required special and very expensive devices (reproduction cameras, precise treatment of drawing materials, screens etc.) and the potential human errors were not easy to avoid. For example, in Hungary, at that time only few state institutes had such infrastructure (Cartographia, the main and practically the only civil map publishing company, the Military Cartography Institute, the Hungarian Geological Survey and the Department of Cartography). The entire map drawing technique was based on special transparent films, which were produced in Western Europe. When the whole map production industry changed to the digital production line, the Western European companies stopped the production of these special films. This made the traditional map production process impossible in the beginning of the 1990s, unless the Hungarian cartographic institutes started to transfer their map production technique to digital.

4. Screen Maps

Screen map images had a special role in the early digital cartography. These raster maps were regularly designed for the screen to make cartographers understand the special requirement of modern visualization.

Such kind of maps were presented even on hobby computers in the 1980s, but due to the very small screen resolution and colour palette (not larger than 320*200 pixels) these images could be used mostly for games only (Figure 4).

Figure 4. Radarsoft Maps World, a Commodore screenshot (1985)

These early maps were mostly made by computer specialists instead of cartographers; cartographers could have been asked to contribute as experts, but the special requirements of screen maps were very unusual for the traditional cartographers at that time. The task required some time for cartographers to be familiar with the digital environment and the very special limitations.

The screen resolution of the home and personal computers improved relatively slowly in the 1990s, because the manufacturers were rather focusing on hardware elements like processors, hard disks, and memory chips.

In the early PC era, there were very strict limitations:

- Hard disks were very small; they were not able to store too many images (the first hard drives with more than 1 GByte were launched in 1992).

- The screen resolution was limited; this was partly physical limitation, but was also due to the poor performance of early graphic adapters. The first colour graphic adapter for PC's was the CGA (Color Graphics Adapter), which was released together with the first PC in 1981. The resolution was 320*200 pixels with 4 colours. The next standard was the EGA (Enhanced Graphics Adapter) in 1984, and later the VGA (Video Graphic Array) in 1987 (640*4801 pixel resolution with 16 colours).
- Colour depth was also a critical factor in the beginnings. Even in the early 1990s, colour palette with 256 colours was the most common, which was much less than perfect for the photographs and very good quality images.
- Screen maps were regularly generated in computer software from a vector database, but they could also be scanned. Scanners were unusual peripherals at that time. They became more affordable when a fast and cheap interface between the PC itself and a scanner was developed: this was the Universal Serial Bus (USB) released in 1996.

The real screen map is optimized for the computer screen. The most sensitive map feature is the text: this should be clearly legible on the screen. Due to the limited screen resolution, maps should be well generalised. The very first interactive global map service was the Xerox Parc Map Viewer in 1993 (Figure 5); the program allowed the user's computer to create on-demand maps from a geographic database. Each interaction with Map Viewer would request a new map from the server that was zoomed in on a specific point. Individual maps were generated in a raster graphic file and presented as a web (HTML) page.

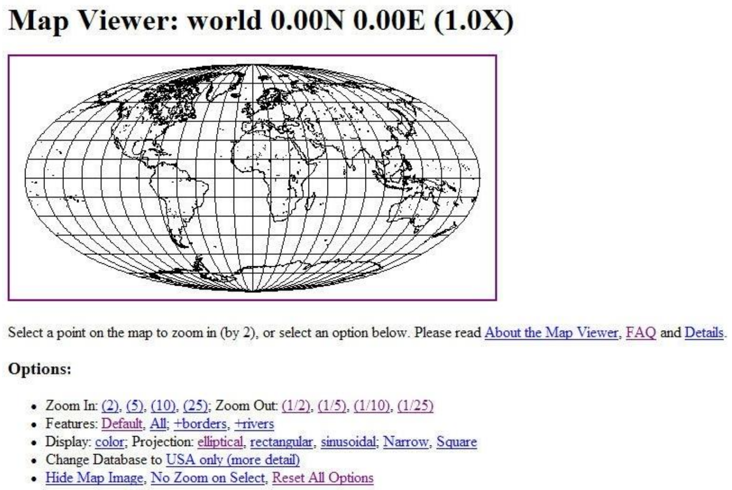

Figure 5. Xerox Parc Map Viewer

The first CD-ROM atlases were also produced at that time (an American company, DeLorme produced the first consumer CD-ROM street atlas called Street Atlas USA in 1991, and the first world atlases were also produced at that time). CD-ROM was a very important storage device. The 640 Mbyte capacity was comparable to or much higher than the storage capacity of the hard drives. This large storage space encouraged the software developers to add contents like audio, photo and video to develop the multimedia product. Even the manufacturers used raster maps or vector maps in their CD atlases, but the required storage place was not too large. Such products were also sold on floppy disks (especially because CD-ROM was not yet widely used), and most users would buy only the floppy disk version. Hungary produced the first vector based world atlas in 1994 in cooperation with various institutes (private firm, map publishing company, national institute). The whole map database was smaller than 10 MB, so the rest of CD-ROM was filled with photographs. The product was not very successful; the Hungarian market was not prepared for CD-ROM products.

The screen maps and CD-ROM products lost their importance around 2000, when the development started to focus on the Internet. MapQuest introduced its online mapping site based on a large database in 1996, which included most streets in North America.

The actual era started by Google in 2005, when the company effectively added a map-based search engine through Google Maps, and the stand-alone Google Earth became a de-facto standard of on-line map services.

The visualization issue of screen maps became important only when the screen resolution and the colour depth was good enough to be comparable to traditional paper maps. When this happened, the users continued insisting on having a printing function in the software product no matter whether it was a special stand-alone product or an Internet service. It is still a challenging problem to manage a professional on-line service or a commercial map product also including a perfect printing function.

5. Early digital maps in Hungary

The conversion process of the Hungarian cartography into a digital era was affected by various factors. Although the limited access of Eastern and Central European countries to the high technology of computer products made it difficult or sometimes impossible to follow the developments, the Hungarian cartographers tried to do their best. The first research on automated map production was carried out around 1972: thematic maps were created by computer printing (dot-matrix print) and plotters (Figure 1). At that time, only the state offices had a chance to access IT devices; the government established a special company on servicing governmental needs in 1974. It was a wise decision to concentrate the limited financial resources (the Hungarian currency was not convertible and Hungary had no many experts in this field).

The conversion of state topographic maps into digital form started in 1987, when the 1 : 200 000 scale military topographic maps were digitized in AutoCAD environment. At that time all topographic maps were classified (including the civil ones), so the digital version (which did not include the contour lines) was not for sale, and was only used in military environment. Even if it had been available for sale, there were very few PC's in the country and they were mostly used by state institutes and authorities. The classification of state topographic maps was discontinued when the political system changed around 1990. The digital version of the 1 : 100 000 scale civil topographic maps (EOTR – Hungarian Unified Map System) was much more influential, because it was digitized by the first and most famous Hungarian GIS company (Geometria Ltd.). This product was named OTAB (National GIS Database) and was especially available for sale; the content of that database was similar, contour lines were also omitted. This product was widely used by the foreign and multinational companies, which started their activities in Hungary at that time.

This was the time when the first paper maps were published by using totally digital methods. Small map publishing enterprises were formed by the former Cartographia employees, who had all cartographic knowledge and market connections. Naturally, it took some years until these cartographers became familiar with the digital techniques. In the first years, few paper maps (small city maps) were also made by IT experts, who had no previous cartographic experience. City maps and road maps were the most common map types produced by the early digital cartographers.

The first fully digital version was the DTA-50 (Digital Cartographic Database), which was the digital version of the 1 : 50 000 scale military topographic maps. The digitizing process was completed in 1996. The process was speeded up by the risk of the Balkan wars; the US Defence Mapping Agency and NATO provided financial support to the digitizing process.

Hungarian cartography has turned to digital including not only the map producing, but also the development of GIS companies.

6. Conclusions

The last two decades of the 20th century were a very challenging era in cartography not only in Hungary, but all over the world. The technological development, the new digital techniques considerably changed cartography, gave much more emphasis on the geographic information systems. This was the time when the technological development partly overshadowed the visualization part of cartography; most companies were focusing on converting the existing paper maps into digital form and the importance of visualization was re-discovered when the GIS software became capable to manage enhanced visualization and map production features.

References

Koop, R. O.: The Impact of Electronic Publishing Techniques on the Training of Practical Skills in Cartography at Utrecht University

International Yearbook of Cartography, 1988. 245-254.

Peterson, M.: The Tile-Based Mapping Transition in Cartography

Zentai, L.: The Role of Output Devices in the Higher Education of Cartography

In.: ed Zentai L, Reyes J: Maps for the Future: Children, Education and Internet: Proceedings of the Joint ICA Symposium. Orléans, France, 2011.06.30-2011.07.01. 90-101.

Zentai, L.: The Role of Output Devices in the Higher Education of Cartography

In.: ed Zentai L, Reyes J: Maps for the Future: Children, Education and Internet: Proceedings of the Joint ICA Symposium. Orléans, France, 2011.06.30-2011.07.01. 75-90.

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