



Cartography M.Sc.

Master thesis

Development of the international schools of cartographic thought

Olesia Ignateva



2021

Development of the international schools of cartographic thought

submitted for the academic degree of Master of Science (M.Sc.)
conducted at the Department of Aerospace and Geodesy
Technical University of Munich

Author:	Olesia, Ignateva
Study course:	Cartography M.Sc.
Supervisor:	Prof. Dr. Menno-Jan Kraak (UT)
Reviewer:	Dr.-Ing. Mathias Jahnke (TUM)

Chair of the Thesis
Assessment Board: Prof. Dr. Menno-Jan Kraak (UT)

Date of submission: 10.09.2021

Statement of Authorship

Herewith I declare that I am the sole author of the submitted Master's thesis entitled:

"Development of the international schools of cartographic thought"

I have fully referenced the ideas and work of others, whether published or unpublished. Literal or analogous citations are clearly marked as such.

ENSCHDEDE, 10.09.2021

Olesia, Ignateva



Development of the international schools of cartographic thought

OLESIA IGNATEVA

Enschede, The Netherlands, September 2021

Thesis submitted to the Faculty of Geo-Information Science and Earth
Observation of the University of Twente in partial fulfilment of the requirements
for the joint Master of Science in Cartography

SUPERVISOR:

Prof. Dr. Menno-Jan Kraak

THESIS ASSESSMENT BOARD:

Prof. Dr. M.-J. Kraak (Chair)

Prof. Dr. M.-J. Kraak (Advisor)

Dr.-Ing. M. Jahnke (Reviewer, TUM)

DISCLAIMER

This document describes work undertaken as part of a programme of study at the Faculty of Geo-Information Science and Earth Observation of the University of Twente. All views and opinions expressed therein remain the sole responsibility of the author, and do not necessarily represent those of the Faculty.

ABSTRACT

A notion of a school of cartographic thought and its criteria are defined in this research. As an example, the characteristics of Russian, German, French, and American schools of cartographic thought were described using the literature, survey, and in-depth interviews. The development of these schools is analyzed by studying the university curricula of cartographic study programs. The research result is the theoretical framework of the school of cartographic thought based on of four international schools of cartographic thought with their interactions and development from the second half of the 20th century until nowadays.

Keywords

theoretical cartography, critical cartography, history of cartography, cartographic education

ACKNOWLEDGEMENTS

First of all, I would like to thank my supervisor Prof. Dr. Menno-Jan Kraak – for the huge support, for staying in touch, and for the feedback that he was giving me.

Secondly, I appreciate the opportunity that was given to me by the Cartography MSc program. These were the unforgettable two years of new experience, working with an international community of talented and bright people. Especially, I would like to thank our coordinator Juliane Cron for her support and help in integration in living and studying in the European Union.

A huge thanks to our professors, for sharing their knowledge and ideas. To my classmates for the friendship. Nargiz, my best friend, who I met here – for staying with me in good and bad life moments.

And, most important, I would like to thank my family and my life partner Linar – for supporting me in the long distance.

TABLE OF CONTENTS

Abstract.....	i
Acknowledgements	ii
The list of figures.....	v
The list of tables.....	vii
The list of abbreviations	viii
Chapter 1 Introduction	1
1.1. Motivation and problem statement.....	1
1.2. Research objective and questions	2
1.3. Thesis structure	3
Chapter 2 Background.....	4
2.1. Related definitions and studies.....	4
2.2. The Russian school of cartographic thought.....	6
2.3. The German school of cartographic thought.....	12
2.4. The French school of cartographic thought.....	15
2.5. The American school of cartographic thought	17
2.6. Summary.....	20
Chapter 3 Survey	23
3.1. Methodology.....	23
3.2. Execution	23
3.3. Results.....	24
3.4. Summary.....	29
Chapter 4 In-depth interviews	31
4.1. Methodology.....	31
4.2. Execution	32
4.3. Results.....	33
4.3.1. The Russian school of cartographic thought today.....	33
4.3.2. The German school of cartographic thought today.....	35
4.3.3. The French school of cartographic thought today.....	38
4.4.4. The American school of cartographic thought today	39
4.4.5. Interactions between schools of thought.....	42
4.4. Summary.....	47
Chapter 5 Education.....	48
5.1. Methodology.....	48

5.2. Execution.....	48
5.3. Results	53
5.3.1. The Development of the Russian school of cartographic thought from an educational perspective	53
5.3.2. The Development of the German school of cartographic thought from an educational perspective	55
5.3.3. The Development of the French school of cartographic thought from an educational perspective	62
5.3.4. The Development of the American school of cartographic thought from an educational perspective	64
5.4. Summary	66
Chapter 6 Synthesis	68
Chapter 7 Conclusion and Reflections	72
References	75
Appendix 1	79
Appendix 2	80
Appendix 3	81
Appendix 4	82

THE LIST OF FIGURES

Figure 1. Thesis structure.....	3
Figure 2. The course of theoretical thought in cartography over 50 years.....	5
Figure 3. A. K. Salishchev.....	7
Figure 4. I. P. Zarutskaya.....	8
Figure 5. A. M. Berlyant.....	8
Figure 6. ICA Awards Ceremony in Rio	9
Figure 7. K. B. Shingareva.....	10
Figure 8. A. M. Aslanikashvili	11
Figure 9. E. Imhof	13
Figure 10. J. Bertin	16
Figure 11. A. H. Robinson	18
Figure 12. J. Jenks.....	18
Figure 13. W. Tobler.....	19
Figure 14. Mind-map of Academic Cartography by Countries and Scholars.....	21
Figure 15. Mind-map of the Major Cartographic Concepts in the research area	22
Figure 16. Major Academic Cartography locations in the second half of the 20th century in the research area	22
Figure 17. Word cloud diagram based on the answers to the first question	25
Figure 18. Three spaces of the cartographic school.....	27
Figure 19. Cartography-related study programs at the TUW and the TUD over time	50
Figure 20. The cartographic subjects in the MSU's curricula over 2009-2021 grouped into general categories.....	52
Figure 21. The overview of specialization disciplines in the curricula of the MSU	54
Figure 22. Cartographic subjects grouped by categories throughout 2009-2021 at MSU....	54
Figure 23. The overview of specialization disciplines in the curricula of the TUD	55
Figure 24. Cartographic subjects grouped by categories throughout 2000-2020 at the TUD	56
Figure 25. The cartographic subjects in the TUD's curricula over 2000-2021 grouped into general categories.....	57
Figure 26. The overview of specialization disciplines in the curricula of the TUW	58
Figure 27. Cartographic subjects grouped by categories throughout 2000-2021 at TUW...58	58
Figure 28. The cartographic subjects in the TUW's curricula over 2000-2021 grouped into general categories.....	59
Figure 29. The overview of specialization disciplines in the curricula of the Cartography MSc	60
Figure 30. Cartographic subjects grouped by categories throughout 2011-2021 in the Cartography MSc.....	61
Figure 31. The cartographic subjects in the Cartography MSc's curricula over 2011-2021 grouped into general categories	61
Figure 32. The overview of specialization disciplines in the curricula of the Parisian programs	62
Figure 33. The cartographic subjects in the Parisian curricula over 2000-2021, grouped into general categories.....	63
Figure 34. Cartographic subjects grouped by categories throughout 2000-2021 in the Parisian programs	63

Figure 35. The overview of specialization disciplines in the curricula of the UW–Madison 64

Figure 36. The cartographic subjects in the UW–Madison curricula over 2000-2021, grouped into general categories..... 65

Figure 37. Cartographic subjects grouped by categories throughout 2000-2021 at UW–Madison..... 65

Figure 38. Cartographic subjects grouped by categories throughout 2000-2020 at different universities 67

Figure 39. The interactions between schools of cartographic thought in 1960-1990 68

Figure 40. The interactions between schools of cartographic thought in contemporary time 70

THE LIST OF TABLES

Table 1. Execution of the survey in numbers according to country of respondents	24
Table 2. Schools of cartographic thought.....	30
Table 3. Positivist vs Naturalist philosophy of research (Rubin & Rubin, 2012)	32
Table 4. Number of conversational partners by country	33
Table 5. The key institutions and study programs	48
Table 6. Observed study programs.....	49

THE LIST OF ABBREVIATIONS

BoK	Body of Knowledge
BSc	Bachelor of Science
CRNS	National Center for Scientific Research
ENSG	National School of Geographic Sciences
ETH	Federal Institute of Technology
GDR	German Democratic Republic
GIS	Geographical Information System
ICA	International Cartographic Association
IGN	The National Institute for Geographic and Forest Information
LBS	Location-Based Services
MIIGAiK	Moscow Institute of Engineers of Geodesy, Aerial Photography and Cartography, from 1993 Moscow state university of geodesy and cartography, abbreviation remains
MSc	Master of Science
MSU	Moscow State University of M. V. Lomonosov
TU	Technical University
USSR	Union of Soviet Socialist Republics
UW– Madison	University of Wisconsin–Madison

Chapter 1 Introduction

1.1. MOTIVATION AND PROBLEM STATEMENT

As a science, cartography is evolving continuously, and cartographers perceive cartography differently. There are numerous paradigms and theories of cartography that are reflected in schools of thought at academic centers and by independent researchers. They can interact in different ways: influence each other, mix, and initiate new ideas. However, the cartographic schools were studied before in a limited way, from the historical perspective, but not as integrated theoretical and educational practice in a particular university or area.

Over time the cartographic schools of thought occurred and evolved in different areas of the world influenced by the social context – traditions, events, language, economy, and politics. It is difficult to imagine two completely similar schools of cartographic thought in different environments. However, globalization might have an impact on the identity of the schools, and their development. The research aims to understand the development of the schools, in particular, which factors influence them and how and how schools interact with each other.

In this research, I will concentrate on schools in different language areas – Russian, German, French, and Anglo-American. The period will be limited as well – from the contemporary period after World War II until today. Schools can be defined after their founders, e. g. Eduard Imhof, Arthur Robinson, Konstantin Salishchev, Jacques Bertin, and others, who originated new paradigms in their geographical region. It is assumed that the society they lived and worked in influenced their work, as well as they might have influenced each other.

Nowadays, with the paradigm shift towards GIS, accepting English as a global scientific language, and the Internet spreading, cartographic schools might change. Therefore, this research is an attempt to find out how schools were developing using the information about changes in educational programs around the world and interviewing prominent cartographers. Cartography as a domain is taught at universities as an independent or associated with different disciplines, therefore the education reflects the character and direction of the school of thought. The trend of merging cartography with other disciplines was stated by Fraser et. al. (2011): “...the weakening of cartography as a discipline in its own right and the dispersal of cartographic theory and practice into many and varied education programs representing allied disciplines” (p. 1).

The GIS&T BoK – a model curriculum in the field of GIS in the USA includes Cartography and Visualization among the other knowledge areas (DiBiase et al., 2006). Nowadays the project is a community of GIS educators from different parts of the world and issues peer-reviewed publications (UCGIS, n.d.). This fact is showing the significance of the project related to GIS education, where cartography is only considered as a part of it, not an independent discipline.

However, there were initiatives from the cartographers to establish the Cartography BoK. In the article, Fairbairn (2014) mentions: “...it is to be hoped that this ICA-led input to the Body of Knowledge can assist in developing contemporary Model Curricula, with a foundation of

cartographic fundamentals, suitable to address the objectives of cartographic education presented above” (p. 466). At the ICA Conference, Fairbairn (2018) stated the need to create a Body of Knowledge for cartography, like it was done for GIS&T, and this resulted in the Cartography Body of Knowledge ICA working group foundation (Kraak, 2018). The Cartography BoK will contain and regularly update the concepts, definitions, individual contributions to it (ICA Working Group, 2021).

Therefore, this project intends to be useful for the Cartography BoK agenda, showing the state of cartography in different areas of the world, which will help to integrate schools of cartographic thought into the coherent and solid Body of Knowledge.

1.2. RESEARCH OBJECTIVE AND QUESTIONS

As reflected in the title of the thesis, the objective of the research is to study the development of the international cartographic schools of thought to see if, how, and when they influenced each other. To reach the sub-objectives (RO), the answers to the following research questions (RQ) should be found.

RO1. To define the criteria that describe a cartographic school.

RQ1.1: What is a cartographic school?

RQ1.2: Which are the criteria that define a cartographic school?

RO2. To describe the characteristics of the Russian, American, German, and French cartographic schools of thought.

RQ2.1: What typifies the Russian school?

RQ2.2: What typifies the American school?

RQ2.3: What typifies the German school?

RQ2.4: What typifies the French school?

RO3. To analyze the schools’ developments over time.

RQ3.1: How did the schools develop over time (in series of curricula)?

RQ3.2: How do the schools influence each other?

The results of the research could be useful for the academic community of cartography, educators, education commission of ICA. From the educational perspective, the result will be the knowledge about the state of cartographic university education in different parts of the world, which is important to define Cartography BoK.

From the theoretical perspective, the result will be the understanding of how cartographic schools of thought have been transforming under different factors and how they interacted. The research scope includes only several schools, due to time limitations. The research result can be reflected in the illustration, where the schools are depicted in the relation to each other throughout the time starting from the second half of the 20th century until nowadays.

1.3. THESIS STRUCTURE

In Figure 1 the thesis structure is depicted, in the left row, there are chapter names. The chapters Survey, In-depth interview, and Education will describe three different approaches to answer the research questions with their methodologies, executions, and results. In the chapter Synthesis, the information gathered from the four previous chapters will be synthesized to get the general research result.

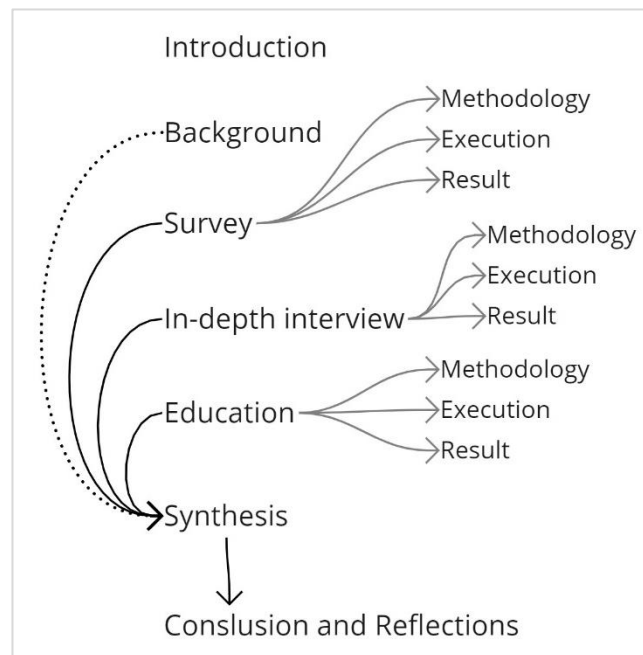


Figure 1. Thesis structure

Chapter 2 Background

In Chapter 2 the notion of the “school of cartographic thought” will be discussed based on related definitions and studies. Then four schools of cartographic thought will be described with the information from the bibliography. The schools of cartographic thought are distinguished based on language areas: Russian (the former USSR), French, English (American), and the German language area. In the end, there will be a summary of the described schools of thought.

2.1. RELATED DEFINITIONS AND STUDIES

According to the Cambridge Dictionary, a school of thought is “a set of ideas or opinions that a group of people shares about a matter” (School of thought, 2021). If “matter” is considered cartography, we can introduce the term cartographic school of thought. The Cambridge Dictionary defines “school” also as “a group of painters, writers, poets, etc. whose work is similar, especially similar to that of a particular leader” (School, 2021a), while Merriam-Webster gives a similar definition: “a group of persons who hold a common doctrine or follow the same teacher (as in philosophy, theology, or medicine)” (School, 2021b).

In their book about paradigms in cartography Azócar and Buchroithner (2014) used along with the term “school of thought” the term “tendencies”, which they define as: “...thoughts, trends, perspectives, and approaches which have been developed within a science or discipline, i.e. geography and cartography” (p. 104). Among the contemporary schools, they distinguished cartographic language, cartographic communication, analytical cartography, cartographic visualization, critical cartography, and post-representational cartography. For these tendencies, they distinguished criteria like study object, research aim, methods and techniques, research result, and cartographic product result. Besides criteria, the authors placed the tendencies in several epistemological spaces, to understand the relations between tendencies from the philosophical point of view. As a continuation of the previous work, Azócar and Buchroithner (2014) published comprehensive research on theoretical cartography. They adapted cartographic trends and paradigms of the 20th and the 21st centuries in a philosophical framework. Notably, their book is a rich source of existing tendencies, theories, and paradigms in modern, postmodern, and contemporary cartography.

Another closely related term is a paradigm; according to the Merriam-Webster dictionary, it is “a philosophical and theoretical framework of a scientific school or discipline within which theories, laws, and generalizations and the experiments performed in support of them are formulated” (Paradigm, 2021a). The definition of the Cambridge dictionary: “a set of theories that explain the way a particular subject is understood at a particular time” (Paradigm, 2021b). As could be seen, the term paradigm reflects only the theoretical site of the school of thought, therefore the terms are not equal.

In 1994, Berlyant made an overview of the existing theoretical concepts in cartography and their development. He defined them as: “Theoretical concepts in cartography constitute a system of points of view concerning its subject and method, as well as the method for interpreting the principal processes of development of cartographic science and production”

(p. 279). He distinguished three basic theoretical concepts: cognitive, communicative, and linguistic. In Figure 2 he showed the position of the major works of the concepts concerning the time of issue and indicated the process, which had been happening with the concepts. He assumed, that in the 1990-s the process of integration will predominate.

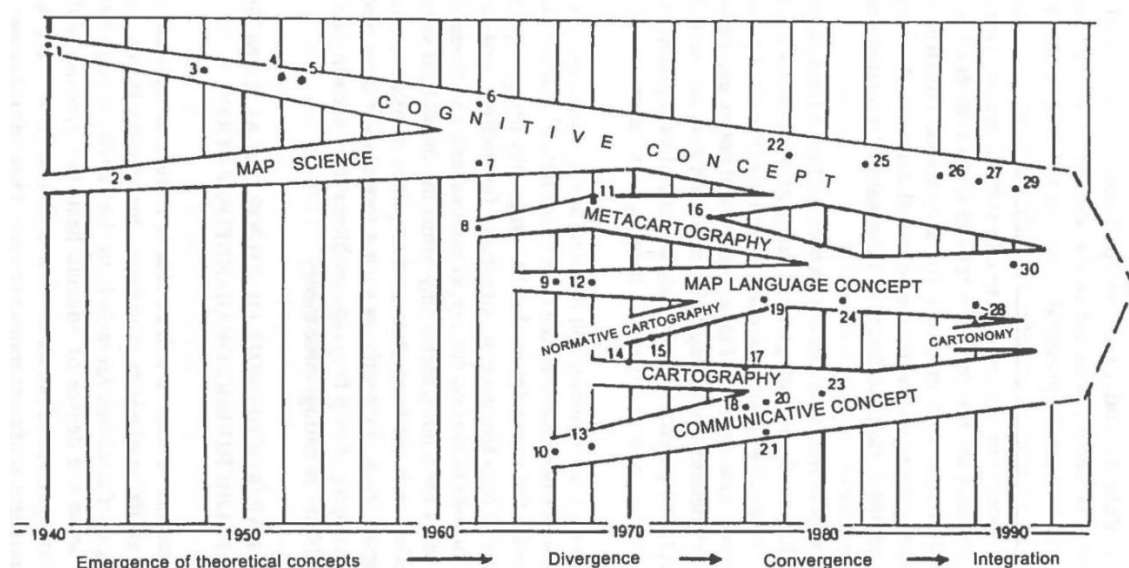


Figure 2. The course of theoretical thought in cartography over 50 years

Note: 1. Baranskiy, N. N., *Economic Cartography*. 2. Salishchev, K. A., *Principles of Map Science, General Part. Second Edition*. 3. Salishchev, K. A., *Problems in Geography*. 4. Gedymin, A. V., *The geographic map as a work tool*. 5. Salishchev, K. A., *The cartographic research method*. 6. Salishchev, K. A., *Principles of Map Science. Third Edition*. 7. Baranskiy, N. N. and A. I. Preobrazhenskiy., *Economic Cartography*. 8. Bunge, W., *Theoretical Geography*. 9. Bocharov, M. K., *Principles of Design for Systems of Cartographic Symbolization*. 10. Arnberger, E., *Handbook of Thematic Cartography*. 11. Aslanikashvili, A. F., *Cartography. General Theoretical Problems*. 12. Bertin, J., *Semiologie Graphique: Les Diagrammes, les Reseaux, les Carles*. 13. Kolacny, A., *Cartographic information – a fundamental concept and term in modern cartography*. 14. Ratajski, L., *Cartology*. 15. Freitag, U., *Semiotics and cartography*. 16. Aslanikashvili, A. F., *Metacartography. Fundamental Issues*. 17. Ratajski, L., *Cartology, its developed concept*. 18. Robinson, A. H. and B. B. Petchenik, *The Nature of Maps*. 19. Pravda, J., *Cartographic language*. 20. Morrison, J. L., *The science of cartography and its essential processes*. 21. Board, C., *Map reading tasks appropriate in experimental studies in cartographic communication*. 22. Berlyant, A. M., *The Cartographic Research Method*. 23. Kretschmer, L., *Theoretical cartography: position and tasks*. 24. Lyutyy, A. A., *Map Language*. 25. Salishchev, K. A., *Ideas and Theoretical Problems in Cartography of the 1980s*. 26. Berlyant, A. M., *Image of Space: Map and Information*. 27. Ogrissek, R., *Theoretical Cartography*. 28. Lyutyy, A. A., *Language: Essence, System, Functions*. 29. Berlyant, A. M., *Geoimages and Geoiconics*. 30. Pravda, J., *Fundamental Concepts of Map Language*. Reprinted from "Theoretical concepts in cartography," by A. M. Berlyant, 1994, *Mapping Sciences and Remote Sensing*, 31(4), p. 284. Copyright 1994 by V. H. Winston & Son, Inc.

Kitchin et. al. (2009) observed representational and post-representational approaches to cartography. The representational cartographic approach sees a map as truth, included the Western academic cartographic theories of the XX century such as cartographic communication, behavioral cartography, analytical cartography, and cognitive-semiotic representational theory. The authors called them "scientific orthodoxies" (p. 3) and marked each theory with the names of their leaders.

Based on the abovementioned, the school of cartographic thought is related to both theoretical aspects of cartography and a group of people, guided by similar thoughts and,

probably, a leader or a scholar. Theories are shaping the body of knowledge that is taught in educational institutions, and as such a school of thought will influence the educational process.

2.2. THE RUSSIAN SCHOOL OF CARTOGRAPHIC THOUGHT

Konstantin Alexeevich Salishchev (1905–1988) founded the Russian school of geographic cartography on the Faculty of Geography at the Moscow State University. His successor Berlyant (n.d.-a) wrote a note on his memory. Based on the note, Salishchev was one of the first students of cartography in the Konstantinovskiy Mezhevoy Institut¹ in 1922. In the 1920-s, he participated in the exploration and mapping of the Cherskiy mountain range and creating the USSR state map with a scale of 1 : 1000000. In the 1930-s, he was a head of the cartography department of the Institute of the Big Soviet World Atlas, where he was an editor and an author of several maps. He started to teach cartography in 1931, first in the Leningrad state university, then in 1936 he was a professor in MIIGAiK, and later in 1942, he became a lector at MSU. From 1950 to 1988, he was the head of Geodesy and Cartography chair at MSU, and during this time the chair became the prominent center of cartography in the country and the world. At the same time, he performed as a head or an editor of various atlases, such as Atlas of the history of geographical discoveries and research (1959), the three-volume Marine Atlases (1950-1953), the World Atlas (1954), the Physic-Geographical Atlas of the World (1964), the capital multivolume Atlas of the Oceans (1974-1980). He started to be a world-scale leader in cartography, being the head of the Commission of National and Regional Atlases of the International Geographical Union (1956-1972). In 1968-1972 he was a President; in 1964-1968 and 1972-1976 a Vice-President of the International Cartographic Association. He was elected an honorary member of many scientific societies in Europe and America.

As Konecny et. al (2005) remembering about Salishchev on his centenary jubilee:

He was always ready to respond to new ideas and trends in cartography, such as cartographic modelling or the application of remote sensing methods for thematic mapping, and a great number of his contributions concerned the prospects of automation in cartography – it is on this base that the development of geoinformation science started in Russia. Textbooks by Prof. Salishchev were translated and published in China, Germany, Poland and Cuba.

¹ Konstantin's Surveying Institute; in 1930 the geodesy department was developed into Moscow Geodesy Institute, now MIIGAiK



Figure 3. A. K. Salishchev

Note: Reprinted from Salishchev Konstantin Alexeevich, In *Letopis' Moskovskogo Universiteta*, n.d., Retrieved July 19, 2021, from <http://letopis.msu.ru/peoples/3556>. Copyright 2021 by Analiticheskaya sluzhba MGU imeni M.V. Lomonosova.

The underlying paradigm was understanding the map as a model of reality with the help of the symbols, to facilitate the cognition about the world (Ormeling, 2015). Therefore, this concept was called by Soviet cartographers “cognitive” (Berlyant, 1994). The cognition here was related to the new geographic knowledge that can be derived from maps, not the process of deriving the knowledge itself. In that context, cartography was considered a part of geography. The cognitive concept of Soviet school opposed the communication concept, where cognition was considered from the perspective of map design research. Salishchev was critical to the communication theory:

His critical view of the communication approach persisted, as that approach did not incorporate the necessary task of evaluating the correctness and usefulness of the information rendered through maps. Neither did it incorporate the development of methods to acquire new information. As opposed to the shallow view of persons adept at informatics, scientific mapping as a modeling process was always aimed at a more thorough understanding of the reality studied. For Salishchev the main issue for contemporary cartography was finding new methods of map production and map use. Its objective was the representation of and research into spatial systems of varying complexity by cartographic modeling. It is impossible to reach this objective without geographical knowledge. In cartographic education this expressed itself in the emphasis on modeling methods, especially for synthesis maps, but also for typological maps, evaluation maps, and regionalization. (Ormeling, 2015, p.7).

As Montello (2002) noticed, there were no empirical studies and psychological aspects of map cognition in the Soviet Union. He also states the cartography in the Soviet Union was influenced by communist doctrine, where the main idea of maps is that they should be “comprehensible by everyone” (p. 294).

Although Salishchev is a person, associated with Russian cartography by historians of cartography in the world (Ormeling, 2015), there was another prominent scholar, who followed the paradigm of geographic cartography and made great contributions to it – Irina Pavlovna Zarutskaya (1908–1990) (Batuev et al., 2019). She was educated at MSU in the soil, geology, and geography department in the 1930-s, and participated in the map production of the USSR State Map, 1 : 1000000 and later “a hypsometric map of the USSR at a scale of 1:

2,500,000 – an outstanding work of domestic and world cartography, which made her name famous” (Berlyant, n.d.-b). From 1951 she started to teach in the Geography Faculty at MSU and headed the creation of the complex regional atlases. She was a member of the Commissions of Geomorphological Mapping, Education, National Atlases of the ICA.



Figure 4. I. P. Zarutskaya

Note: Reprinted from Zarutskaya Irina Pavlovna, In *Centr geodezii, kartografii i infrastruktury prostranstvennykh dannykh*, n.d., Retrieved July 19, 2021, from <https://cgkipd.ru/75-years-day-of-Victory/posle-voini/zarutskaya/>. Copyright 2021 by FGBU “Centr geodezii, kartografii i IPD”.

In 1976, Alexander Mikhailovich Berlyant (born in 1937), wrote the doctoral dissertation on the topic of the cartographic research method. This work was an extension of Salishchev's ideas, meaning that using the maps as a method of research, new knowledge could be gathered. In the 1980-s Berlyant developed the concept of geoikonika² – “the general theory of geo-images, located at the intersection of cartography, remote sensing and geoinformatics” (Berlyant A. M., n.d.). From 1990 until 2009 he was the head of the Cartography chair at MSU, following Salishchev.



Figure 5. A. M. Berlyant

Note: Reprinted from Berlyant Alexander Mikhaylovich, In *Letopis' Moskovskogo Universiteta*, n.d., Retrieved July 19, 2021, from <http://letopis.msu.ru/peoples/4681>. Copyright 2021 by Analiticheskaya sluzhba MGU imeni M.V.Lomonosova.

² geoiconics

Another prominent scholar in the Russian geographic cartography school is Vladimir Sergeevich Tikunov, who is known for his international cooperation in the field of cartography and GIS. Tikunov was a student of the chair in the Salishchev period and became a doctor of geographic sciences in 1983. He is the head of the Laboratory for Integrated Mapping since 1995 and the Center for the World Geographic Data System since 2011 of the Faculty of Geography in MSU. He wrote a student book *Geoinformatika* and translated the student book *Cartography* by Kraak and Ormeling. He was a vice-president of the ICA in 2007–2011, the chairman of the Commission on Education and Training 1999–2003, the Working Group on GI for Sustainability (2007–2011), the Commission on GI for Sustainability (2011–2015) (Schmidt, 2015). Tikunov was an editor in different journals in Russia and worldwide.



Figure 6. ICA Awards Ceremony in Rio

Note: From left to right: Trisha Moriarty as representative of David Fraser, José Jesús Reyes Nuñez, Elri Liebenberg, David Fairbairn, Vladimir Tikunov, Corné van Elzakker. Reprinted from ICA Awards Ceremony #icc2015rio, In *International Cartographic Association*, 2015, Retrieved July 19, 2021, from <https://icaci.org/ica-awards-ceremony-icc2015rio/>). Copyright by ICA.

Back to the 21st century, Berlyant (2009), wrote about the conception of the university's innovative geographic-cartographic education. He emphasized the principles of education, where the most important one is the integration of cartography, geoinformatics, and remote sensing as the base for geographic-cartographic education. The second principle is seen in expanding the connection with the geosciences, while the other principles are related to the innovations in technology and education. Berlyant also stated that education must be conservative, because of the importance of the accumulated knowledge in the domain, which serves as a fundament to the innovations. He considered that modernization must expand the previous body of knowledge, not cancel it.

The present head of the Cartography and geoinformatics chair at MSU Irina Konstantinovna Lurie (2011) wrote about the modern modifications to the geographic cartography paradigm regarding the development of geoinformation science, which started from the 1980-s by Berlyant, Martynenko, Serbenyuk, Tikunov, and others. In this regard, cartography is seen in the strong connection with geoinformation science, geosciences, and social sciences. The main change in understanding the map is not only as an image but as a database. The geographical cartography is seen as cartography, based on the database and the map as a result of the processing and visualization of the data, which is organized in the geographical database.

Lurie and Prasolova (2017) discussed the current situation around the Russian geographic cartography school, particularly the educational standards in connection with professional

standards together with curriculum modules. The paper represents the modern state of the Russian school of geographic cartography from different aspects, showing the current state of its education. They stated that in 2007, MSU was granted by the government to develop study programs that later were the basis of the educational standards. Consequently, cartographic education standard was developed in MSU as well, it propagates to the other universities in Russia. Authors claim the predominance of traditions over the new technologies in their university cartographic school, as was stated earlier by Berlyant (2009).

In terms of the theoretical basis of the geographic cartography school, cognition through maps has many similarities with spatial analysis in GIS, when the multiple layers combined to understand the patterns on the territory. The approach has some similarities with the school of analytical cartography in the US, but the Russian school is used to be more geographic and does not focus on a mathematical way of displaying the reality but understanding and explaining the reality via maps to facilitate geographers in their research and decision-making processes.

Not only at MSU, but also in the different parts of the Soviet Union and later Russia, there were and still exist the departments of Cartography at classical universities, e. g. Sankt-Peterburg State University, Perm State University, Udmurt State University, Irkutsk State University, etc., and surveying institutes – MIIGAiK and Siberian State University of Geosystems and Technologies. There are many more universities in the country, which offer cartographic education either geographic or geodetic faculties. In Russia, the universities follow the federal standards of education, and therefore study programs in different universities for the same profile do not vary significantly.

The MIIGAiK is considered to have one of the oldest cartography study programs in the World (Ormeling, 2008). Here the cartography is taught as an engineering discipline, unlike scientific at MSU. Its professor Kira Borisovna Shingareva (1938–2013) made a great contribution to the sub-field of planetary cartography and the ICA commission of it, in particular (ICA Commission on Planetary Cartography, 2013). She was educated as a cartographer at the MIIGAiK and later in TU Dresden, where she became a doctor. Later she was teaching and working in the laboratory of the Planetary Cartography Laboratory of MIIGAiK. ICA Commission on the Planetary Cartography wrote on her memory (2013): “Kira Shingareva was the driving force behind the ICA’s Planetary Cartography Working Group (co-chair: 1995–1999) and Commission (chair: 1999–2007)”.



Figure 7. K. B. Shingareva

Note: Portrait of Kira B. Shingareva. Reprinted from *Kira B. Shingareva* by H. Hargitai, In *International Cartographic Association*, 2013, Retrieved July 19, 2021 from <https://icaci.org/kira-b-shingareva-1938-2013/>. Copyright by ICA.

Along with Salishchev, there was another prominent scholar of Soviet cartography at that time that followed a different approach in cartographic theory – Alexander Mikhailovich Aslanikashvili (1916-1981) from Tbilisi State University. He developed his theory of cartography, which is called *Metakartografiya*³, which was published in the Georgian language in 1968 and 1974 translated to Russian. The concept was considered as semiotic, unlike the cognitive geographic approach of the Moscow university's cartography school, but Salishchev accepted the theory of Aslanikashvili (Wolodtschenko, 2017). Montello (2002) highlights that Aslanikashvili has early formulated the role of cognition in cartography in 1968. The book *Metakartografiya* was translated from English to Japanese by Tositomo Kanakubo in 1998 (Wolodtschenko, 2017).



Figure 8. A. M. Aslanikashvili

Note: Professor Alexander Aslanikashvili. Reprinted from *Wikimedia Commons*, n.d., Retrieved July 19, 2021 from https://commons.wikimedia.org/wiki/File:Alexander_Aslanikashvili.jpg. CC BY-SA 4.0.

Besides, Wolodtschenko (2017) also mentioned the contributions of Mikhail Kuzmich Bocharov (1914–1997) to the semiotic theory in Soviet cartography with his book *Osnovy teorii proektirovaniya sistem kartograficheskikh znakov*⁴, which was published in Russian in 1966. However, Wolodtschenko notes that he “was a cartographic “dissident” in the former Soviet Union and a victim of Soviet academic cartography in the era of K. Salishchev” (p. 2). He called Aslanikashvili and Bocharov together with Bertin “pioneers of cartosemiotics” (p. 1).

Thus, in the Soviet period, Russian cartographers made a prominent contribution to cartography as a scientific domain, famous for the paradigm of geographic cartography, which was resulted in the various atlases and maps, highly recognized in the world. The figure of Salishchev remains the most important in Russian cartography and his view on cartography as a scientific field in the strong connection with geography, modernized with the current development in the field of geoinformatics remains a standard in the Russian university cartographic school. This highlights the strong personal influence of Salishchev on cartography as a science, and Russian cartographic school as a whole, especially if consider the contributions of Bocharov that were not accepted by the mainstream cartography at that time. The school influenced mainly the countries of the Warsaw pact (published textbooks). The contribution to the planetary cartography was very significant as well by the engineering part of the Russian cartographic school led by MIIGAik. Today the Russian geographic

³ Metacartography

⁴ Foundations of the Design Theory of Map Sign Systems

cartography school preserves the legacy of Salishchev but includes into the discipline also geoinformatics and remote sensing.

2.3. THE GERMAN SCHOOL OF CARTOGRAPHIC THOUGHT

In the History of Cartography Ormeling (2015) wrote about the start of German academic cartography. He called Germany and Austria at the beginning of the 20th century “hotspots of cartographic development” (p. 6), referring to Alfred Hettner (1910), Karl Peucker with *Schattenplastik und Farbenplastik* (1898), and Max Eckert’s *Die Kartenwissenschaft* (1921–25). Ormeling highlights the applied character of German cartography at that time: “To Eckert, Kartenwissenschaft (the science of maps) was the discipline that taught how to produce maps” (p. 6). The influence of M. Eckert ideas was emphasized by Scharfe (1986):

...the development of modern cartography started again and delayed in the German speaking area after 1945, and more than two decades passed before the books of Arnberger, Witt and Imhof – especially devoted to thematical cartography – were published, based on Eckert's fundamental work. If one knows the Kartenwissenschaft and then starts to study the great publications of Arnberger and Witt, one cannot avoid the impression of very close connections between the ideas of Eckert and this post-war comments in several parts. Therefore one can say today without exaggeration that Max Eckert and his Kartenwissenschaft have laid the foundations of modern and autonomous scientific cartography in the German speaking area. (p. 66).

Ormeling (2015) considered Eduard Imhof (1895–1986) as the first German-speaking scholar, who presented cartography as the scientific discipline. Imhof (Figure 6) was taught as geodesy engineer at the ETH Zürich, received a degree in 1919 and later “founded the first academic institute of cartography, Kartographisches Institut der Eidgenössischen Technischen Hochschule in Zurich, in 1925.” (p. 6). Ormeling described Imhof’s views on cartography as a science:

To Imhof, theoretical cartography was an applied science whose subject matter was the representation of the surface of the earth. The final objective was the improvement of this representation, and this could be realized by applying order systematically to the immense number of graphic shapes available. Cartography also contained a strong artistic trend, and in that regard, there were strong similarities to architecture. As an artist Imhof emphasized the visual effects, without attaching to them the perceptual characteristics... (p. 6).

In the note on the memory of Imhof, Ormeling (1986) described his contribution to the cartographic design, relief cartography, thematic cartography, atlas cartography, and ICA. The author states that Imhof became the first president of ICA in 1959, where he facilitated the consolidation of the Western and Eastern countries in the ICA, despite the political situation at that time. He emphasized: “The impact that Imhof has had on cartography, is based on the combination of scientific sense, artistic talent and technical proficiency, something that is rarely found in a single person”. Based on the abovementioned, Imhof was probably the first, whose research and practice in cartography had a triple character of science, art, and technology.



Figure 9. E. Imhof

Note: Imhof, Eduard (1895-1986). Reprinted from *Wikimedia Commons*, by F. Schmelhaus, 1922, Retrieved July 20, 2021 from [https://commons.wikimedia.org/wiki/File:ETH-BIB-Imhof,_Eduard_\(1895-1986\)-Portr_00154.tif](https://commons.wikimedia.org/wiki/File:ETH-BIB-Imhof,_Eduard_(1895-1986)-Portr_00154.tif). CC BY-SA 4.0.

The English-speaking auditory mostly know Imhof by the translation of his book *Kartographische Geländedarstellung* (Cartographic Relief Presentation). However, his textbook on thematic cartography *Thematische Kartographie* (1972) was never translated to English. Ormeling (1986) states the different approaches to thematic cartography in this textbook, related to graphical structural types rather than map themes, which was even criticized in the West German journal on cartography *Kartographische Nachrichten*. This fact shows us that although the Imhof was a key figure in the German-speaking area, his authority was not sacrosanct, as might be. The reason for criticism might be that thematic cartography was booming in German-speaking countries, with the textbooks of Erik Arnberger *Handbuch der thematischen Kartographie* (1966) and Werner Witt *Thematische Kartographie: Methoden und Probleme, Tendenzen und Aufgaben* (1967), which were published before the Imhof's textbook.

Erik Arnberger (1917–1987) was an Austrian cartographer, educated as a geographer, and later became a professor at the University of Vienna. Ormeling (2015) stated Arnberger's views on cartography as:

...a Formalwissenschaft (a discipline, like mathematics or statistics, concerned with the forms and not with the contents) as opposed to a discipline such as geography, where it is the contents that matter. For Arnberger the objective of cartography was to work out adequate graphic representations of information whose spatial relationships had to be expressed through cartographic means. (p. 7).

According to Ormeling (2015), Arnberger divided cartography into practical and theoretical parts, the second one was supposed to “elaborate the standards according to which practical cartography had to be effected” (p. 7). As Ormeling noticed, the same views with Arnberger, even more practical, was a German cartographer Werner Witt from Hannover.

From 1979 another approach to cartography in Germany emerged at the Free University of Berlin driven by Ulrich Freitag (born 1931). Ormeling (2015) wrote on about his views on cartography as the combination of three views on the map language, which expanded the theory of Bertin:

The interrelationships between the graphic elements were termed syntactic aspects by Freitag (<...> carto-syntactics); the relationships between the elements and their meaning were termed semantic aspects (carto-semantics), and the relationships between the graphic elements and the map users were termed pragmatic aspects (carto-pragmatics). (p. 10).

Montello (2002) also mentioned the contribution of Günter Hake together with Freitag to the cognitive map-design research: "...presented models of the cartographic process that incorporated the idea of map communication as symbolic, thereby pointing to the role of semiotics (the study of signs and symbols) and linguistics in cartographic communication" (p. 291). He emphasized that because of them, who recalled the tradition of Eckert, "cognitive map-design research, both empirical and theoretical, flourished in German cartography" (p. 293).

In 1989, Freitag wrote an article on cartographic education and research in the FRG. He stated that cartography as engineering was taught at the polytechnics in Berlin, München and Karlsruhe. At universities, cartography was a minor subject, which might be chosen with geodesy or geography, so there was no university cartographic education in West Germany. He stated the body of scientific knowledge in the West German cartography based on the already mentioned textbooks by Imhof, Arnberger, and Witt, but also Encyclopedia of Cartography and Related Fields (Arnberger, Kretschmer) and Dictionary of Cartography.

To summarize, the theoretical framework of cartography in German-speaking countries in the 20th century, except the GDR, was defined by different approaches, related to practical or applied aspects of cartography, sometimes even without the relation to geography, as a formal science proposed by Arnberger. From the 1970-s the map-design research was booming with the work of Hake and Freitag (Montello, 2002). Montello also mentioned Koch (Dresden), Bollman (Berlin), Vanecek, and Arnberger (Austria), who was doing empirical research, or research on map perception during the 1980-s.

Although Koch began his research in GDR, Montello (2002) called him "a recent leader of map-design research" (p. 293) that is showing the unification tendency of eastern and western Germany cartographic schools. Before that time, in the GDR, particularly at the TU Dresden, the situation was the opposite: it was influenced by Salishchev's school (Ormeling, 2008). He emphasized the special role of Dresden cartographic school as "...a bridge between socialist and capitalist cartography, as through the translation of Russian literature it showed us what was happening in cartography behind the Iron Curtain" (p. 179).

In 1990, there was the reunification of Germany due to the collapse of the socialism regimes in Eastern Europe and this forced the reunification of Eastern and Western German cartography as well. As Ormeling (2008) wrote, it caused problems, because of the difference in the educational and professional standards for the field of geoinformation, which was ruled in West Germany by geodesists. Müller (1996) noted that thematic cartography was represented in surveying departments, and emphasized the growing importance of GIS, database management, and computer graphics in the curricula due to the technological development. He described the common core in cartographic education of the three German universities.

Schewtschenko et. al. (2012) emphasized the changes that the Bologna process has brought to cartographic education in post-socialist countries (Ukraine, Lithuania, and the former GDR). The authors stated the connection between cartography and GIS, the unification of cartographic education, and the crisis for cartography in Germany. The TU Dresden was the

only standard university in Germany that held bachelor's and master's degrees in Cartography until 2013, mainly because of its GDR legacy. TU Dresden is considered to be the oldest and for a long time was the single German university with cartography as an independent discipline.

As Peters et. al. (2009) declared, cartography courses are offered in geodesy and geography-related programs at the world's universities and sometimes as only an introductory course. In 2009, they presented the concept of the joint Cartography and Geoinformation master program at the ICA conference. The program aimed "to improve the high level of cartography science in Europe", and to TU Munich, TU Vienna, and TU Dresden. The program started in 2010th, later the University of Twente ITC has joined the program, and still exists as the only university program in Cartography in three countries of Germany, Austria, and the Netherlands.

The higher cartographic education is preserved only in several schools (Koch, 2013). Koch discussed three training paths of cartographic education in German-speaking countries: vocational courses, the university of applied sciences (former polytechnics), and universities, which inherits cartographic education in the 20th century. He observed study programs on cartography and geomatics at the universities of applied science, cartography education within geodetic study programs, and geographic study programs. He emphasized that cartography in association with geoinformatics is not an independent discipline nowadays which is connected to either geography or geodesy courses and the cartographer profession is replaced by the profession of geomatichian. Besides the Cartography master's program, the University of Vienna offers [a master's program in Cartography and Geoinformation](#) (*Cartography and Geoinformation (Master)*, n.d.), which is in the geographic department.

As for today, it is unknown, which school of thought is now leading in German-speaking countries. However, among the new tendencies there are VR Cartography, introduced in 2005 by Buchroithner from TU Dresden, and Cartographic Information System, introduced by Kelnhofer in Vienna in the 1990-s (Azócar & Buchroithner, 2014). It is suggested that there was a kind of a German cartographic school of thought, based on the applied character of theory, the common textbooks on thematic cartography published in German, and connection with survey engineering. The key persons of the school were Imhof, Arnberger, Witt, Freitag, Hake and unlike with the Russian geographic cartography school of Salishchev, there was no person, who had the biggest authority. The Dresden school cannot be considered as a part of this school at least before the 1990-s, due to its relations with the Russian geographic cartography school. However, as it could be seen for today, with the development of the Cartography master program, the different cartography education model, and, perhaps, school is developing, which is has to be observed in this study.

2.4. THE FRENCH SCHOOL OF CARTOGRAPHIC THOUGHT

In France, in the 20th century, there was a semiotic school of Jacques Bertin (1918–2010), whose legacy spread far beyond the country and influenced cartographers around the world. His major work *Semiologie Graphique* (1967) was translated to German (1974) and English (1983). To introduce the scale of Bertin's figure, Palsky (2019) wrote: "To French cartographers, he is a founding father, a hero of our Grand Narrative..." (p. 191). He stated in the article, that Bertin was trained as a geographer-cartographer in the Cartography school at Sorbonne, Paris. After WWII he founded a laboratory in École pratique des hautes études:

“The laboratory became the essential center for education and research in cartography in France, for 30 years. Bertin directed the laboratory until his retirement in 1985; the laboratory finally disappeared in 1992” (p. 190).

Palsky emphasized, that Bertin started to think about his conception of semiology in the 1950-s. The experienced, he gained in CNRS and his laboratory resulted in his theory where “the grammar of graphics emerged from the systematic analysis of hundreds of representations” (p. 191). Palsky notes that Bertin was not referring to anyone in his work, because “he did not try to fit into the scheme of other theories, such as the general theory of signs (semiology), or the communication model. Thus, his work appears very practical, empirical, and within the reach of everyone” (p. 191). Palsky also mentioned the second part of his major work and *La graphique et le traitement graphique de l'information*, which were written in the 1970-s, where Bertin discussed tools of graphic data processing and data classification. He concludes that the legacy of Bertin is remaining actual, as he anticipated in the information visualization field.



Figure 10. J. Bertin

Note: Jacques Bertin. Reprinted from 1993 Jacques Bertin, In *Deutsche Gesellschaft für Kartographie e.V.*, 1993, Retrieved July 20, 2021 from <https://www.dgfk.net/1993-jacques-bertin/>. Copyright 2021 by Deutsche Gesellschaft für Kartographie e.V.

Palsky (2011) reported on the spreading the ideas of Bertin to cartographic education:

In France, Bertin’s laboratory was a small structure. Through courses and seminars, it certainly diffused semiology of graphics among students and researchers, but Bertin’s ideas appeared more like a set of unchanging rules rather than matters of research, and little was made to extend or improve them. Cartography, in France, had long been subsumed to geography, and for geographers “la graphique” was above all else considered as a tool, to present and eventually process the data. (p. 2).

He pointed, that there is not apparent that the work of Bertin will be updated (Palsky, 2011). Therefore, it is impossible to say that the French cartographic school nowadays is following the semiotic approach, proposed by Bertin.

After Bertin, the notable developments in geography and cartography were done by Roger Brunet (born 1931). He and his colleagues participated in the RECLUS research group, founded in 1984, which specialized in regional geography. Brunet developed the “choreme” approach, the abstraction designations of point, linear, areal, and network processes to facilitate spatial and, particularly, regional analysis. Ormeling (1992) considered the group as the revival of the French cartography, but in 1996, the group was closed.

The special role in French cartography plays the IGN – the French national mapping agency, which organizes education and research. The IGN focuses on the research in different areas, [the research group COGIT](#) (*COGIT Laboratory*, 2018) is the closest to the task of cartography, which includes visualization, interaction, and immersion aspects. It manages the engineering school, [ENSG-Geomatics](#) (*School*, 2018), a member of Gustave Eiffel University, which is specialized in geomatics, mapping design, remote sensing, cadaster, and computer science applied to GIS. The school is a partner of the University Paris 1 Pantheon Sorbonne and the University Paris 7 in [the master program Carthageo](#) (*Master parcours Carthagéo*, 2021). The program offers two directions: “thematic” and “digital”, for students with geographic or social science backgrounds and for those who were studying mathematics or computer science respectfully.

Therefore, cartographic education and research in France have a minor character in addition to geography as a science and geomatics as engineering. It is not possible to say of the development of theoretical cartography research these days and to therefore to see the distinct school of thought, but the former school of Bertin still influences on different domains.

2.5. THE AMERICAN SCHOOL OF CARTOGRAPHIC THOUGHT

The history of academic cartography in the USA was divided by McMaster and McMaster (2002) into four periods, starting from the “Incipient period (1900-1940)” (p. 306). The pioneer of American cartography was Edwin Reisch, with the first academic cartography textbook “General Cartography” published in 1938. However, in this paragraph, the following periods will be discussed. The second period is “The Post War Era of Core Graduate Programs (1940-1985)” (p. 306), which is famous for developing cartographic concepts and university education at the universities of Wisconsin, Kansas, and Washington. McMaster and McMaster wrote, Reisch, who was a cartographic leader in the 1940-s, distinguished cartography from surveying, cartographers-geographers, and carto-technicians. The need of a country after WWII facilitate the further development of cartographic education.

This period was commemorated by Arthur Robinson (1915–2004), who introduced the school of cartographic communication in the United States. He published the book *The Look of the Maps* in 1952 at the University of Wisconsin, where he was teaching cartography, which is based on the communication concept. Robinson was inspired by the work of German cartographer Eckert, who anticipated map design and psychological research in cartography, and by another German work of Peucker on “color and relief representation” (Montello, 2002, p. 287). Montello also mentioned the influence of cognitive research on map education on Robinson’s work. Montello (2002) in his article discussed the influence on further cartographic research development after Robinson: “The Look of the Maps led to “application of psychophysical methods to map-design research” (p. 288). He states that research was concentrated on psychophysical measurements such as recording eye movements, related to graduated symbols. The methodology for cartography was borrowed from psychology. The importance of Robinson’s figure in the context of American cartography was expressed by McMaster and McMaster (2002): “Arthur Robinson established himself as the unofficial “Dean” of American academic cartographers, building the program in cartography at the University of Wisconsin into the very best in the United States during the 1970s and early 1980s” (p. 311). They emphasized the impact of the University of

Wisconsin, where the first offered the bachelor's degree in cartography in the US, and also a master's degree, which has resulted in "several hundred students" (p. 312). The textbook *Elements of Cartography*, written by Robinson and co-authors had six editions.



Figure 11. A. H. Robinson

Note: Arthur H. Robinson, University of Wisconsin, Madison, professor emeritus of geography and renowned cartographer, in 1979. Reprinted from Reimagining Maps, In *ESRI*, n.d., Retrieved July 20, 2021 from <https://www.esri.com/news/arcuser/1010/lookofmaps.html>. Copyright 2021 by Photograph courtesy of the University of Wisconsin, Madison, University Archives

As McMaster and McMaster (2002) wrote, the Kansas school of cartography followed George Jenks (1916–1996), whose theoretical work concentrated on map design, classification, and symbolization. They mention, Jenks understood the demand for cartographers after WWII and declared the ways to the improvement of education. The problem of American cartography at that time he had seen as theory was poorly applied to the practice of making good maps. Besides the research, Jenks's efforts were directed to developing better education in cartography. McMaster and McMaster emphasize the period of the 1970-s when the Kansas program was growing, and Jenks concentrated on the research of map design and geostatistics. They note: "one major thread throughout Jenks's career: cartographers should have a broad base of geographic education as well as a clear understanding of cartographic communication" (p. 315).



Figure 12. J. Jenks

Note: Dr. Jenks expounding on something map related. Reprinted from "View of The George F. Jenks Map Collection" by T. M. White, 2018, *Cartographic Perspectives*, 91, p. 114. CC BY-SA 4.0.

Another academic location for cartography in this period was in Washington, led by John Sherman (1916 – 1996). McMaster and McMaster note that at this school more attention was

given to map production, unlike at the other schools. Sherman was interested in map design and communication research, but some of his students followed the analytical cartography concept.

As could be noticed, all of these three scholars were researching the map design, and Montello (2002) states the boom of cognitive map-design research in the 1970-s, following the decline in the 1980-s. The communication concept was critiqued by other scholars, such as Salishchev because it was not considering the geographic content of a map. Another issue was “lack of ready application to the production of maps” (p. 294) because psychophysics methods were allowed only to focus on the “low-level map tasks such as feature detection and size perception” (p. 295). Montello also emphasizes the technological development was another reason for declining cognitive cartographic research, as more scholars started to concentrate on GIS projects.

From 1975 to 1990 there was a period of “diffusion of cartographic programs with geography departments” (McMaster & McMaster, 2002, p. 316). In this period cartography was added to geography programs at various universities of the USA. The authors described in their work a paradigm of analytical cartography, guided by Waldo Tobler (1930 – 2018) in this period, who like some other analytical cartographers, was a student of Sherman. The analytical cartography was related to the mathematical aspects of cartography. McMaster and McMaster emphasized the importance of analytical concepts “the principles of numerical/analytical/digital cartography became the core of modern GISs” (p. 320).



Figure 13. W. Tobler

Note: Waldo Tobler in front of Newberry Library, Chicago (USA). Reprinted from Wikimedia Commons, 2007, Retrieved July 20, 2021 from https://commons.wikimedia.org/wiki/File:Waldo_Tobler_2007.jpg. CC BY-SA 3.0.

McMaster and McMaster (2002) declared the decline of cartographic education and research, caused by the spreading of GIS in the 1990-s. They noted the popularity of the term “geovisualization” instead of cartography. The issue of “geovisualization” was discussed by Montello (2002), who noted the 1990-s as the rise of cognitive map-design research. He argues that although GIS caused the decline of the interest in cartography, the computer era facilitates map-design research. The school of cartographic communication was replaced by the cognitive and semiotic approaches, influenced by Alan MacEachren (Kitchin et al., 2011).

In 1995, MacEachren wrote comprehensive research and introduced the semiotic and cognitive approach. Montello (2002) highlights that MacEachren understood the mistakes of his predecessors, which followed the communication paradigm. MacEachren introduced the idea of geographic visualization in his work, combined cognition theory, and semiotics. As a result, “Geovisualisation research flourished and spread during the 2000s, especially with

respect to the cognitive approach. In fact, since 2009, cognitive issues in geographic information visualization have been published in the scientific journal *Cartographica*” (Azócar & Buchroithner, 2014, p. 53). Azócar and Buchroithner noted scholars from different countries besides the US follow this approach such as Kraak, Ormeling, Fabrikant, Schiewe. They distinguished the tendency or school of cartographic visualization related to the cognitive-semiotic paradigm.

Currently, the key institution of cartography in the USA is the University of Wisconsin–Madison, the only university in the US with a [bachelor's](#) (*Cartography and Geographic Information Systems, B.S.*, n.d.) and [master's program](#), (*Cartography and Geographic Information Systems, M.S.*, n.d.) which contains the word cartography in its name. In 2021, Wike and Sinton analyzed all academic programs related to cartography in the US, asking the question reflecting in the article's title. They discovered that cartography is still taught in most of the Geography and Geoinformation study programs, but as a part of the GIScience and Technology domain:

... we can speculate that cartography has lost academic ground to the growing emphasis on GIS&T and other emerging geospatial technologies such as Global Satellite Navigation Satellite Systems (GNSSs) and Small Unmanned Aerial Systems (sUASs). Today, few college and university graduates identify as cartographers. (p. 148).

MacEachren (2013) described the perspectives of cartography as an academic field in LBS, interactive applications, geovisual analytics, etc.

2.6. SUMMARY

In the research areas, there were prominent scholars, the leaders of academic cartography in the second half of the 20th century. In almost all cases they created their schools of thought – theoretical concepts or paradigms at their universities, except Bertin, who was not related to any university. In Figure 14 these scholars and their research foci are grouped by countries on the mind-map. The mind map was made based on the bibliography of the previous sections in the chapter.

Not every scholar who is shown in Figure 14 represents a theoretical concept, because they were concentrated in the teaching and building schools of cartography, e. g. Sherman or Jenks. In Figure 15 there is the mind-map, which shows the major cartographic concepts in the research area with their founders and the connection between these concepts. Figure 16 shows the map of the main academic locations of the schools, where theoretical research and teaching were performed in the second half of the 20th century. The locations are based on the location of scholars that was mentioned in this Chapter and therefore in Figure 14.

From the review, some patterns could be observed, such as the centralization versus branched developments. In the former USSR, the cartographic school was formed by the prominent leader Salishchev and his followers, who did not contradict his theory, whereas in the USA there were several cartographic schools, differentiated by the research objectives, but all based on the paradigm of cartographic communication, except the Tobler's school of analytical cartography. In France, developments were also centralized. In the German-speaking area, the difference among schools of thought was caused for political reasons – the division of Germany in the Cold War influenced the Western countries and the Warsaw Pact countries. In terms of concepts, both American and German schools stemmed from Eckert's work, but the communicational paradigm flourished in the US, while in German-speaking areas there was booming research in thematic cartography.



Figure 14. Mind-map of Academic Cartography by Countries and Scholars

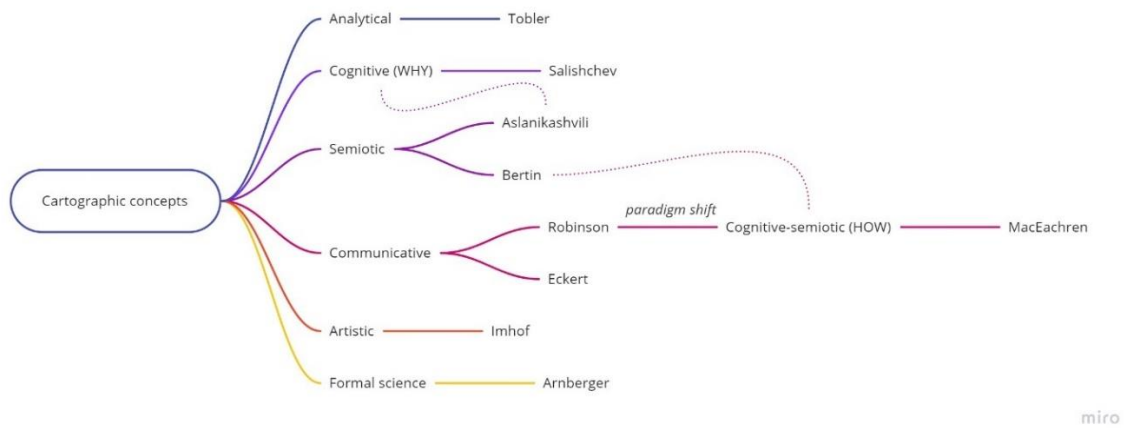


Figure 15. Mind-map of the Major Cartographic Concepts in the research area



Figure 16. Major Academic Cartography locations in the second half of the 20th century in the research area

Chapter 3 Survey

In Chapter 3 the survey approach is described. The survey aims to gather general information about different schools of thought and based on the results the notion of the school of cartographic thought is further formulated. The chapter's structure first describes its methodology; secondly, the execution, and thirdly, the results.

3.1. METHODOLOGY

To get an impression of how the notion of cartographic schools of thought is understood among scholars from different countries a short survey via email was executed. The survey serves as a starting point in formulating further interview questions. From the answers people are giving, it is possible to extract ideas that were not considered by the researcher before. The survey included four general questions.

1. What do you consider a school of cartographic thought, and what characterizes it?
2. Do you consider yourself a part of a cartographic school, and if yes, which school?
3. Is there a single cartographic school in your country or there are more, and if more can you describe them?
4. Do you witness a convergence of cartographic schools, and if so, what do you see as the main reason?

The first question aims to verify how the respondent understands the term school of cartographic thought. These definitions will help to formulate the general term and criteria, as was stated in the RQ1. The second question helps to gather insights about what school the respondents belong to, what people they are influenced by. The third question helps to understand if there are different schools within a single country, which will help to answer the RQ2. The fourth question is about the convergence of schools caused by the assumption that the globalization process might influence the schools, this will help to answer the RQ3. However, the word “globalization” was consciously skipped not to suggest the idea that globalization is a factor of convergence to the respondents and to allow them to propose their ideas.

After gathering questions, both quantitative and qualitative analyses of the answers were performed. The answers to the first question might formulate the definition of the term “school of cartographic thought”. Often, the word cloud diagram is used for the quantitative analysis of the text, to visualize the occurrence of each word, for example in the research of Kraak and Fabrikant (2017). To gather the insights and formulate the theory, based on the given answers, a detailed qualitative analysis was performed.

3.2. EXECUTION

The survey was sent to 58 prominent scholars by email. All doctors and professors of Cartography in the countries Russia, Georgia, Germany, Austria, Switzerland, UK, USA, France, the Netherlands. In Table 1 the numbers of people who received a survey and numbers of eligible answers to the survey according to each country are shown.

Table 1. Execution of the survey in numbers according to country of respondents

<i>Country</i>	Number of people who received a survey	Number of eligible answers to the survey
<i>Russia</i>	6	1
<i>Georgia</i>	1	1
<i>Germany</i>	10	5
<i>Austria</i>	2	1
<i>Switzerland</i>	6	0
<i>UK</i>	5	0
<i>USA</i>	13	4
<i>Australia</i>	1	0
<i>The Netherlands</i>	1	1
<i>France</i>	12	1
<i>Belgium</i>	1	0
<i>Sum</i>	57	14

An answer was considered eligible if the person was able to answer the questions without asking to provide any sources to read before answering the question, in other words, can answer from their experience. It is also was an issue once when a person formally answered the question, but with the confusion in their answers, so it was not possible to gather the information from them. Therefore, only two sets of answers were not eligible, which is not critical to the number of eligible answers (14). Thus, the response rate, which is a proportion of people who gave eligible answers to all surveyed people, is 24,6%. All eligible answers to the survey can be found in Appendix 1. All of the respondent names were replaced with pseudonyms for anonymization.

The quantitative analysis was performed using the word cloud diagram, which is showing the occurrence of the distinct words in the school of cartographic thought definitions given by respondents. Before generating the word cloud, the text was cleaned from the collocations “school(s) of thought”, “cartographic school(s) of thought” and other text not related to the definitions. Only the definitions given by participants were kept avoiding unnecessary words in the diagram. The word cloud was generated with [the JavaScript d3 tool](#), where the parameters are the number of words, which is 90, and the scale, which is natural, so the size of a single word is in direct proportion with its occurrence in the text.

However, as could be seen from the results described in Paragraph 3.3, the word cloud does not visualize the important details and does not give a deeper insight from answers. Therefore, a qualitative analysis of the answers to the entire set of questions was performed. For the first question, the citations and the keywords from the answers were taken to understand the common features, as well as differences. The second and third questions, mainly depending on the country which the person is from, while the fourth question depending on the person’s point of view.

3.3. RESULTS

From the answers, it is possible to distinguish three major perspectives that the respondent linked to the notion of a school of cartographic thought: theory, education, and people. The

There were definitions given from the perspective of the people's community, the examples below, the keywords are underlined.

"...scientific community, school and traditions". (Karl)

"...a group of cartographic scientists that agree about the nature and goals of cartography". (Eduard)

"This nucleus usually is being built by influential scholars (can be few) and/or institutions." (Leonard)

"...tends to be associated with particular key figures in a field." (Victor)

"...often is defined by some figurehead or position..." (Nickolas)

"...is the community of scholars and practitioners who pursue a specific set of academic questions about maps and mapping through a particular body of literature." (Thomas)

"...thought occurs in a relatively closed space where intensive brainstorming takes place among a small number of scholars." (Alice)

Some definition also has key words, related to the education (underlined).

"...cartographic training model..." (Karl)

"...it is related to the cartographic teaching approach and material used during training." (Pauline)

"...a scientific and educational direction, created thanks to the establishment of traditions in the process of research and while training highly qualified personnel". (Natalia)

"...a place where only cartography, in all shapes and practices, would be taught and learned and explored". (Angela)

"... proportions of teaching and research, structure, and pedagogy of teaching, national or international orientation of teaching and research (etc.)". (David)

In Figure 15, the underlined keywords were picked from the answers above and located inside three spaces of education, people, and theory. The spaces intersect each other and construct the definition of a school of cartographic thought.

The education space has the intersection with the people space – influential scholars and institutions, as they could have the educational functions. The space of people has an intersection with the theory space related to the questions the people ask about maps. Theoretical space intersects education in the unified scientific and educational direction. In the intersection of all three spaces traditions are placed, because they are made by people and could be educational and theoretical.

According to the answers to the first question of the survey, a school of cartographic thought is a group of scholars who share the same ideas about the core of cartographic knowledge, education, and practice. It can be distinguished from other schools by its views on cartography. Two of the respondents mention the term "paradigm", emphasizing that the term "school of thought" refers to the role of authorities, rather than theories. However, one

respondent prefers the term “school of thought” over the term “paradigm”, because he considers the different theories of cartography as parts of the general cartography paradigm. He mentions as an example some paradigms in other sciences, that consist of “multiple particular schools of thought”. Although there are controversies in the terminology, the respondents do not deny the existence of “cartographic schools of thought” at some time in history.

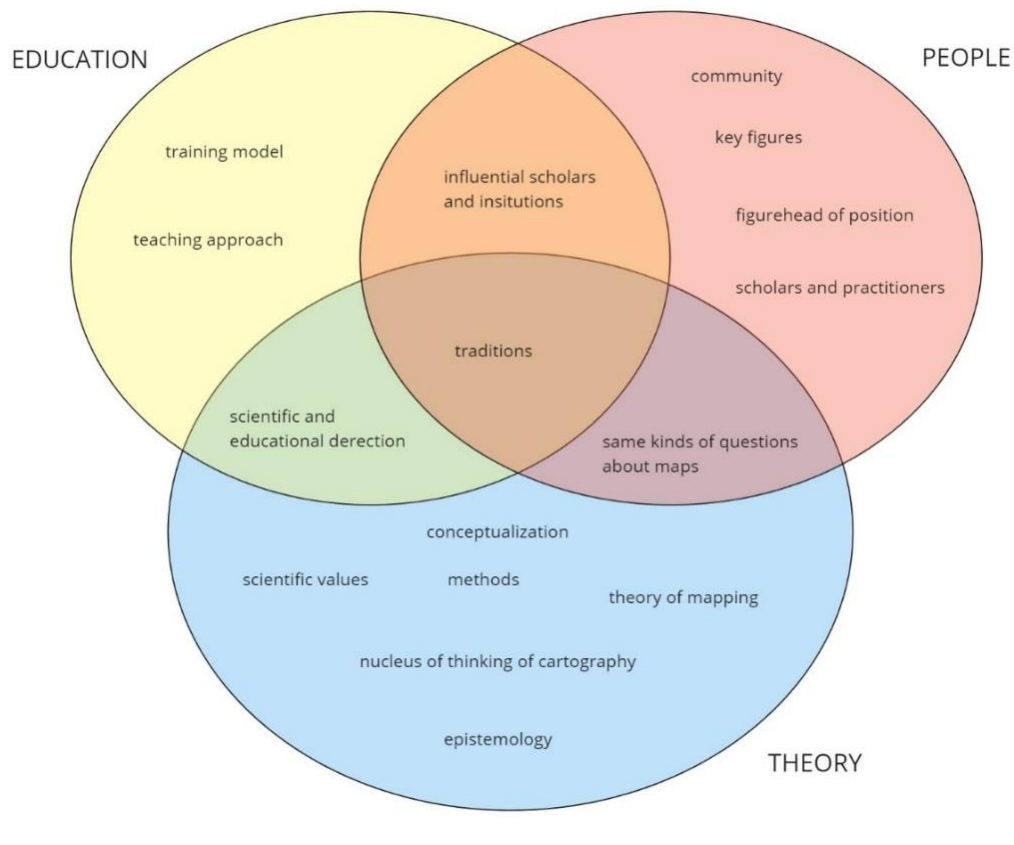


Figure 18. Three spaces of the cartographic school

Nevertheless, theory or a paradigm is a basis of a school, such as communication theory defined the school of cartographic design in the US and viewing the map as a model of reality defined the Russian school. Depending on the theoretical basis, a school of cartographic thought has a different position to the other disciplines – the place of cartography as a science or technology. It can be seen as a branch of geography, semiology, design, communication science, formal science such as mathematics, or an engineering field. Therefore, the different schools of thought can operate different methodologies to gather knowledge.

Answering the second question, people relate themselves to schools named by prominent scholars or geographic regions. There is a clear pattern that respondents from Germany and Austria mention the same scholars such as Imhof, Arnberger, Hake, and Witt (Paul, Pauline, Leonard). One respondent from Austria called this school “central European” (Leonard) and another respondent from Germany referred himself to the “European school” (Karl).

Three respondents from the US mention that they were influenced by the Robinson school (Victor, Nickolas, Fiona). Two of them mentioned the influence of the Jenks school (Victor, Fiona), one of them mentioned additionally the Tobler's school (Fiona). The fourth respondent from the US does not consider himself as a follower of any of the above-mentioned scholars and refers himself to Brian Harley's school of critical cartography (Thomas). The respondents from the other countries refer to the other schools and scholars such as a Georgian school (Sofia), a semiotic school (Karl, the Netherlands), an engineering school at ENSG (Angela, France), a Russian school of Salishchev (Natalia). Two persons were influenced by several schools – Russian, French, or German, and Anglo-Saxon (Eduard, Alice).

Respondents related themselves to the school, where they were studied or worked, therefore it can be concluded that the schools of thought exist within the educational institutions and are distinguished by prominent scholars. Moreover, there is a pattern that respondents mentioned the scholars from their own country or language area. Two respondents wrote about the influence of scholars from different language areas. One person does not consider himself as a part of any school but mentions two prominent scholars that were involved in his training and work.

Answering the third question, three of five respondents from Germany mentioned the academic locations in Berlin, Dresden, Hannover, Karlsruhe while answering the question (Paul, Pauline, David). The one (Pauline) wrote that there is “a sharp distinction between topographic and thematic cartography”. Another one (Alice) described the Chinese school instead of German, because she is originally from China, and according to her, the Chinese school was influenced by Russian and later American schools. The one from Austria wrote about two academic programs in his country, that are followed central European schools and a “kind of global school” (Leonard).

Respondents from the US had similarities in their answers, mentioning the school of cognitive cartography of Robinson, analytical cartography of Tobler, the school of Jenks, the map design school of the Penn-State university and the University of Wisconsin–Madison, geovisualization and geovisual analytics, but also scientific and critical approaches to cartography.

The respondent from Russia mentioned that there is an engineering and geographical school in her country. She calls the geographic school as “university and scientific” and name some universities which follow this school but has their features. There is a common pattern of Russian and German respondents to see cartography divided on the geographical or thematic and engineering or geodetic approach. In Georgia and the Netherlands, there are single cartographic schools. The respondent from France argued that there is no school in France because it is not considered an independent discipline but included geography.

In the answers to question number four, five respondents agreed that convergence of schools is taking place, on a world scale – all of them from the German-speaking countries (Paul, Pauline, Leonard, Alice, David). One respondent suggested that geographic and engineering schools in Russia are converging, because of the common scope of problems to solve (Natalia). The rest of the respondents do not agree about the convergences of schools. Three of them consider merging cartography with geoinformation science (Karl, Fiona, Eduard). Another three respondents suggested that there are intersections of schools or their cooperation (Sofia, Victor, Nickolas). One person from the USA assumed that the reasons

for differences are “the nature of academia” and that cartography is associated with various domains, not related to each other (Thomas).

Five respondents from the German-speaking countries and the Netherlands mentioned the different sides of the globalization impact such as general digital globalization (Paul), teaching materials based on scientific papers, international exchange (Pauline), easy access to the publications and programs (Leonard), and the global trend of “onset of GIS” (Eduard), global mobility and the internet networking (Alice).

As could be identified from the answers, the cartographic school has the criteria:

- theory, the view on cartography, the methodology,
- a leader, prominent scholars,
- own way of education and research,
- language or country.

Respondents often mentioned some prominent persons who influence their education as a cartographer. Some of them suggested that a school of thought is guided by authority, and that could identify a single school. There was always a person behind, who founded the school, bring new ideas in cartographic theory, and led the education.

Together with the names, respondents often mentioned the universities, where the scholars built their schools and raised the successors. The university is home to a school of thought, and this might reflect in the educational programs and research, e. g. when the teaching staff is designing curricula. Another feature is belonging to a language area or a country. Respondents focus on their own experience, which is defined by some external reasons. This reason could be language, because respondents from Germany, the USA, and Russia recognize themselves as a part of a school in their country or as being influenced by the prominent scholars in their country or the language area.

However, in a single country such as the US, the different views on cartography could coexist. It is impossible to join them based on common territory or language because they are different in their core. Consequently, language can only be an additional feature while defining a school. From the variety of answers, the different processes, influencing cartographic schools can be distinguished:

- globalization impact (internet, international exchange, global trends),
- cooperation of different schools,
- integration with GI Science,
- influence of other domains.

3.4. SUMMARY

Based on the survey, the notion of a school of thought notion studied – the majority of respondents acknowledge its existence now or at some period in history. The term “school of cartographic thought” is formulated, and the three components – theory, people, and education are distinguished. Criteria of the school of cartographic thought include these components as well as a language or the country. The processes, which influence a cartographic school are described. The survey confirms the information about the different

schools gathered from the literature. Table 2 is showing the overview of the schools by the criteria distinguished in Chapter 3.

Table 2. Schools of cartographic thought

<i>School</i>	Russian (former Soviet)	German	French	American
<i>Theory</i>	Cognitive concept, semiotic concept	Cartography as an applied discipline, thematic map design framework	Semiotic concept	Communication and representational concepts, cognitive map design research
<i>Key people</i>	Salishchev, Zarutskaya, Aslanikashvili, Berlyant	Eckert, Imhof, Arnberger, Witt, Hake, Freitag	Bertin, Brunet	Robinson, MacEachren, Jenks, Sherman, Tobler
<i>Education</i>	Geographical department at MSU and other universities of the former Soviet Union, TU Dresden before 1990	ETH Zürich, HS Hannover, Free University of Berlin, University of Vienna, TU Dresden after 1990	Paris Sorbonne 1, University of Paris, ENSG, geographic departments of universities	University of Wisconsin–Madison, Penn State University, University of Minnesota, University of Kansas, University of Washington
<i>Language</i>	Russian, languages of the other republics in the USSR, and the Warsaw bloc	German	French	English

Chapter 4 In-depth interviews

In this Chapter, the in-depth interview will be discussed. The philosophy of responsive interview is used to answer the research questions on what typifies schools and how schools interact. In the results section, there is an analysis of the interviews for each research question in sub-paragraphs.

4.1. METHODOLOGY

RQ2.1-4 is aiming to gather deeper information on each school than was provided in Chapter 1, while RQ3.2 aiming to understand the interactions between schools. They require the qualitative methods of research since the answers should contain the reasoning why the schools of thought are what they are and understanding what kind of interaction happens with them.

Among these methods, there are surveys and interviews. The interviews can be conversations, unstructured, semi-structured, and structured depending on the amount of control. In the structured interview, all questions are predefined, and this kind of interview follows the positivist approach, where the knowledge is objective and neutral, and the social rules are discovered. However, it is not a suitable approach for the above research questions, aiming to understand the school of cartographic thought with its social component and subjective opinions of the people involved. Therefore, for research purposes, the semi-structured or conversation types could be useful.

Rubin and Rubin (2005) suggested the methodology of responsive interviewing, which corresponds to the naturalist philosophy of research. The difference between the naturalist approach and the traditional positivist approach is shown in Table 3.

The responsive interview has several principles. Rubin and Rubin (2005) emphasize that both conversational partners are subjective, and the interviewer should be self-aware about his or her biases, the interview style should suit the personalities of conversational partners and the design of the interview should be flexible. The depth of the interview is achievable by making the pauses and analyzing the interview:

“Pauses for reflection are built into the design, and during such pauses researchers compare what they asked with what they should have asked and what requires more depth, and alter questions accordingly. In the responsive interviewing model, analysis is an ongoing part of the research process, not just something that happens at the end.” (Rubin & Rubin, 2005, p. 37).

Therefore, to understand a complex situation around the cartographic schools of thought in different countries, it is reasonable to use all advantages of responsive interviewing. In terms of the amount of control, the interview will be semi-structured, with a predefined scope of themes, but not necessarily the same questions for each interviewee. The questions depend on the personality of a conversational partner, therefore the set of questions for each person is unique, but in the frames of the research topic. This defines the in-depth interview style as semi-structured and responsive at the same time.

Table 3. Positivist vs Naturalist philosophy of research (Rubin & Rubin, 2012)

	Positivist Theory	Naturalist Theory
Measuring reality	Possible with instruments	Cannot be measured directly because it does not exist outside a perceiver
Goal	The universal truth – a rule or explanation that is correct under specific conditions	Understanding what has happened in a specific circumstance
Researcher	Neutral recorder, measures in a replicable way	People make interpretations and that it is neither possible nor desirable for the researcher to eliminate all biases or expectations
Truth	There is only one truth	There are different standpoints
Research design	Test hypothesis	Describe a complex situation without simplifying it
Result	Seek for theories that apply to the society broadly	Seek for themes

Following the interview, audio was transcribed into text and the text was edited. When all transcripts are ready, for analysis Rubin and Rubin (2005) suggest distinguishing concepts, themes, and events in the interviews and compare them to elaborating them into theory. The final stage is showing the results in the written narrative.

4.2. EXECUTION

The survey respondents were invited to the interview in the same e-mail they received for the survey. Some needed extra nudging to participate and others did not respond. There was a reversed situation when a person did not answer the survey but participated in the interview. If there was a lack of representatives, the people, who did not participate in the survey were asked for the interview and who were advised by their colleagues and were representative. Table 4 shows the distribution of conversational partners by country.

As can be seen from Table 4, the distribution by country is not equal. That is unintentional, as it could not be anticipated how many conversational partners agreed to the interview. The main constraint will be to keep a minimal number of 2 for each of the four studied schools, since a single conversational partner is not representative, and would miss alternative points of view, which is important for the interview.

Before the interview, the conversational partners got a reminder with the invitation to the video call and the interview outline. The interview outline contains sample topics of the interview and it has a purpose to make a conversational partner familiar with the topics to be discussed. However, it does not mean that the interview follows the outline strictly, it aims to help the partner to be ready for the interview. The sample of the outline can be found at the end of the thesis in Appendix 2.

Table 4. Number of conversational partners by country

<i>Country</i>	Number of conversational partners	Number of people who were invited to the interview
<i>Russia</i>	2	7
<i>Georgia</i>	1	1
<i>Germany</i>	3	10
<i>Austria</i>	1	2
<i>USA</i>	6	13
<i>The Netherlands</i>	1	1
<i>France</i>	2	14
<i>Other countries</i>	0	11
<i>Sum</i>	16	59

The interview was in a format of a video call and it was recorded every time. The duration of the interview ranged from 30 minutes to 60 minutes, meaning there was no strict time limit. It depended on the interviewer's feeling on how well the intended questions and topics are covered and if the conversational partner was allowed to ask more questions and spend more time on the interview.

After the recording, all interviews in English were processed in the transcribing software automatically, with further manual editing. The interviews in Russian were transcribed manually. The interviews were anonymized – the names of conversational partners were replaced by pseudonyms, and when it was needed, other names of people or things were anonymized to, e. g. in square brackets. The same pseudonyms for the persons who participated both in the survey and the interview were used. Some pieces of text were deleted, for anonymization. Sometimes the words from the recordings were difficult to distinguish and therefore it marked with <...> signs. The transcripts can be found in Appendix 3.

The analysis was performed manually by reading through the interviews and highlighting the main concepts, themes, and events. Among the concept, a school of thought, a paradigm, and a paradigm shift were distinguished. The themes are Russian, American, German, and French schools, a language barrier, finances, international cooperation, scientific gap, global trends, etc. The events are the Cold War, the advent of GIS and the internet, and conferences. The citations with the highlighted concept, theme, or event were grouped into a separate text file. This material was used to write the Results section.

4.3. RESULTS

4.3.1. The Russian school of cartographic thought today

Maria, the Doctor of Science from the MSU declared that the Russian school of cartography is generally referred to as the university school of geographic cartography – the school, which was founded by Salishchev at MSU, Geography Department. She distinguishes the school from the engineering school of cartography which is located in MIIGAiK. The difference between those schools in the research aims – in the university school it is “the solution of some scientific problem, the answer to some question that reality offers us”, while the

engineering school's objective is to create maps. However, she notes that in both schools "set of disciplines is the same", but the difference is on the number of hours spent on disciplines, the university school has more hours of geographic disciplines, while the engineering has more hours of technical disciplines.

Maria highlights that "Moscow University is leading the educational trajectory in our country" and that Salishchev's students were teaching in the different universities all over the Soviet Union. This proves that the Russian cartographic school is homogeneous and defined by the MSU, although some regional differences exist, such as the Irkutsk school and the Novosibirsk branch of the Russian Academy of Science.

In the university school the disciplines of cartography, geoinformation, and remote sensing became the integrated whole:

"In the 90s, all this strictly existed according to the canon separately, and then there were people who used GIS, and those who made maps, and those who used images. And now the distinction between them has disappeared, there is such a mixing" (Maria);

"Cartography and geoinformatics are domains with blurred boundaries, and it is difficult not only for me to determine where one begins and the other ends" (Ivan).

Ivan, the Candidate of Science⁵ from the MSU, distinguishes several periods in the history of the Chair of Cartography in the MSU. Before the 1980-s – the old Soviet school with classic academic professors "the analog age of hand-drawn cartography". Then, after the 1980-s the period of "automatization". Ivan described the next period, which has begun from 1990 when Berlyant became the head of the Chair:

"Those were the years when it was necessary to actively rely on high technologies, rather than it was done. Of course, we tried to introduce technologies, for example, web atlases, automated interpretation [of the image], but all this was perceived as something secondary and auxiliary, which complemented the technologies and methods of the classical university cartographic school. And in fact, it is not something that would have outlived itself, but it exhausted its resource back in the 1980-s when it was necessary to get on a new track".

From the words of Ivan, it could be concluded, that the modernization of the school was not successful. However, he makes efforts to create a new school of cartography with the help of other young colleagues of him:

"Now we have, in the last 5 years, young staff and employees of my age who are interested in automation... <...> I think that within 5-10 years we will be on a new track, at least there is such a trend, and the change in the structure of the educational discipline reflects this".

Ivan told about the drawbacks of cartographic education in his school – the lack of technological and artistic proficiency of educators. He mentioned that the design course is the weakest in the educational program as well as the course about geospatial databases. However, he sees the advantages of the school in classical education of the thematic mapping of different geographic phenomena and considers that it is necessary to have a geographic part in education, but less than it is taught now.

⁵ Russian equivalent of Ph.D.

Eduard, who was familiar with Salishchev, remembered that the mapmaking in Russia was defined by the standards and it was unacceptable by Moscow school to do something individual:

“If you look at atlas production, there was the Moscow school and there was the Leningrad school and when they produced atlases in Leningrad, then Salishchev was fulminating ‘Oh, they are not doing as they should do’ and this was a bit detrimental, really to the development of cartography, you need to have different views that it should blossom so that they can implement each other than should not be dictated, well, it should only be like this and that, that has been a negative influence, I think on Russian cartography”.

This story highlights that the strict rules were used in Russia in atlas production, the rules which have not allowed cartographers to be creative. Regarding the artistic part of cartography, the conversational partners have different opinions. Maria considers that the artistic aspect is redundant to cartographers: “...art takes 10% and science takes 90% [of cartography]” but agrees that cartographers should be familiar with the design aspect. Ivan agrees that the artistic part is as important as scientific and technological: “You can make a high-tech cartographic product that will be an artwork”.

Maria agreed that they preserve the traditions, built by Salishchev, but understand the importance of the new technologies as well:

“...all these technologies do not prevent us from preserving our traditions; on the contrary, they pose new challenges to us, demand new methods from us”; “...if we want to get some kind of result, then all the technologies that we may need for this are included in our domain”.

Maria and Ivan named the global trends in cartography: the open code software and the demand for programming from students and scientists. They also noted the hyperspectral images in remote sensing and presenting the maps on the web or mobile platforms. Maria’s research interests lie in “the boundaries problem”, on how to draw boundaries for different phenomena, which is the case of generalization. Ivan is interested in programming and reads the lecture for Geography faculty students about programming at MSU.

Therefore, the Russian cartographic school, in particular, its geographic branch that still exists and developing towards the new technologies. The school’s objective remains unchanged, as it is still related to understanding geographic phenomena. Cartography is seen under the umbrella of geographic sciences and as a whole together with geoinformation and remote sensing. The school is highly centralized at MSU, where the educational standards are been establishing, but still has local “dialects”. Although there is also the engineering school of cartography, the body of knowledge remains the same as at MSU. The school is conservative in its objectives, but at the same time allows the new technologies to be adopted to serve these objectives.

4.3.2. The German school of cartographic thought today

In German-speaking countries, cartography was under the umbrella of geography or geodesy and was not an independent domain. Theodor, the retired professor of cartography from Germany said:

“...in most cases, cartography was specialized or interested in technical problems. We didn't have a special type of school. Maybe we should distinguish between chairs or cartography departments of geography and departments of geodesy at technical universities. At technical

universities, they concentrated on technical aspects of improving the quality of map production, map generation <...>. At geographical departments, however, the interest was here on the aspects of map content”.

The same notes Pauline, the professor of Cartography from the university of applied science:

“At least in Germany, [cartography] been treated as part of either geodesy in the field of topographic mapping, or as part of geography in the other field of thematic mapping. Of course, cartographers never like that. They want to be independent and yeah, the same rights”.

A theoretical concept or a paradigm, which is essential for any school of thought – was not distinguished in the cartography of German-speaking countries. This confirms the comments from the professors outside the German language area. The American professor Harry, who was teaching cartography in German-speaking at some period, in the interview described his experience and thoughts about the scientific character of the German school: “...while the German-speaking school produced very wonderful maps and nice-looking maps, there was nothing there that could help us to better understand or to understand scientifically, in a way, how to make maps better...”; “...I would say that German school represented a paradigm, but it was not a paradigm that could be furthered by any kind of research...”. He presented in the lecture of the Swiss professor, and he described his impression about it: “...I think even he realized that there was nothing particularly scientific about what he was teaching as he was just teaching best practices, what he thought of as best practices...”.

However, when I asked to comment the Austrian professor Leonard about that issue, he disagreed with the thoughts of the American colleague:

“People like Edward Imhof or Eric Arnberger or Werner Witt or Günter Hake, they understood that the term user-centered which we use now, they understood that term at that time already, I think. And it was only after that period, where technology takes over, so to say where it was very much technology-oriented, but before digitalization, there was a lot of theory and methodology-based research ongoing in the German-speaking countries, I think. And we do have a lot of publications from that area as well. So, I would disagree”.

In contrast, concerning the theoretical work of Arnberger and Witt, the professor from the Netherlands noted:

“The ideas of German cartographers. It's difficult to... establish what these ideas were, it was the books by Arnberger or Witt on thematic cartography, they just showed you have to do it like this, there were not much of general ideas that were behind them, it was like prescriptions only, or descriptions of what was the actual practice”.

Therefore, there are different thoughts, and this opens the discussion on how people from different countries understand cartography as a science. Cartographic theory in Germany had the applied character and that is not considered to be scientific by American scholars. However, this was the issue for the 20th century, while the German school of cartography has changed in the 21st century. The professor from German technical university Alice consider that theoretical part of cartography related to spatial cognition: “...we are going to set more emphasis on spatial cognition. That's why we had to introduce the eye-tracking lab and so on because we want to make a substantial contribution to artificial intelligence”.

I asked several scholars about the Cartography MSc program, which includes partners in Germany, Austria, and to a less extent⁶ the Netherlands, therefore, the Cartography MSc represents the German school. “I think the MSc cartography program in a lot was bringing a scientific perspective to Western and Central Europe for the first time. I think it was probably piecemeal, and that program is trying to tighten a lot of the methodological gaps in European cartographic education,” – said Nickolas, the Ph.D. from the USA, who is supporting the Cartography MSc program. Leonard, as a professor of the Cartography MSc program, emphasized the need to include the cognitive cartography paradigm in the program’s curriculum: “...I think we need to include, especially the paradigm of cognitive cartography better in the curriculum, that's my aim...”.

Besides the Cartography MSc, there are several higher education programs in Cartography, e. g. in the Universities of Applied science. I interviewed a professor from such a university in Germany – Pauline, to understand this form of cartographic education. She said that they focus on automated and thematic cartography, GIS, and remote sensing at her university. She is convinced that it is important to reveal the patterns through visual variables. Among the problems in cartographic education, she sees the lack of the students and the difficulties with involving students in the scientific discussion:

“...what is missing to my understanding is that they look into books or other atlases, and first, learn what they could do, instead of right away, they just do something. I believe they need to be a mix of both. So, I try always to first give them a scientific question to answer”.

Among the global trends in cartographic education and research professors from German-speaking countries see interdisciplinarity, collaboration with data scientists, orientation to visual analytics, the influence of global corporations (ESRI, Google), open data, mixed reality, spatial data infrastructures, semantic web, LBS, and the cognitive revolution. Leonard sees cartography’s future in human science: “I think we will end up in a cognitive discipline in a human-oriented discipline”.

German-speaking countries have a common background in cartography, and it is difficult to distinguish a solid school of cartographic thought in this area. In the 20th century, cartography was not an independent scientific field there and it served the needs of geodesy and geography. German cartographic school was developing in the different centers and the knowledge was dispersed among the universities of the German-speaking area. There was no such university as the MSU in Russia that defined the educational standards and dominated in a scientific sphere, meaning that the German school is not centralized. Even the Cartography master program is shared between three German universities.

However, from the interview, the growing interest in the cognitive cartography paradigm from professors was distinguished. That represents that the German school of cartographic thought has undergone a paradigm change or was influenced by the scientific development of the other school of thought. The last assumption will be discussed later in Paragraph 4.4.5.

⁶ The ITC as a partner university participate in the study process in a limited way: there are two online courses and as well as other partner universities it could be chosen by students to write a master thesis

4.3.3. The French school of cartographic thought today

In France, there are two major streams in cartography – thematic cartography, led by universities' geographers, and engineering cartography, led by IGN. Helene, the doctor of cartography from IGN said: "I would say the French cartography is it's certainly a good mixture between topographic and thematic".

Cartography as a domain is a part of geography; to be a cartographer in France, a person needs first to receive geographic education: "the first geography and cartography is a specialty" – noticed Julie, the doctor of cartography from the University of Paris. She claimed that at universities the number of cartographers is very small, while in the IGN the group of cartographers is bigger.

However, cartography, GIS, and remote sensing in France are seen as separated fields, and that was stressed by Julie:

"...you need cartography to do GIS, <...> but the purpose of the GIS is not to do a map, the purpose of a GIS is to understand what's going on. And so, in France, these two fields are completely separated. <...> And there is also a difference between [them and remote sensing]".

That shows these domains have different objectives and the boundaries between them are distinguishable by French cartographers.

The heritage of the French cartographic school is not limited to Bertin or Brunet like it was observed earlier in Charter 2. There are a lot of researchers and educators beside them, who are not widely known internationally. Helene named the people, who influenced her as a cartographer from the French school: Michel Morel – prominent cartographer, who was a professor at IGN, Michele Beguin – academic cartographer, who was teaching thematic cartography at the University of Paris 1 and the ENSG, Denise Pumain – a geographer, but "specialized on the data analysis and mapping", Colette Cauvin – a professor that shaped the school of thematic cartography at Strasbourg University.

When I asked Helene, who would be in the same row with the famous scholars like Imhof or Robinson, she said that depending on the question, it could be Bertin or Cuenin: "...Bertin would be the one, the most well-known person internationally, of course. But if you say as a builder of mapping, it will certainly be this person <...> Cuenin is very classical. <...> Cuenin is a small Imhof". She emphasized especially the share of Cuenin to the French cartography, comparing him to Imhof – he wrote a book on topographic cartography and his follower Weger.

Bertin's theoretical concept of cartography is still dominating in French cartography. Both Helene and Julie mentioned that cartographers in France follow the principles proposed by Bertin or Cuenin. Helene noticed that in the research division COGIT at IGN the research is about automation of these principles or extend them: "...from Bertin we have this principle and even in Cuenin, you will find principles of organization of information. I think it's included in our training. And it explains certainly a large part COGIT research also". She emphasized that in COGIT the research on color is developed very well, different aspects of color were studied by her doctorate and master students. She sees the research on color as an extension to Bertin: "Bertin was very black and white, what he proposed was definitely for black and white, and for colors, he didn't push so much".

Julie mentioned the strict rules, which are taught during the cartographic training in France: "...explaining how to represent data, like Bertin, in France is very conventional, and we have very strict rules". She explains that Bertin's principles are still relevant because they are related to the physiological character of perceiving information: "And the Bertin it's still going on <...> Because his theory is based on the physical procedure of the eye, physiological elements of everyone, of human people".

However, the cognitive research is going to the US as well, but the methodology used by French researchers is different. In general, they do not use eye-tracking measuring of stimuli, but measuring the time needed to understand the map content. Julie said: "...to be understandable, and to be right away understandable, less to understand, the better is the map. And that is the purpose of the cartography".

That links to the aspect of generalization, which is important for French cartographers. When I asked Julie her opinion about Russian cartography, she said that the maps she has seen are not enough generalized. Eduard, a professor from the Netherlands, stressed that generalization typifies the French cartography: "So, you have to reduce as much as possible, and keep the essential aspects. And that's important in communicating spatial information. And that aspect was also stressed by Bertin and it's still survived in French cartography nowadays". Along with Bertin, he was mentioning the RECLUS group as what came after and Helene agreed that the RECLUS is "a heritage of Bertin". In particular, the work of Brunet, the dynamic choremes as a way of how to generalize the processes. Another thing that distinguishes French cartography is the relation to art. Julie mentioned: "In French [school], we always put an aesthetical and artistic thing in our maps". Helene said that besides semiology, the painting influenced French cartography.

The same as scholars from other countries, I asked French representatives about the global trends in cartography. Helene, as a researcher from IGN, answered that it is machine learning, artificial intelligence, and color theory. Christine included GIS, open data and software, and the big data to the trends.

The researchers from IGN and universities follow the same principles and the main objective is the same, but the meanings on how they facilitate cartography are different. For IGN it is automation, the engineering approach, while for universities departments – defining the rules of data representation. In that sense, the French school of cartography is homogeneous, preserves, and modernizes the principles of Bertin, Cuenin, and their followers. The main research is going at IGN, while the training on thematic cartography is (or was) going at the geographic department of universities – in Paris, Strasbourg, Orléans, etc.

4.4.4. The American school of cartographic thought today

In the survey, some respondents from the USA used the term of paradigm actively, making a difference between it and school of thought, which is related to a particular person. In the previous century, the schools were concentrated around the professors and their departments. Nowadays there are more key figures in the field, but there is no scholar equivalent to Robinson as said Victor, an American professor:

"...my impression of schools of thought are of sort of bigger units, where there are quite a lot more people who study with a few key individuals. Cartography is just kind of small. <...> probably Arthur Robinson had the most Ph.D. students, but I don't remember how many he

had, either. So, I don't know that any of these things are big enough to be called a school for one thing”.

Nickolas, a cartography doctor from the USA described three paradigms of American cartography: communicational or functional paradigm led by Robinson, the representational paradigm of MacEachren, and the post-representational or processional paradigm. He noticed that the communicational paradigm is not experienced in the US anymore and the representational paradigm together with critical is represented in cartographic education. Unlike Nickolas, Harry considers the representational paradigm as a school of MacEachren.

In the US cartography was a part of geography, and this was confirmed by conversational partners: “In America, most cartography is in geography” (Nikolas); “...most cartographers in the United States in geography department” (Andrew). However, psychology and cognition studies influenced the geographic domain, and interdisciplinarity emerged in the fields of cognitive geography, spatial cognition, cartographic communication, and later the representational paradigm in cartography. As it was earlier discussed in Charter 2, the cognitive research on the map design was a common thing, because cartographers used the methods from psychophysiology to measure the map symbols:

“Arthur Robinson in the US, who started with his dissertation and carried on throughout his career focusing on using empirical evidence about how people see and think about maps, to make decisions about how to design maps more effectively” (Victor).

In the 1990-s, the paradigm shift from cartographic communication to geographic visualization repeated the paradigm shift psychology:

“...a paradigm shift would normally be in psychology; you go from behaviorism to cognition. In cartography was a similar paradigm shift, where research went from behaviorist type research to cognitive type of research <...> I think what happened was the cartographic communication paradigm became sidetracked by computers in the 1980s. And then by the 1990s, it was total there was a paradigm shift towards visualization”

– commented Harry, a professor from the US, who has experienced the communicational paradigm. He emphasized the role of computers in that process; therefore, the paradigm shift was caused by the revolution in technology.

Eduard, a professor from the Netherlands criticized the psychophysical approach that was used in the US because it was not resulting in a good map design: “they had all these perceptions, psychological tests in the United States, but it didn't produce much useful information if you look at it, so it looks very scientific, but the results were minimal”. I asked Victor to comment about this issue, and he agreed that testing is not necessarily lead to good map design:

“Most of the psychology-based testing is very theory-driven. And it's focused on incremental advances in theory about how people see and think about maps, that doesn't necessarily very quickly translate into better maps <...> So, I would agree there, there are a lot of people that produce the graphically nicest maps probably never test anything”.

The development of cartography in the USA reflects not only the paradigm change but also a change from positivist to critical approach in cartographic science. I interviewed the prominent professor Thomas who follows the critical approach in cartography. He noted that the critical approach in cartography is criticized by positivists because it does not offer solutions for better map design. Thomas argued that the critical approach helps to make a

map “better in terms of morality, in terms of social equity” and declared the idea that “mapping is an open practice”, which is available nowadays to everyone and that helps cartography to be more inclusive. The critical approach is not related exclusively to the USA, and as Thomas mentioned that it is “Anglo-American with a heavy French contingent”.

However, in academia, the critical paradigm is represented in the USA. Nickolas shared his experience about the hybrid approach of critical and representational in cartographic education:

“...I would say, it's probably 50/50, a design or representational perspective and a critical. And so, there's a lot of cartography courses where you wouldn't ever learn about normalization, or classification, or different thematic map types would be more of kind of like a history of cartography. You learn about maps and segregation, and you learn about maps and colonialization. So, it's much more of a critical take versus a technical one”.

In the USA, there is a decline in cartographic education and research, while the GIS is booming. All of the conversational partners from the USA agreed that there is a decline, and the reasoning was the attractiveness of GIS for students and researchers, and therefore geography departments supported GIS courses better. The following comments confirm this.

“I find fewer and fewer students who want to come to graduate school to study mapmaking”. (Fiona)

“GIS as a paradigm sort of, almost killed American cartography, in the 1990s”. (Nickolas)

“In the United States, it's [cartography] been challenged by GIS, it's been challenged by visualization, I suppose. I think the geography programs have less interest in supporting cartography as an area of study. <...> if you look, now you would not find a position available at a university that uses the word cartography...”. (Harry)

“GIS has become popular. And as a result of the need to teach GIS in geography departments. Departments have tended to move away from cartography”. (Andrew)

“...it might be just because cartography has shrunk a bit since then, because a lot of a lot of cartographers switch to other parts of geographic information science and teach GIS classes instead of cartography classes now, <...> the younger people that came intended to get heavily involved in the technology and kind of gravitated toward GIS...”. (Victor)

Fiona, who has experienced analytical cartography, explained that cartographers have taken only the visualization aspect and stopped to do analytical research and therefore allowed GIS to take its place:

“And I think some cartographers, this is in the past, probably 15-20 years ago, just said: ‘We don't need to do that, visualization is everything’. And they kind of backed themselves into a corner not moving forward with managing data and working with statistics and working with programming and open-source coding and so forth”.

The paradigm of analytical cartography emerged in the GIS domain. Generally, cartography became the visualization component to the GIS in the US: “...cartography is kind of a small subset of GIS because that web-based tools have caused cartography to reach <...> a much wider audience” (Victor).

Computer science is another discipline that influenced cartography in the US: “Certainly, we talk about interactive cartography, and the web and all that, and certainly, computer science

plays a huge role...” – Andrew said. Victor noticed that cartography nowadays does not consist of geographers only, but also of the people from computer science: “And there are a lot of people in information visualization and computer science, they're doing a lot of cartography now, and there are more of them than there are of us [geographers]”. Among the trends that influenced cartography nowadays, conversational partners from the US distinguished: open-source platforms, big data, research reproducibility platforms, tools to study temporal patterns, machine learning, world wide web, GIS software that allows more people to learn cartography, and critical theory.

Therefore, the things that typify the contemporary American cartographic school are cognitive studies and representational paradigm, integration with GIS, and critical theory. American school of cartographic thought shows interdisciplinarity with the fields of psychology and computer science. Cartography is not seen outside geography or GIS in educational programs and the reason for that is researchers' orientation to the domains of geovisualization and GIS which are driven by computer science.

Nowadays the center of cartographic education is at Wisconsin–Madison, because of the legacy of Robinson:

“The cartography is taught often in a GIS degree or a spatial data, degree, or job. <...> I think that we have four courses in cartography and have a cart lab and a lot of infrastructures, but those are I think, legacies of Arthur Robinson” (Nickolas).

However, cartography is done by different researchers in the country, and therefore it is rather dispersed than centralized.

The schools of thought in the US that existed in the past have evolved: the analytical school into GI Science, cartographic communication school into geovisualization. The new schools of geovisualization or critical cartography represent paradigms that exist internationally. However, this issue will be discussed in the next paragraph.

4.4.5. Interactions between schools of thought

As it was discussed in Chapter 1, cartographic schools of thought were well distinguishable in the second half of the 20th century, they had their leaders and the language area bounded them. However, the globalization trend including the internet as a better means of communication, and some political events that promoted global integration, such as the end of the Cold War in the 1990-s, have changed the way of how cartographic schools interact. In this paragraph, those two assumptions of a) cartographic schools were stronger before globalization and b) cartographic schools are better integrated nowadays, will be developed.

In the past, the language barrier prevented schools from interacting. It is widely known that the book of Bertin *Semiologie Graphique* was translated to English from French 16 years later than the original was published: “For instance, the ideas of Bertin only were made available to Americans after 20 years, it was only after 20 years that it was translated. So, there was, there was a language barrier there” (Eduard).

However, some scholars could read the original text or translate it by themselves. Sofia, a professor from Georgia said: “Firstly, we had this book by Bertin in French at the Institute of Geography, and one of our employees, who speaks French, made a translation for Aslanikashvili, in particular, he used his ideas”.

Aslanikashvili was familiar with the semiotic concept at that time and published his book based on this concept firstly in Georgian and a few years later in Russian. Salishchev accepted the theory of Aslanikashvili:

“So, from the very beginning, Konstantin Alexeevich was familiar with what Aslanikashvili was working on. And then, when the work was completed, Aslanikashvili asked Salishchev to be an official opponent, in the sense that “you know this work better than anyone else, and you will be able to evaluate better”. And Salishchev agreed. The defense was held at the Tbilisi State University, and Salishchev came to it and he said: “This is a new word in cartography”,”

– remembered Sofia. That is how the semiotic concept was adopted in the USSR, where the cognitive concept of Salishchev was dominating. The ideas of Bertin inspired Aslanikashvili and indirectly influenced Soviet cartography and made it more diverse.

In the US some scholars read Bertin in original and shared his ideas with students, but the research in cartography might go a different way if the translation appeared earlier:

“I think a lot of people in the US in cartography would have done things differently if Bertin's work was available to done sooner. I was familiar with some of it when I was doing my Ph.D., even though it hadn't been translated because my advisor could read French. So, I could barely read French, <...> but because my advisor read Bertin, he communicated quite a few of the ideas to the rest of us” (Victor).

Besides the concept of Bertin, the earlier example of school interaction would be the work of Eckert, a German scholar, who influenced the American school because of Arthur Robinson, who further developed Eckert's ideas in his communication concept. However, these two cartographic schools – American and German were developing independently, but both understood cartography through the concept of communication:

“...to understand cartography as an interface, or as a communication part, Robinson wrote something in his book, which was very, very clear in 1913 in Germany already. So, we always argued in the German-speaking countries that the Americans are way behind. <...> There's nothing new that comes across from the ocean” (Leonard).

The difference between those schools was that American school was more influenced by psychology and done empirical tests with maps, whereas German school had an applied character. This shows that there was no significant exchange between German and American schools after Eckert, perhaps because of the language. Leonard from Austria agreed that the language barrier prevented cartographers from acquiring the knowledge of their foreign colleagues, he felt that it was more difficult than now, with the aid of machine translation services:

“Language played a role for sure at that time. I remember that in the 70s, there was a multilingual dictionary, where the key terms have been translated from French to Russian, to English, to German, <...> but at the time, we don't have any Google Translator or whatever. Because it was so hard to get into it, to find out what has been done in other areas. <...> As I said, I think we didn't know a lot about the Russian cartography, we saw the products, the big Atlas project, for instance, the has been fantastic. We didn't know about the French much, and also, about the Americans. And I think the other way around as well”.

Eduard mentioned that he uses machine translation services nowadays to overcome the language barriers as well:

“So, yes, language barriers are there, which, fortunately, this Google Translate and Bing translate, actually solve this problem if you take the time <...>. As I said, I'm translating for myself this book on the regional atlases by Salishchev and Zarutskaya. And it is very rewarding to do so and to be able to do that”.

However, in some cases, machine translation does not solve all the issues related to the language barrier. If a scholar wants to be heard in the international community, he or she has to have a particular level of fluency in English or French, the official ICA languages, and therefore the English-speakers have the privilege, argues Nickolas:

“You can be a brilliant scholar, but until you have a particular level of fluency in English, your ideas won't ever have reached that international audience. And so really good ideas in particular locations are never, never getting beyond that readership, right, because of the language barrier. <...> And that's where English-speaking countries have a real sort of differential amount of power and voice because I don't have to think about translating my writing, it just comes out and I'm done. Right? And that's a huge advantage over everyone. I could be easily three or four times more productive...”.

Although French is the official language of the ICA as well, and the scholars from France can use their language for papers and presentations in the conference, they still have to be fluent in English to understand the others, non-French speakers. Julie confirmed that the French community of cartographers became more open because they started to use English: “Yes, we are more open than we were. <...> people began to read in English, that's it”.

ICA promotes national conferences in the local languages, this allows scholars to be published, but at the same time this does not help them to be heard in the international community, Ivan said:

“The language barriers certainly affect. There are not very many [Russian] participants at international conferences <...> Tikunov's Interkarto conferences under the auspices of the ICA are Russian speaking, they provide an opportunity for regional specialists to publish, receive Scopus and close a speech at the conference. In principle, this is a necessary format, but its negative side is that it hinders the development of regional specialists and the growth of their qualifications so that they could perform in the global scene”.

This confirms that English fluency is essential for the researchers in other countries if they would like their ideas to reach a broader audience and influence the other researchers, from different parts of the world and thus facilitate international cooperation. Therefore, the ideas of English speakers have more chances to propagate in the scientific community. However, there is another opinion on the interaction barrier that is not necessarily the language, but financial:

“I do not think that this is the language problem is the main problem, but the support, the financial support of cartographic projects. You can get more financial support for major projects in the United States than in other countries where very often when you have distinct projects, there is a barrier, that the financial supporter wants to keep the results of the research for itself”

– believes Theodor. There is also the issue when the government does not support financially the participation in international conferences and therefore this is impossible for the cartography researchers from the whole country to participate. Ivan mentioned the financial problems as well:

“A couple of times it happened that Russia [the government] did not pay the registration fee because of a misunderstanding of the importance of our presence in this organization, especially since our country has rich cartographic traditions, nevertheless, this is how everything developed against the background of the fact that our field in the country is falling out of favor”.

The politics influenced how cartographic schools interacted during the Cold War. There were two world's poles of influence during the Cold War, and at the same time, there were two poles of cartographic theory – the cognitive concept of the Soviet school and the communicational concept of the American school. Salishchev argued with Morrison and Robinson about their theory and criticized it: “...in the journal *Canadian cartographer*, here he had this exchange of views with Joel Morrison and, and Robinson” (Eduard). Maria noted that the main difference was concerning generalization: “We all know this from textbooks, there was a conflict between the theoretical concepts of communication and model-cognitive. <...> when the process of generalization occurs, even new knowledge may emerge. And the communicative concept did not allow this...”. However, Thomas argued that Robinson and Salishchev were not opponents in that sense:

“But he [Robinson] then started adding this extra process called induction, which is for him the learning, that the cartographer undergoes the new knowledge, the new understanding of the world of the cartographer has, because of having made this map so that there is this intuitive engagement with the with the subject matter, that leaves the cartographer to think about new realization, so and in that sense Robinson and Salishchev, were not that far apart”.

Perhaps, the greatest difference was in the objectives that both schools were aiming for: “We always thought that the Russian school, though, was different, because it gave a very theoretical framework going beyond communication. So that is something which we recognize, but at that time, it was difficult because of language...” – said Leonard from Austria.

The concept of Salishchev is cognitive but the word cognitive here referring to the research on how people cognize the map, rather than what knowledge people can cognize through the map: “He used cartography in order to understand things better to understand spatial processes to understand the spatial distribution of things. And I think that is indeed one of the major reasons why we are mapping at all” – said Eduard. At the same time, cognition as communication of spatial information was the core of Robinson's concept.

Because of the Cold War, Germany was divided into two parts and political reasons obstructed the exchange of ideas:

“...we had in West Germany, the influence of the United States and Britain, more British and American influence on cartography, in East we had translations from Russian into German. However, these translations, only showed that Russian cartography was dominated, on the one hand by political concepts, and by the other hand the restrictions of secrecy. But anyway, we had Russians and British, American, English influences in Germany. And the Germans could combine all these...”

– said Theodor, who was studying cartography both in the East and West. However, the unification of the concept under the common umbrella did not happen. Theodor explained that the reason was the secrecy of the developments by the Soviets, but also the inner problem of German society's unification:

“Russian would not show all the research results, because they kept secret. <...> You know even in Germany, we have the unification in 1990, but you can still see that from the West German side, there was a reluctance to cooperate with East Germans. It is still not solved, this problem”.

Therefore, the Russian and the American schools of cartographic thought opposed each other in the period of the Cold War, and this still affects the interactions of these schools, Nickolas from the US confirmed it:

“I don't know as much about Russian cartography. I think that's there are probably big geopolitical reasons why that's the case. A lot of my cartography, so Robinson's era would have been creating cartography for the Cold War, which is why power is such an important question to ask that mapping in my country was always tied up in military interests, right. And I know the Soviet is similar. And that's probably why we haven't had as great of an exchange”.

However, all kinds of barriers – language, financial and political might be overcome, and the ICA plays important role in the interactions of contemporary schools of thought. The internet helps the better communication between scholars and help to overcome the barriers within the ICA commissions as well, and therefore the schools of thought interact better, said Victor:

“I think that has happened a lot because of communication technologies being so much more available now, and that people know about each other's perspective sooner. So that has facilitated sort of cross thinking across the different perspectives. I guess, one particular example of that is within the ICA, some of the Commissions have been very active in meeting together. <...> And that has brought together the cognitive perspectives, the engineering perspectives, the geovisualization perspectives, into small group meetings where people had a chance to interact with one another on a one-to-one basis for several days. And I think that has created a lot more bridges across those different areas more quickly than it might have otherwise”.

Alice mentioned that researchers, in general, became more open in terms of sharing the research results and that facilitate nowadays integrations as well:

“...we look around more often than keeping a kind of cold body of knowledge for ourselves, we are more willing to share with our colleagues without having the concern of being stolen because we notice that by sharing, we can get more quickly other ideas, and borrow those ideas integrated into our system. And this will make our system more sustainable”.

However, the existence of the school of thought is still disputable. Leonard argues that there are no schools of cartographic thought anymore because people within the discipline have better connections to each other:

“Because we are global. We are all global now, we have global publication means we have adopted a global language. We have the same standards in quality control, carrier development, curriculum. Also, we have the same tools. We have the same dissemination platforms, we use the internet, all of us also disseminate our results. It's standardized, in a sense. That has the impact that I can see no island, which has remained, we're all connected. And that's why I think we have kind of no schools anymore, no bubbles, but kind of dynamic development of a discipline”.

The different opinion on that issue has Alice, she argues that even if the society is well-networked, there are still schools of thought because people still working in groups:

“...if a society is more interdisciplinary, then those disciplines will be more fashionable like cartography is going to be more fashionable than a hardcore discipline, but a school of

thought will sustain even in web because people come together, they share some similar thoughts, even if they can debate and argue. So, I'm also curious to observe how the school of thoughts evolve in the well-networked society, maybe they change differently than early days, where there is a barrier, a physical barrier or not that easy to transfer, that is also a danger for us because people get easily manipulated by influences”.

The transformations of the schools noticed Fiona, she emphasized that the schools became less powerful:

“...I think there are still the schools of thought, but they're not like the big schools like <...> school in Germany, or the French, the IGN, even in the Netherlands <...>. You know, those big powerhouses: Wisconsin, Kansas, Washington, are not. They're not around. It's much more diffused today”.

Another argument for the school's existence is the difference in cartographic products produced by the distinct schools, as Eduard noticed:

“Yes, the old different schools still exist. <...> If I look at the maps, like the one behind me these enormous productions, a geological map of the world, produced in Russia, the old atlases of the oceans, these are enormous work, well... I've never seen something similar from the United States. They are very good at producing databases that they don't know how to generalize and that's what Russian cartographers are very well able to do and to relate things to one another, show that there is a certain growing together. And this is also much stimulated by the International Cartographic Association by the fact that we have joined conferences and exchange our views there”.

Therefore, the different schools of thought in cartography still exist, but they have changed, developed in the new schools. The language, physical and political barriers became less important for knowledge distribution because of globalization and the schools of thought started interacting better.

4.4. SUMMARY

There are still national differences in the cartographic domain, depending on the institutional organization, cartography might be seen as an independent domain or the part of the bigger discipline, it might be seen as an engineering or scientific domain. In Russia, cartography is a part of the compound discipline together with GIS and remote sensing, and strongly related to geography. In contrast, in France cartography is seen as geography specialization, which is well distinguishable from GIS and remote sensing. In Germany, cartography has never been an independent domain, it was more an engineering field than a science. As a science, cartography in Germany and France is similar to cartography in the US, where it is seen as a design, visualization discipline with an emphasis on cognition. Cartography in Russia is still different science, which is not concentrated on the map design or communication of spatial information, but on acquiring knowledge about spatial phenomena with the help of making and reading maps. The development of cartography as science in those countries was influenced by different “scientific orthodoxies” and the worse conditions to interact in the second half of the 20th century. However, nowadays, because of globalization and the global trends, the better means of communication, international conferences, and international societies, cartographic schools interact better and intermixed. The authoritative scholars and the language barriers influence less nowadays, and the people from different countries can form different schools of thought with greater freedom.

Chapter 5 Education

In this Chapter, the development of international schools of cartographic thought will be observed from the perspective of cartographic education. The school's curricula will be compared throughout the past ten-twenty years in terms of shares that the cartography discipline takes with other disciplines, and how cartographic subjects have been changing. This changing of cartographic subjects reflects the development of the observed schools.

5.1. METHODOLOGY

In Chapter 3, education is distinguished as one of the criteria of a school of cartographic thought together with theory and key people. If one assumes that university education reflects the character of the cartographic school, then it is possible to compare study programs over time and see potential trends. This will help to define the nature of schools, how they position cartography as a science, which subjects within a cartographic discipline they emphasize, and what has changed.

Table 5 shows the university programs which consider Cartography as a major discipline in the observed language areas. These programs are related to the schools of thought, which were reviewed in the previous chapters. In this chapter, the curricula from the following study programs will be used.

Table 5. The key institutions and study programs

University (-ies)	Language area	Study program	Degree
MSU	Russian	Cartography and Geoinformatics	BSc, MSc
UW–Madison	American	Cartography and GIS	BSc, MSc
Paris 1, Paris 7, ENSG	French	Carthageo	MSc
TUM, TUW, TUD, (UT)	German (and Dutch)	Cartography	MSc

A series of curricula in individual university programs and among the different universities' study programs will be examined to see the changes over two decades and identify the common trends in cartographic education. Curricula usually consist of elements from different disciplines, and the first stage of analysis will be defining the shares of the different disciplines related to specialization, such as cartography, geography, GIS, remote sensing, and geodesy in curricula. The second stage will be the analysis of subjects of cartographic discipline in curricula to understand the trends in a particular school.

5.2. EXECUTION

First, the curricula were obtained via websites and local staff. The collected data was represented in different digital formats: images, websites, tables, or PDF. All the data was transformed and processed into a table form, in Microsoft Excel (Appendix 4). Machine translation and online dictionaries were used to translate the name of subjects from Russian, German, and French to English. The study programs and years of gathered curricula are

represented in Table 6. As can be seen in the table, the study programs vary in levels. This aspect, as well as the duration, will be taken into consideration during the analysis.

Table 6. Observed study programs

N	Degree(s)	Program	University	Year(s)
1	Spec. ⁷	Cartography	MSU	2009
2	BSc, MSc	Cartography and Geoinformatics	MSU	2016, 2018
3	BSc, MSc	Cartography and Geoinformatics	MSU	2021
4	MSc	SIG-DESS	Paris 1, ENGS	2000
5	MSc	Carthageo	Paris 1, Paris 7, ENGS	2009
6	MSc	Carthageo	Paris 1, Paris 7, ENGS	2021
7	Dipl. ⁸	Cartography	TUD	2000
8	BSc	Cartography and Geomedia techniques	TUD	2009
9	MSc	Geoinformation Technologies	TUD	2011
10	BSc	Geodesy and Geoinformation	TUD	2020
11	MSc	Geoinformation technologies	TUD	2015
12	Dipl.	Surveying and Geoinformation	TUW	2000
13	BSc	Geodesy and Geoinformation	TUW	2009
14	MSc	Geoinformation and Cartography	TUW	2009
15	BSc, MSc	Geodesy and Geoinformation	TUW	2021
16	MSc	Cartography	TUM, TUD, TUW	2011
17	MSc	Cartography	TUM, TUD, TUW, UT	2021
18	BSc, MSc	Cartography and GIS	UW–Madison	2000, 2004
19	BSc, MSc	Cartography and GIS	UW–Madison	2009
20	BSc, MSc	Cartography and GIS	UW–Madison	2020

Study programs have changed over time, and the greatest changes are observed in the German-speaking areas (Figure 19). At the TUW there the study program of Surveying and Geoinformation, changed into a bachelor program Geodesy and Geoinformation and master program for Cartography and Geoinformation. In contrast, at the TUD the study program of Cartography existed before and later it was canceled. Starting from 2011 both universities joined forces into a single study program each offering one semester in the same study program – Cartography MSc. As a result, both universities integrated cartography subjects into the programs of Geodesy and/or Geoinformation. These programs were analyzed to see the development of those cartographic schools, separately from the Cartography MSc.

At MSU, TUD, and TUW the Bologna process brought changes in the format of studies. At MSU the “specialitet” study program of Cartography merged into Cartography and Geoinformation BSc and MSc, whereas at the TUD there was the BSc program Cartography and Geomedia Techniques. At the TUD the MSc degree is called Geoinformation. At the

⁷ “Specialitet” (Rus.) – the level of higher education in Russia, where the Bologna system was adopted later than in other countries.

⁸ Diplom (Ger.) – the level of higher education in Germany before adoption of Bologna system.

TUW, the initial program consisted of two parts – the first part is common for all students and the second part was either Geoinformation, Geodesy, or Geophysics. The same principle was preserved in the bachelor's and master's degrees in 2009 – in the bachelor's there was a basis for all students, and in the master's a student could choose the specialization. Only the specialization Geoinformation and Cartography was analyzed. Another example of change is found in the study program at the Paris universities which has changed the name and partner universities. Study programs at the UW–Madison have not changed significantly in terms of study organization.

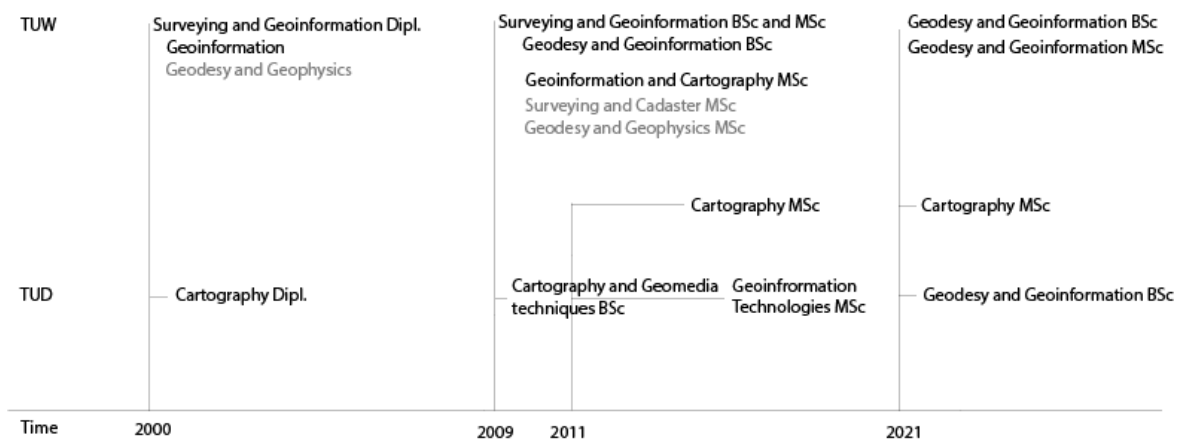


Figure 19. Cartography-related study programs at the TUW and the TUD over time

The curricula usually include the subjects' names, designations, and the hours or credits required for each subject. Certainly, in the past, the 'size' of a credit depended on the educational regulations in the particular country and makes a balanced comparison not easy. To standardize the conversions were made, e. g. in the SIG-DESS study program there were hours indicated for each subject instead of credits, whereas in Carthageo program – credits. The sum of hours (516) was divided by the number of credits in the Carthageo program (78). Therefore, using proportion, it was found, how many credits takes each subject in the SIG-DESS program. A similar issue was observed with the MSU 2009 curriculum – each subject was measured in hours. To estimate how many hours is one credit, the division of the number of hours by the number of credits in the 2016's curriculum was performed. Therefore 1 credit in Russia is equal to 36 hours, and with the division of the hours by this value in the 2009's curriculum, the approximate number of credits was defined for each subject.

To see cartographic subjects in the context of the other disciplines such as geoinformation, remote sensing, geography, geodesy, and surveying, the contribution of each discipline was included in the bar charts. Generic subjects, related to culture, natural science, mathematics, etc. were not included in the analysis, because they might be common for the broad range of study programs and therefore are not representative, as well as the hours and credits dedicated to the course works, thesis, projects, traineeships, and internships. The bar charts were created (Figures 21, 23, 26, 29, 32, 35) showing the shares of cartography, related subjects, and other subjects. This allows us to compare individual programs over time and among universities.

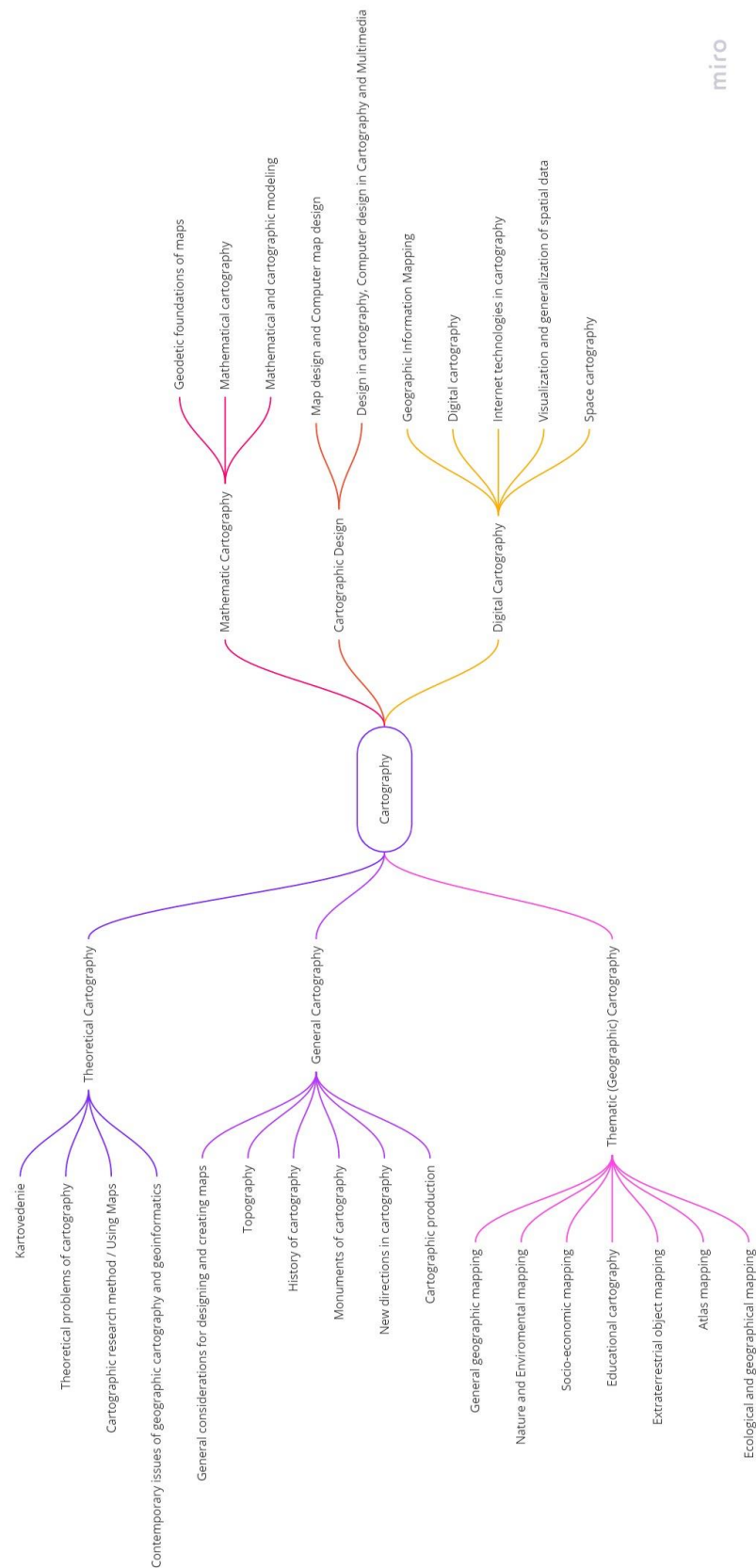
Secondly, the analysis of the differentiation of cartographic subjects in each study program over time was performed. For the representation of the changes, the radar diagram was used, which shows the main categories of the subjects with their credit values in the different time

series. The subjects were grouped in the main categories, and the principle of grouping is represented in the mind-maps (Figures 20, 25, 28, 31, 33, 36). In the diagram, the line color represents the year – it varies by the color saturation; it intersects the radial axis where the correspondent number of credits or hours for the subject is given. Radar diagrams represent the pattern of cartographic education in each study program over time and answer the research question on how the schools have been developing over time.

In this task the main issue was the level of detail – the curricula could contain subjects or the modules – a group of subjects. The curricula have a different level of detail, e. g. the MSU's and TUD's curricula are more detailed than the others. The individual subjects with a similar category of cartography were grouped to keep the same level of details in diagrams. The main categories of cartography were defined: Theoretical Cartography, General Cartography, Geographic (Thematic) Cartography, Mathematic Cartography, Cartographic Design, and Digital Cartography. If there are no subjects related to the category, then the category is empty – therefore the diagrams will be comparable.

As an example, the subjects and categories in the MSU's study program are shown in Figure 20. The Geographic Mapping subjects are related to representing the various geographic phenomena on the map depending on its theme – similarly to Thematic Cartography in other study programs but including General Geographic Mapping. The subjects about general issues such as history, topography, production are included in the General Cartography category. Mathematic Cartography includes Mathematic Cartography with Geodetic Foundations of Maps because both of them deal with the study of mathematical equations in cartography and the questions of projections and coordinate systems and Mathematic and Cartographic Modelling.

Theoretical Cartography includes *Kartovedenie*, a subject developed by Salishchev – he wrote a textbook with this title and it has not been translated to English. This word consists of the two words “karta” – which in Russian means “map” and “vedat” – which means “to know, to learn”. This textbook reflected the general issues about the theory of cartography from the perspective of the Russian school of thought. The Cartographic Research Method subject is related to acquiring knowledge about the geographic space by using maps including the analysis of maps and mathematical modeling using the information from maps. The conception of the Cartographic Research Method was emerged by Berlyant, in 1978 he wrote a textbook about it. In 2009 this subject was called Using Maps – this might confuse the European or American reader because the word using might be wrongly associated with the user studies in of map communication and map usage. The next category is Cartographic Design, which includes all subjects related to the design of maps. Digital Cartography covers the subjects related to cartographic visualization in the digital form.



miro

Figure 20. The cartographic subjects in the MSU's curricula over 2009-2021 grouped into general categories

The same procedure of subjects' generalization was applied to the other curricula. At the TUD curricula, the categories are similar to the MSU's, but there is Thematic Cartography instead of Geographic Cartography (Figure 25). At the TUW, Applied Cartography means Thematic Cartography, while Theoretical Cartography includes subjects about Cartographic Interfaces and Cartographic Information Systems – as they are part of the theoretical concept, accepted at that university (Figure 28). In Cartography MSc curricula the subjects related to the Remote Sensing mapping are placed in the Geographic (Thematic) Cartography category (Figure 31). In Parisian – the subjects related to Mapping and Statistics, and Application (Figure 33). At the UW–Madison, in analogy with the MSU program, the subject of Cartographic Methods in Research is placed in the Theoretical Cartography category (Figure 36). There were the cases when the use of the same term can refer to different content and different terms to the same content, and therefore to decide which subject is going to which category, research on information about the content of module was performed, when it was possible.

5.3. RESULTS

5.3.1. The Development of the Russian school of cartographic thought from an educational perspective

In the 2009 study program, cartographic subjects dominated, followed by the geographic subjects, and the minor disciplines are geoinformatics, remote sensing, and geodesy, and surveying (Figure 21). Later, the 5-year study program was split into four-year BSc and two-year MSc. In the curriculum for masters and bachelors, more electives were added, and the share of geoinformatics and remote sensing disciplines increased in comparison to the 2009's program. The disciplines' contributions in bachelor's and masters are not the same, in master's curriculum, the contribution of geographic subjects is less.

The pattern for bachelors has not changed significantly since 2016 – one could see a similar share for disciplines, but in the current curriculum there are fewer credits are given for elective courses. Geographic discipline was moved from the new master's curriculum completely to the bachelor's curriculum. Overall, there are more specialization disciplines in the current master curriculum than in the previous one – cartography and geoinformatics subjects are doubled, and the other subjects were reduced. Also, fewer credits were given for internship and research work.

Summarizing, the general trend shows the increase of geoinformation discipline in a curriculum, cartographic discipline shows a temporary decrease between 2016-2018, but in 2021 increased again. Remote sensing discipline increased in the 2016-2018 curricula and later decreased. Geographic discipline has roughly the number of credits, and therefore it is the most constant discipline on curricula. In the end cartographic share of the curriculum remains the major part among the compulsory specialization subjects.

The cartographic curriculum diagram at MSU is represented in Figure 22. The subjects are grouped according to the mind-map which is represented in Figure 20. In general, there are similar patterns for three periods, the main similarity is in the bigger number of credits related to Geographic (Thematic) Cartography, which represents the association with the geographic discipline. Students spent a lot of time studying different types of geographic maps – thematic

and general. Mathematic Cartography and Map Design had a similar number of credits over time. Digital, General, and Theoretical Cartography decreased.

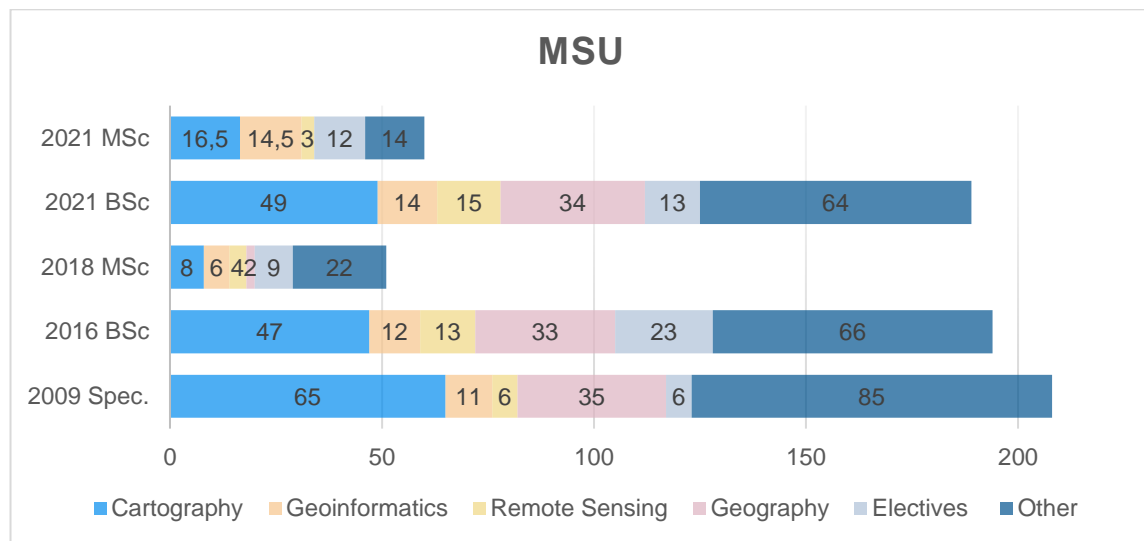


Figure 21. The overview of specialization disciplines in the curricula of the MSU

Some subjects taught in 2009 disappeared later, e. g., General considerations for designing and creating maps, Basics of Geographic Information Mapping, Educational Cartography, and Map Production. Internet Technologies in Cartography in the current curriculum are called Web Geoinformation Technologies, so it was moved from the cartographic discipline to the discipline of Geoinformatics. By 2021 subjects Space Cartography, Extraterrestrial object mapping, Contemporary issues of Cartography have grown in the number of credits. In 2021 the new subjects appeared – Visualization and Generalization of Spatial Data and Atlas Cartography.

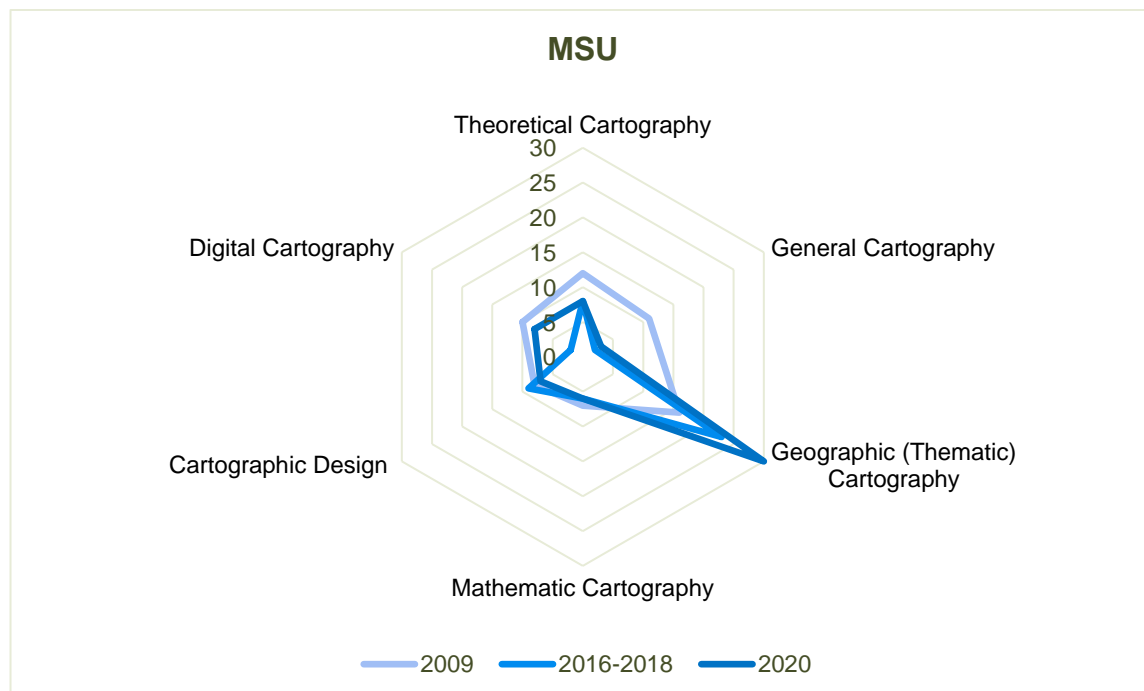


Figure 22. Cartographic subjects grouped by categories throughout 2009-2021 at MSU

Therefore, there are several major trends in the development of this cartographic school, which could be distinguished from the study programs: 1) the dominant and constant focus to the Geographic (Thematic) Cartography; 2) the declining interest in the subjects related to General Cartography; 3) disappearing of outdated subjects; 4) the growing interest to the new subjects of Visualization of Spatial Data and Extraterrestrial mapping. The last trend represents the new categories in development towards the Geovisualization discipline and the Planetary Cartography. However, the general development of school demonstrates stability, because of the cartographic tradition of the school of thought.

5.3.2. The Development of the German school of cartographic thought from an educational perspective

TUD had a 5-year Cartography “Diplom” program, and later it was modified into the bachelor’s program Cartography and Geomedia techniques, which was canceled. Currently, the bachelor’s program of Geodesy and Geoinformation and masters of Geoinformation are taught entirely at the TUD. These changes are reflected in curricula: one could see the decreasing share of cartographic discipline in curricula after 2009 (Figure 23). The most cartographic content in 2009 is found in the bachelor’s program. However, in the master’s program, most modules are electives, therefore the shares of disciplines in curricula can vary depending on the student’s choice. The curriculum for the Geoinformation master’s program remains unchanged – cartography, geoinformation, and remote sensing are approximately equal.

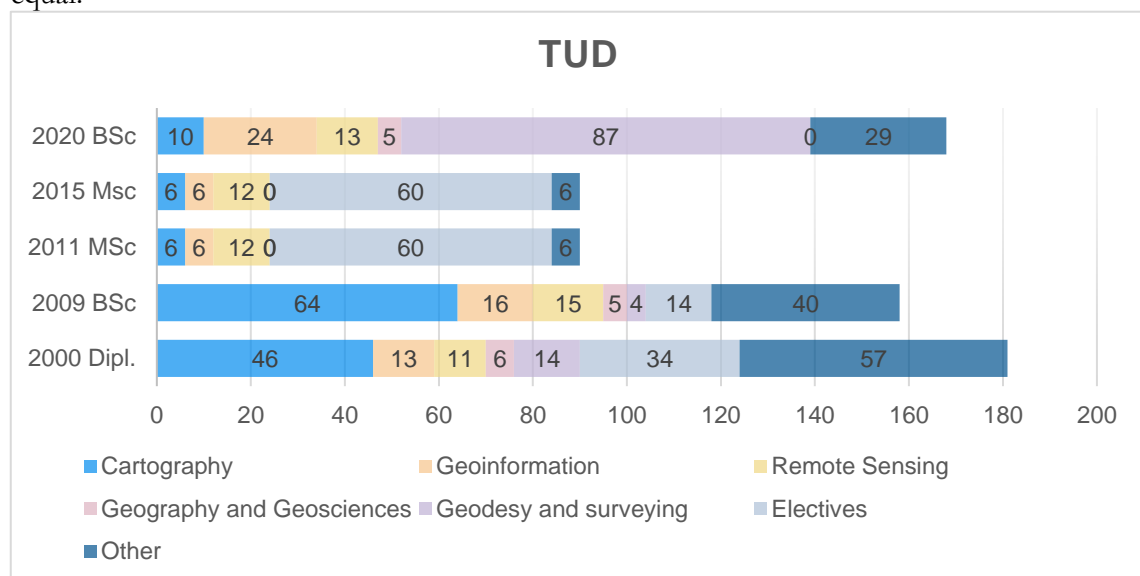


Figure 23. The overview of specialization disciplines in the curricula of the TUD

The cartographic subjects in curricula have significantly changed in the 10-year interval time stamps (Figure 24). The subjects included in each category can be seen in the mind-map in Figure 25. In 2000 the major category was General Cartography followed by Geographic (Thematic) Cartography. In 2009, the orientation changed toward subjects related to Digital Cartography. Subjects like Map production, World Maps / Atlases, Tourist Cartography, Planning Cartography, and Generalization had disappeared. Instead, Internet Cartography, Regional Cartography, Cartographic Visualization and Interactive map making, Virtual

Landscapes, Cartographic Software adaptation, Geomedia techniques, and Multimedia Cartography were added to the curriculum.

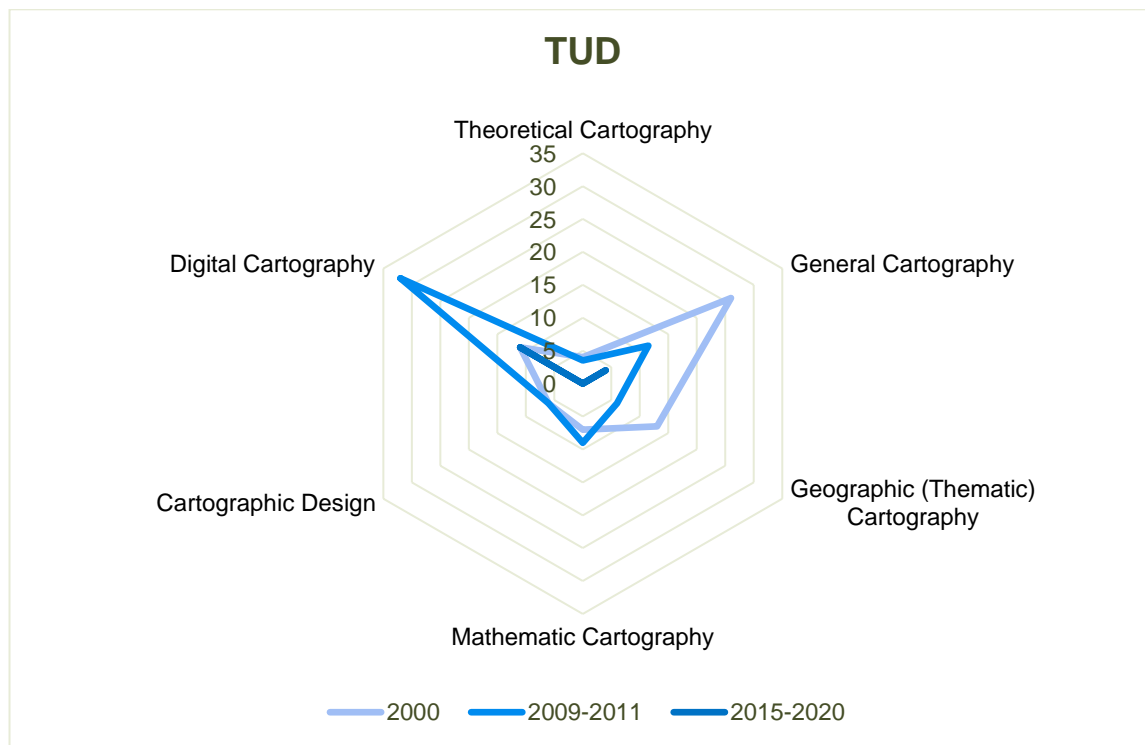


Figure 24. Cartographic subjects grouped by categories throughout 2000-2020 at the TUD

Nowadays, at the TUD, cartographic subjects of Mobile Cartography, Cartographic Visualization or Geovisualization and Generalization, Cartographic Software Adaptation are taught, which are related to the Digital Cartography category, and one subject Cartography which might be related to the common aspects of cartography and therefore it is counted as General Cartography. The ending of the local Cartography program at the TUD had quite an impact on cartographic education there. As a result, the Dresden cartographic school was not able to save their cartographic traditions and introduced new subjects, related to the various aspects of Digital Cartography.

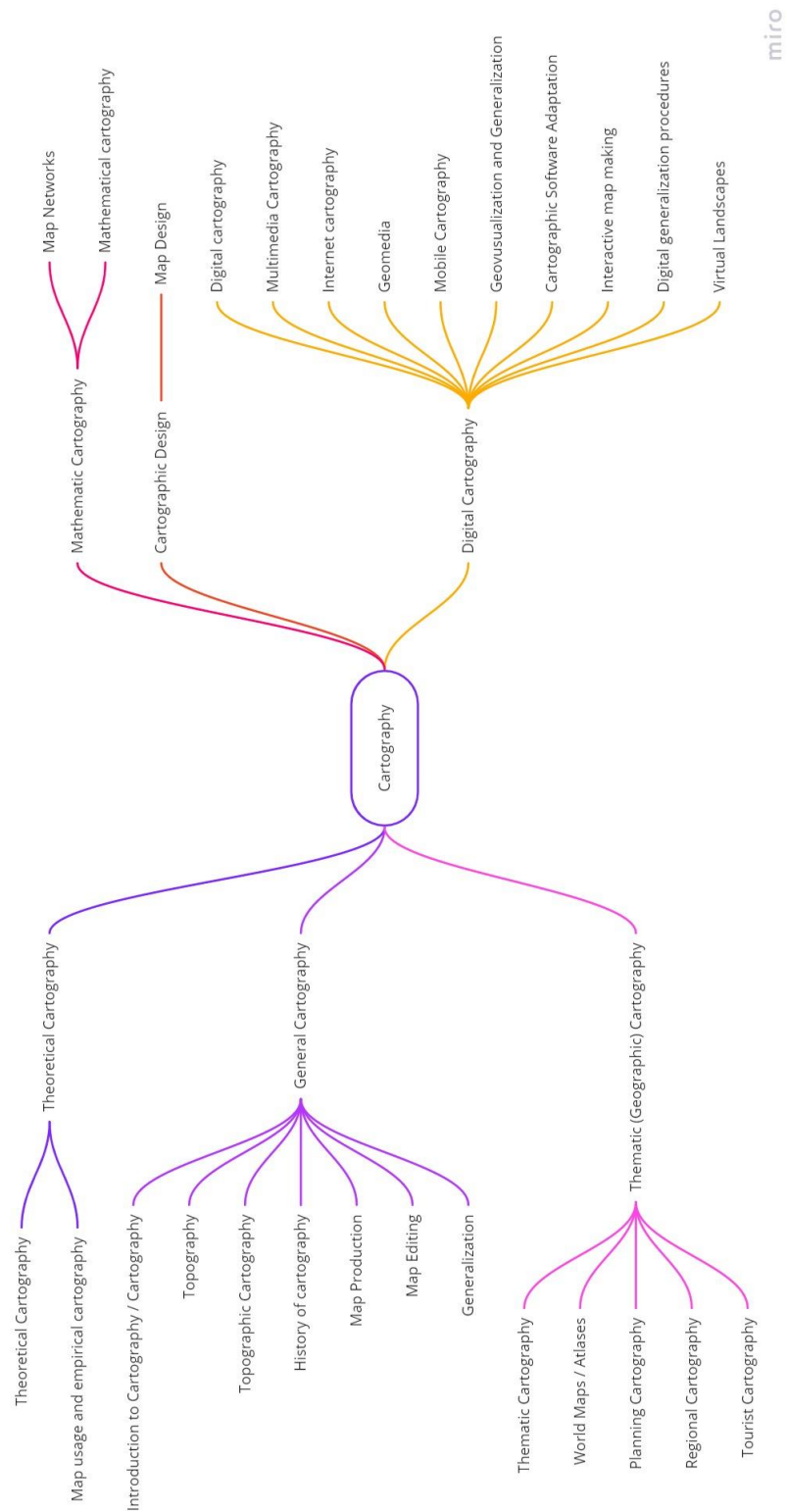


Figure 25. The cartographic subjects in the TUD's curricula over 2000-2021 grouped into general categories

At the TUW there was no independent Cartography study program, and cartographic subjects were always taught in the Geodesy and Geoinformation study programs. As could be noticed from diagrams (Figure 26), cartography was a minor discipline. In the current programs, the share of cartographic elective modules is significant, therefore the specialization is optional, especially on the master program.

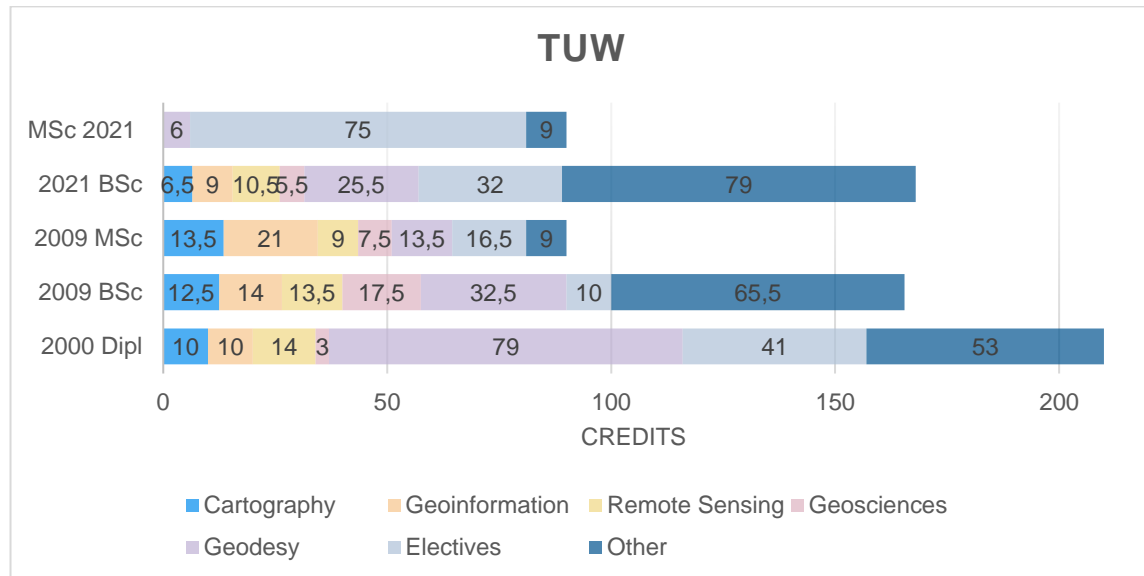


Figure 26. The overview of specialization disciplines in the curricula of the TUW

At the TUW the patterns of cartographic subjects' categories have significantly changed over time as well (Figure 27). In 2000, the largest category was General Cartography, followed by Theoretical Cartography. General Cartography at that time included various subjects about Cartographic Foundations, Map Production, and Editing (Figure 28). By 2021, the majority of these subjects have been canceled, and the only remaining course of Cartography is a general introduction.

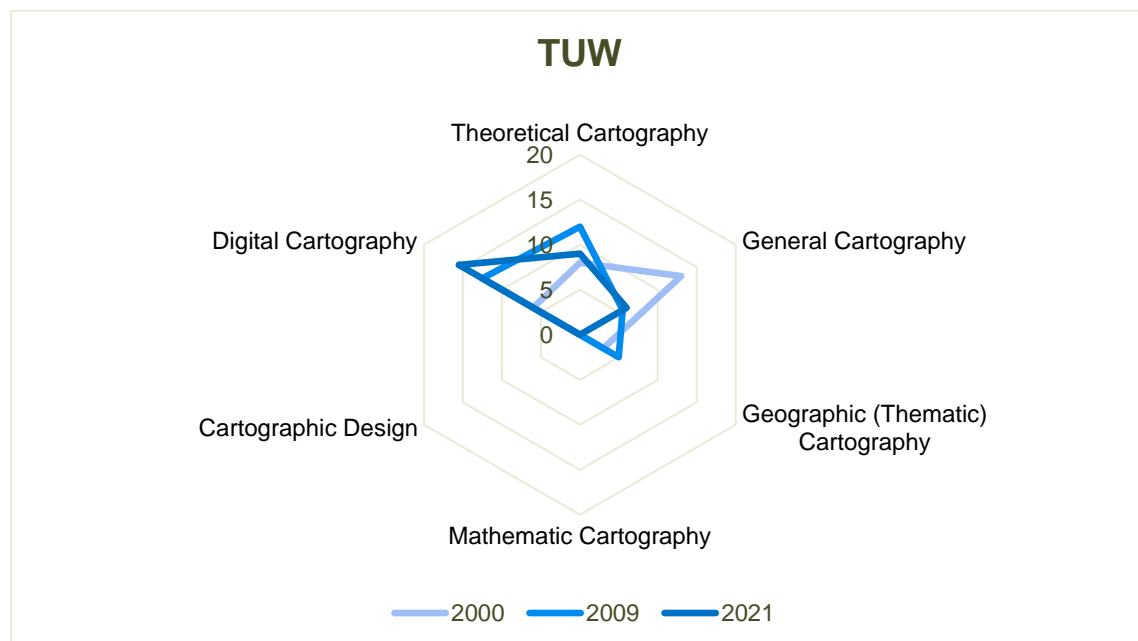


Figure 27. Cartographic subjects grouped by categories throughout 2000-2021 at TUW



Figure 28. The cartographic subjects in the TUW's curricula over 2000-2021 grouped into general categories

Theoretical Cartography included Interactive Cartography and Information Systems and Topographic Information Systems, which were in 2009 replaced by similar subjects of Cartographic Interfaces and Cartographic Information Systems. Theoretical Cartography as a subject itself, only appeared in 2009, with Communication Research Seminar, which was canceled later. Geographic (Thematic) Cartography in 2000 consisted of Application-oriented cartographic issues, in 2009 – Applied Cartography. In 2021, there are no subjects related to this category.

Digital Cartography initially included Multimedia Cartography, Internet Cartography, and Programming for cartographic tasks. Later the LBS was added to this category, replacing Internet Cartography. Geomedia techniques had appeared and the number of credits of these subjects was rising. By 2021, Geomedia techniques have disappeared, but Multimedia

Cartography got more credits and therefore the Category of Digital Cartography has been constantly rising.

In the past, cartographic subjects were related to the technological aspects of cartography. The curricula reflected the trend towards Digital Cartography and in terms of theory, the communicational concept of cartography. Such subjects as Cartographic Information Systems and Interfaces are characterizing the Viennese school of cartography – there are no analogs for them outside it. If compare both TUD's and TUW's charts, the common trends could be seen – in 2000, the decrease of General and Geographic (Thematic) Cartography subjects and the increase of the Digital Cartography Subjects. The subjects related to Cartographic Design and Mathematic Cartography have not been taught. Unlike at the TUD, at the TUW there is still theoretical cartographic education.

Nowadays both above-mentioned programs are sharing the Cartography MSc program, and each contributes different aspects of cartographic education. The program started in 2011 and continues to be – it is the only Cartography MSc program in German-speaking countries and the Netherlands. Most of its curricula take the cartographic discipline (Figure 29). However, in Cartography MSc by 2021 the share of elective modules has increased significantly and cartography and geoinformation subjects decreased, meaning that the specialization between cartography and geoinformation varies by the student's choice.

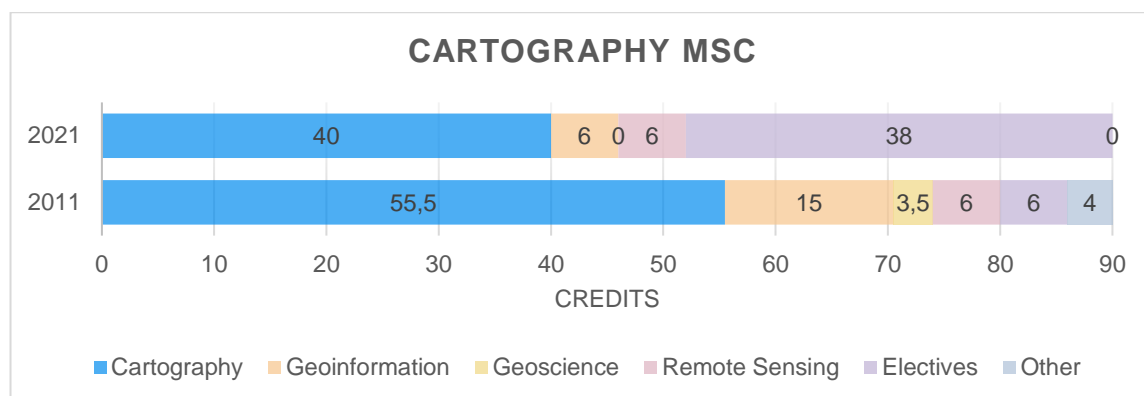


Figure 29. The overview of specialization disciplines in the curricula of the Cartography MSc

The cartographic subjects represent three universities, and it could be seen that from 2011 until 2021 the subjects from TUW have not changed and has the same number of credits. The TUD's subjects Mobile Cartography and Remote-Sensing-based Environmental Mapping slightly increased in credits, as well as 3D-Cartography which is called now Virtual Landscapes. Radar Cartography has been canceled. TUM's subjects changed significantly – in 2011, the only cartographic subject was Cartographic Presentation, and it was canceled. The current subjects are Cartographic Foundations, Geovisualization and Geostatistics, and Mapping Project. Therefore, the categories of Digital and General Cartography increased (Figure 30). There are no subjects related to Cartographic Design and Mathematic Cartography. The grouping of subjects in the categories is shown in Figure 31.

Thus, the Cartography MSc program is currently representing the integrated German school of cartographic thought. At the beginning of the century, cartographic education at the TUD and the TUW were different, and they developed differently as well. There are no old cartographic subjects that have remained at the TUD since 2000, the new subjects are related

to geovisualization and 3D cartography concepts. At the TUW the orientation to the communication concept and applied cartography remains and reflects in Cartography MSc.

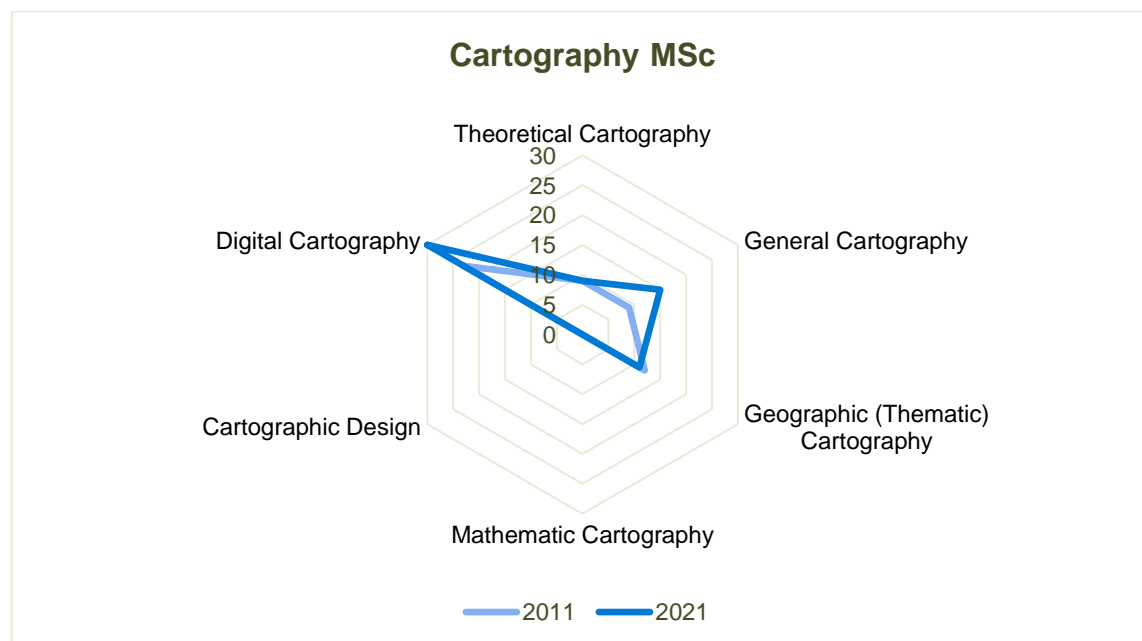


Figure 30. Cartographic subjects grouped by categories throughout 2011-2021 in the Cartography MSc

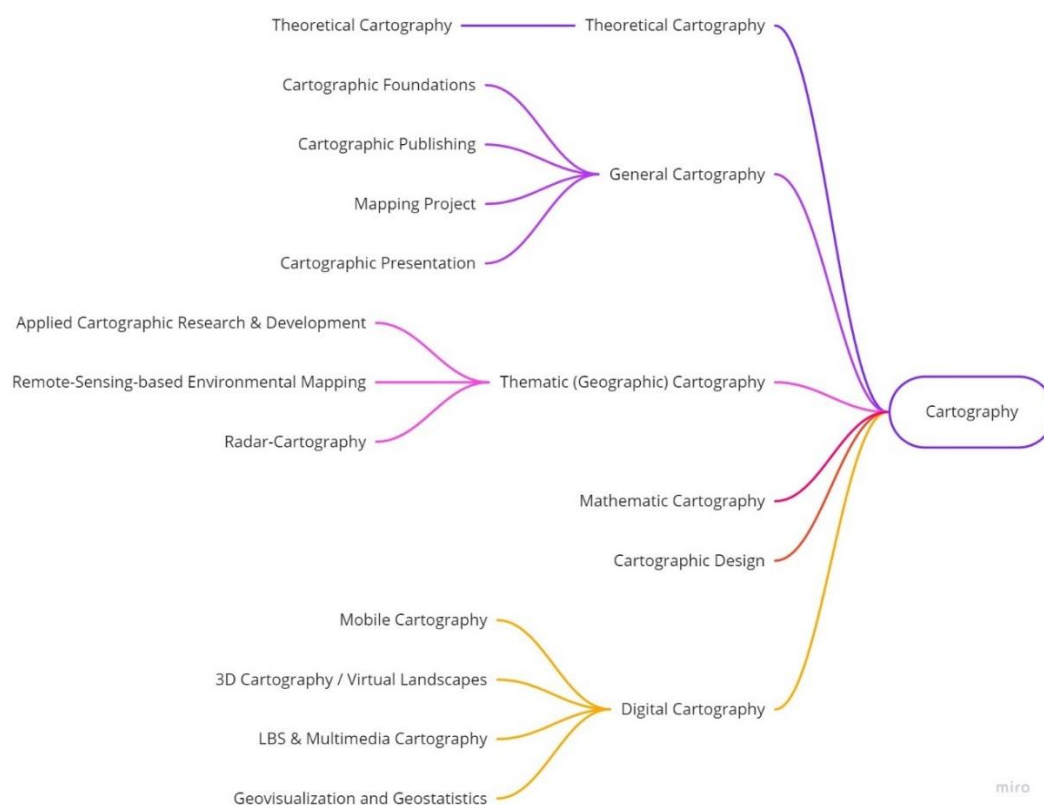


Figure 31. The cartographic subjects in the Cartography MSc's curricula over 2011-2021 grouped into general categories

5.3.3. The Development of the French school of cartographic thought from an educational perspective

The study program Carthageo previously was called SIG-DESS, but the concept of the program remained unchanged. The first-year student studied the geographic discipline at the geographical department of Paris 1, later also in Paris 7, and in the second year, they studied cartography and GIS at ENGS, the technical school. Cartographic disciplines do not vary much since 2009, but there is less geoinformation and no geography in the compulsory part of the current curriculum because they were moved into the elective part (Figure 32). In 2000, there was no geography, instead, there were graphics.

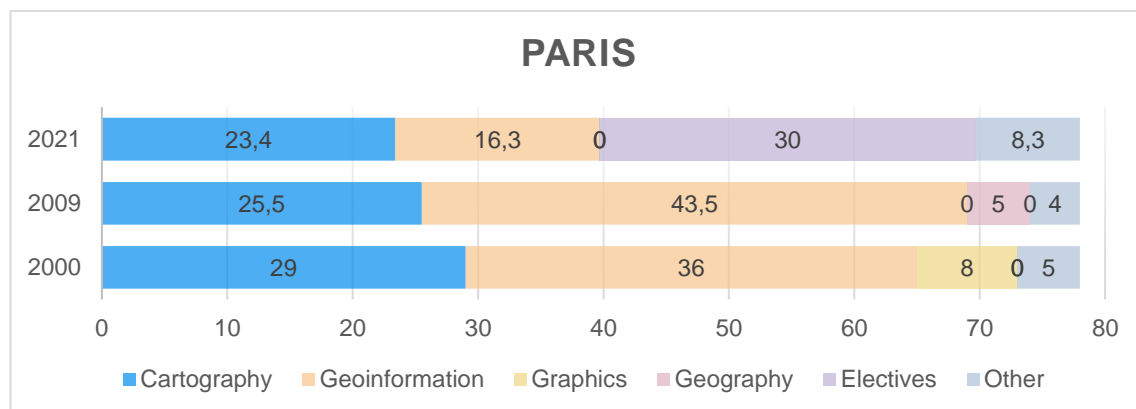


Figure 32. The overview of specialization disciplines in the curricula of the Parisian programs

In 2000 the curriculum included Digital Cartography, General Cartography, and Geographic (Thematic) Cartography categories (Figure 33). The cartographic curriculum diagram is shown in Figure 34. By 2009, the subject of Digital Cartography had been canceled, instead, the subject Cartography on the Internet appeared, and in 2021, the Geovisualization was added. General Cartography had grown since 2009 when Cartographic Project was added. (Geographic) Thematic Cartography peaked in 2021 with the new subjects of Mapping, Research and Applications, and Statistics and Mapping. More credits were allotted to the Semiology, consequently, the Theoretical Cartography category had risen in 2021.

Semiology as a core concept is still considered in French cartographic education, and there is growing interest in the new concepts such a geovisualization. Similar to the other countries, Internet Cartography and Geovisualization is getting more attention. Therefore, the French school is developing towards the new technologies and concepts and trying to combine them with semiology.

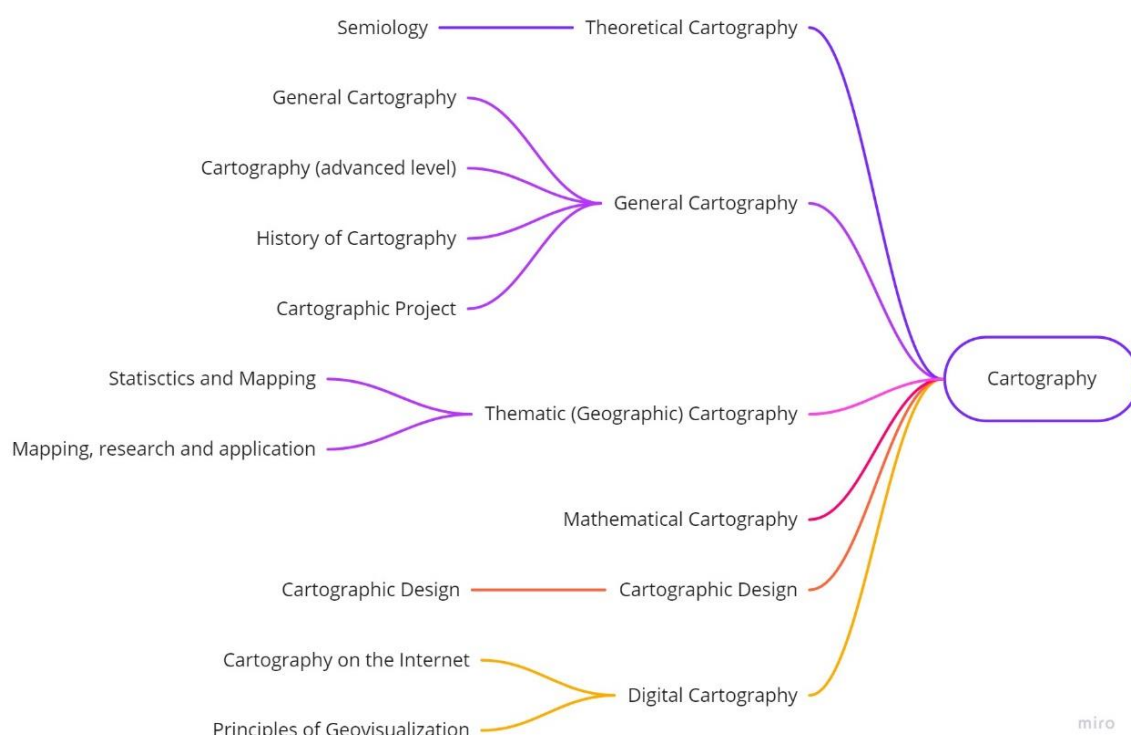


Figure 33. The cartographic subjects in the Parisian curricula over 2000-2021, grouped into general categories

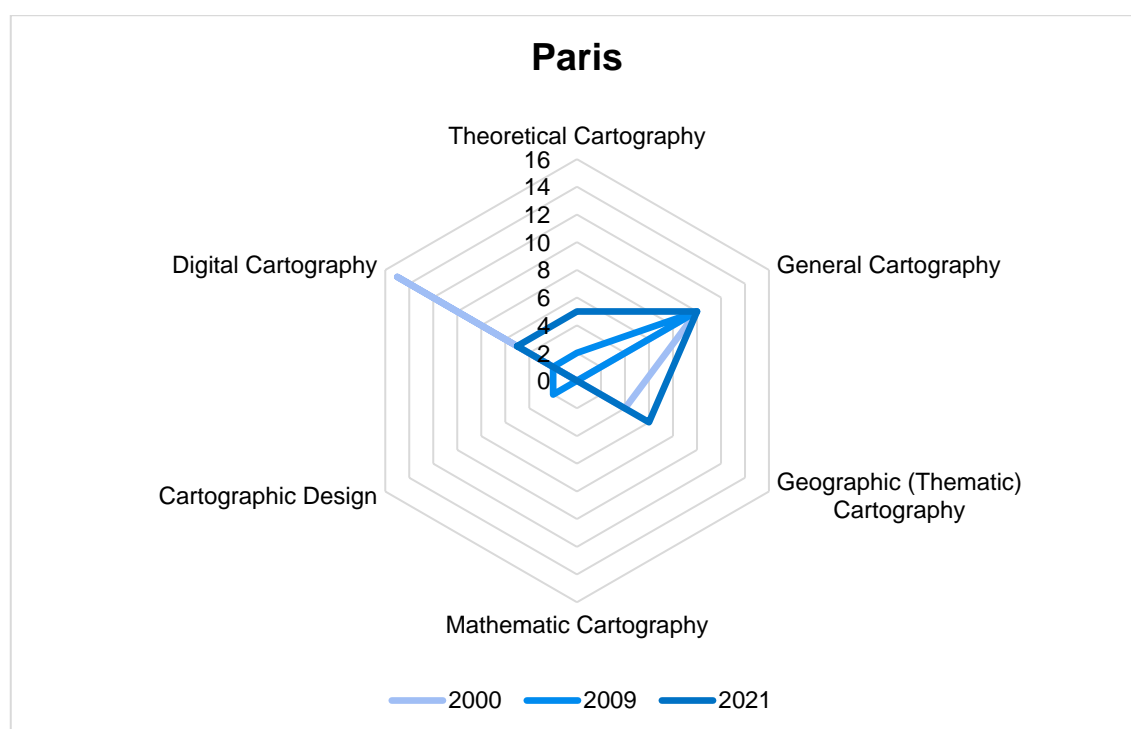


Figure 34. Cartographic subjects grouped by categories throughout 2000-2021 in the Parisian programs

5.3.4. The Development of the American school of cartographic thought from an educational perspective

In bachelor's study programs at the UW–Madison, there are four disciplines of specialization subjects – Cartography, GIS, Geography, and Remote Sensing (Figure 35). In bachelor's curricula, the significant part is related to generic geographic subjects and also remote sensing subjects, while the master's degree is more specialized. The numbers of electives do not vary significantly, and they occupy a small part of the curricula. Overall, the geography and remote sensing discipline decreased. In the current curricula, GIS disciplines are doubled, while cartography disciplines are almost halved. Therefore, the common trend is the increasing share of GIS discipline in a favor of other disciplines.

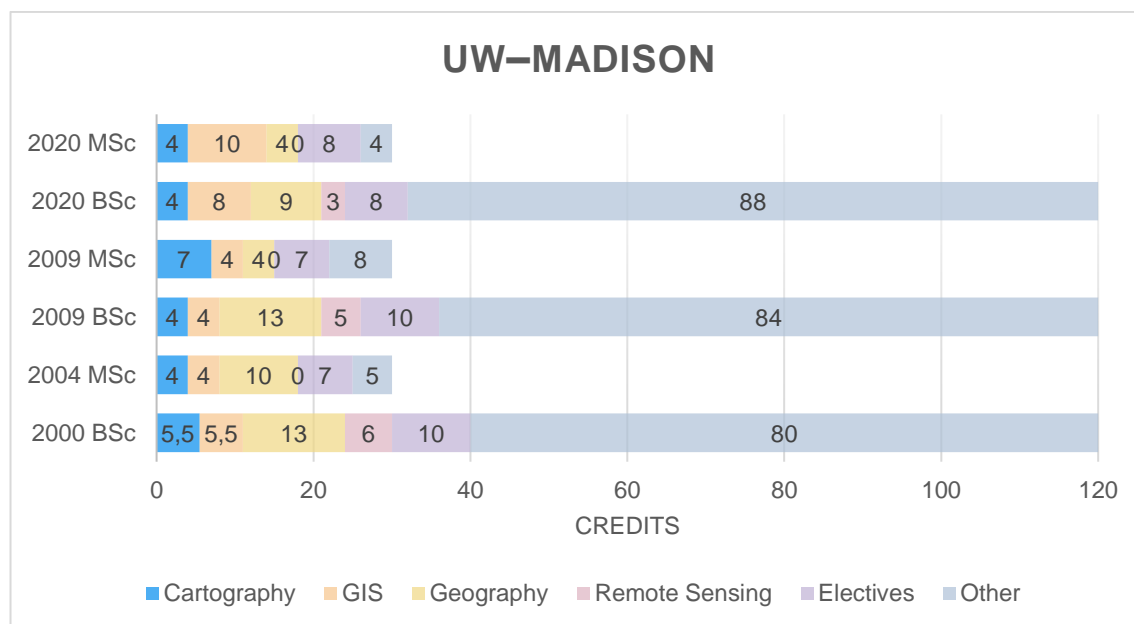


Figure 35. The overview of specialization disciplines in the curricula of the UW–Madison

The subjects were grouped into categories according to the mind map in Figure 36. The curricula of 2000 and 2009 are almost similar, except the subject of Cartographic Methods in Research related to the Theoretical Cartography category, which was canceled, and the subject of Animated and Web-based Mapping, related to the Digital Cartography, which was added (Figure 37). In the current curricula, the subjects History of Cartography and Problems of Cartography related to the General Cartography were canceled. Instead of Animated and Web-based Mapping, there is a subject of Interactive Cartography and Geovisualization, instead of Computer Cartography - Geocomputing. Cartographic Design and Introduction courses were constant over time. The Mathematic Cartography category nowadays is empty because the subjects related to the Projections were canceled. As could be noticed, there are no subjects related to the cartographic communication concepts, but there is the recent one related to the geovisualization concept. There is no topic, related to Geographic (Thematic) Cartography.

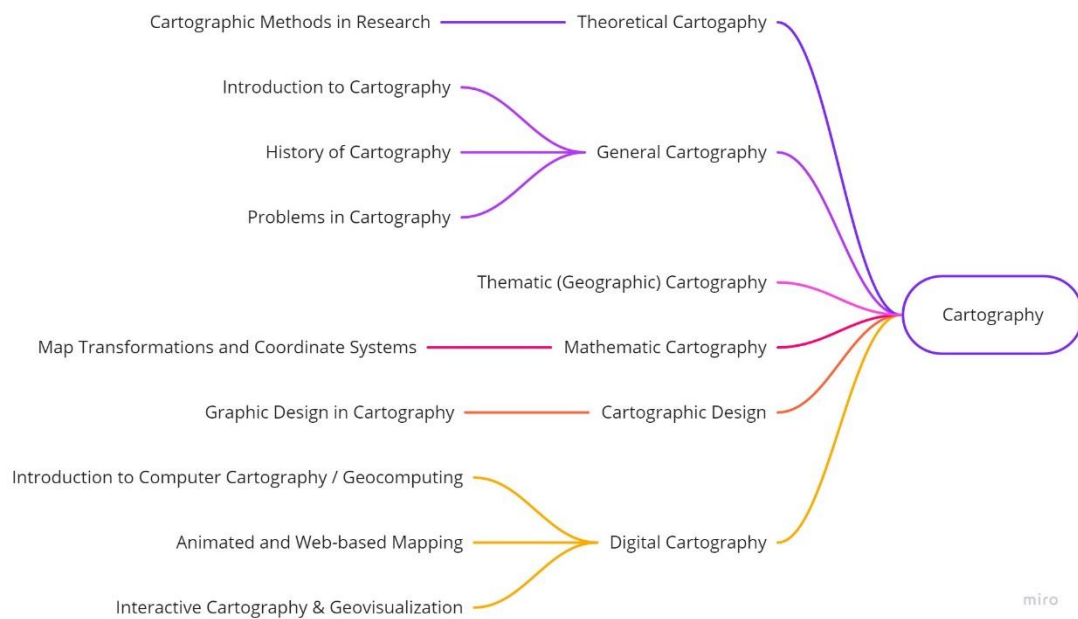


Figure 36. The cartographic subjects in the UW–Madison curricula over 2000-2021, grouped into general categories

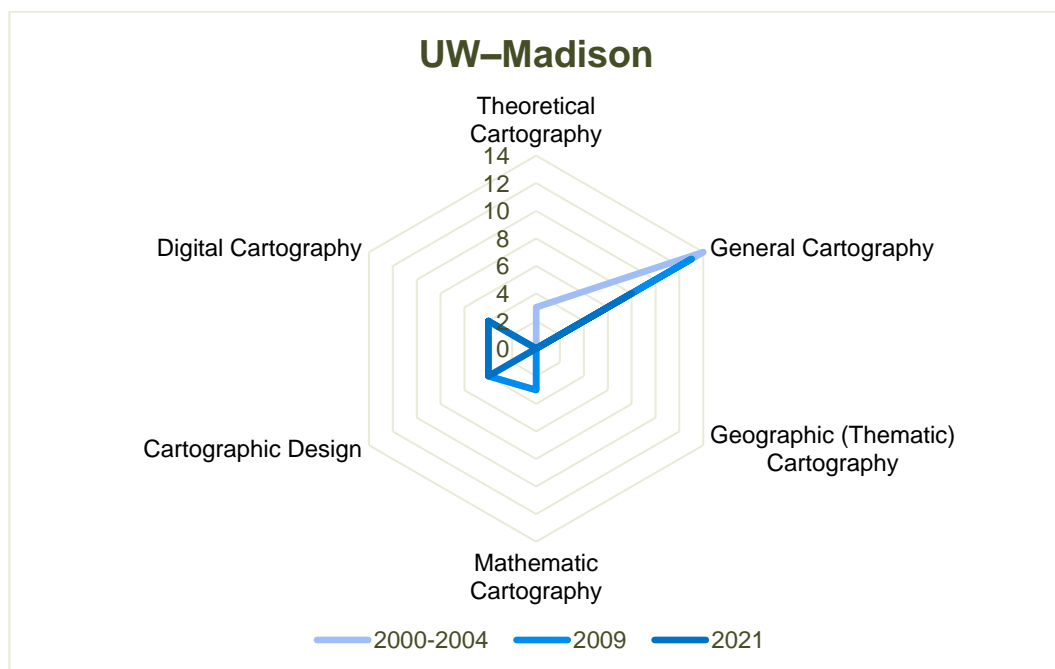


Figure 37. Cartographic subjects grouped by categories throughout 2000-2021 at UW–Madison

5.4. SUMMARY

The observed curricula reflect the character of their schools of cartographic thought. The core concepts of schools are still considered in some universities, e. g. Kartovedenie at MSU, Cartographic Information Systems at the TUW, and Semiology at Paris school – at those universities the role of Theoretical Cartography remaining significant (Figure 38). The Russian school is more oriented to Geographic (Thematic) Cartography more than any other school. German schools emphasize Digital Cartography subjects nowadays. It could be observed how the Dresden school changed from being oriented to General and Thematic Cartography to the Digital as a kind of school “in-between” Russian and German. Both French and American taught more courses in General Cartography, but French also offers courses in Geographic (Thematic) Cartography. Cartographic Design is only taught nowadays in Moscow and Wisconsin, and Mathematic Cartography – in Moscow. The last one is decreased everywhere over the observed period, probably because of GIS.

The curricula are developing over time, there are common trends in their development such as the increasing role of the geoinformation discipline – some subjects transit from cartographic discipline to geoinformatics, and cartographic subjects are decreasing. Another trend is the orientation to Digital Cartography including Geovisualization and the application of cartography to the new technologies. The subjects, appeared in the Digital Cartography category might be referenced to the hype technologies such as the internet, multimedia, mobile, and other digital means of visualizations – all of them are still kinds of digital, but referring to the different trends in technology, depending on the hype, and cartography as a part of it. Moreover, in each university, the number of elective subjects

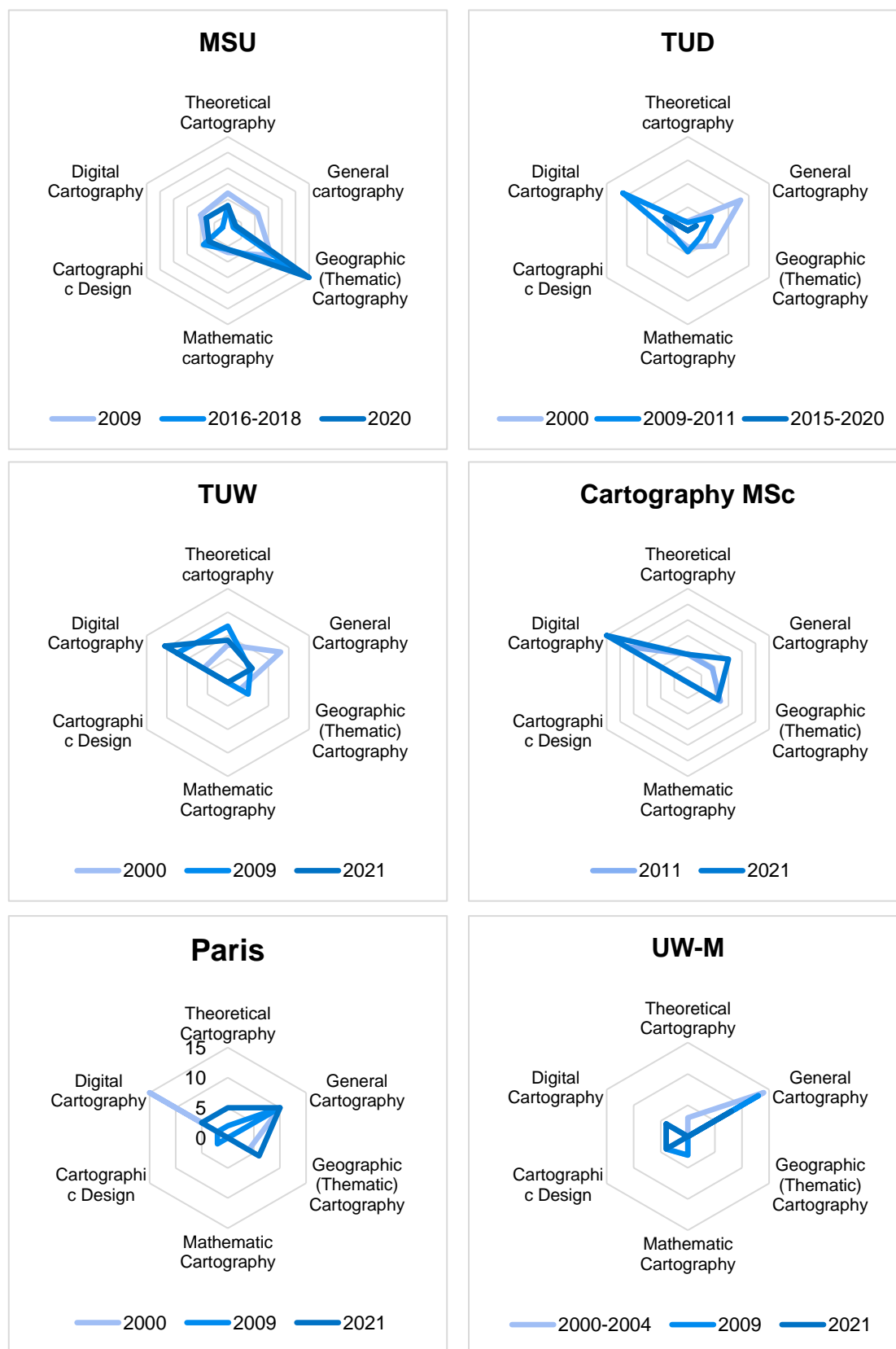


Figure 38. Cartographic subjects grouped by categories throughout 2000-2020 at different universities

Chapter 6 Synthesis

In the second half of the 20th century, the schools of cartographic thought could be recognized. They were guided by prominent leaders, who established their concepts in cartographic theory, however, the outreach of most schools was limited to their language area. The schools' concepts were reflected in educational programs and the tradition of mapmaking. The schools of cartographic thought were orthodox and powerful – cartography belonged to cartographers, and the leaders of cartography defined the development of the domain. The schools interacted within the ICA, where they communicated their concepts to the world. Occasionally, controversies between schools occurred, not only due to the significant difference in theory but also to the ideological differences (between East and West) that influenced the research in different parts of the world. An example is the debates between Salishchev and Robinson. In contrast, the ideologically neutral concept of semiology influenced cartography everywhere – in both poles.

In Figure 39 the interactions between the four schools at that period are shown using the method of choremes proposed by Brunet (1986). The circles are schools of thought and they have different outline colors – red for Russian, yellow for German, blue for French, and black for American. In the grey text above each circle, there is the name of dominating paradigm. In smaller circles, there are academic centers in cartography they are labeled in black. The arrows show the interactions, expressed in the main books, they have different colors, each color corresponds to the language of the school. The dotted arrows show the interactions within a school, whereas the solid arrows show the interactions between schools. The labels in the circles show the names of the prominent scholars.

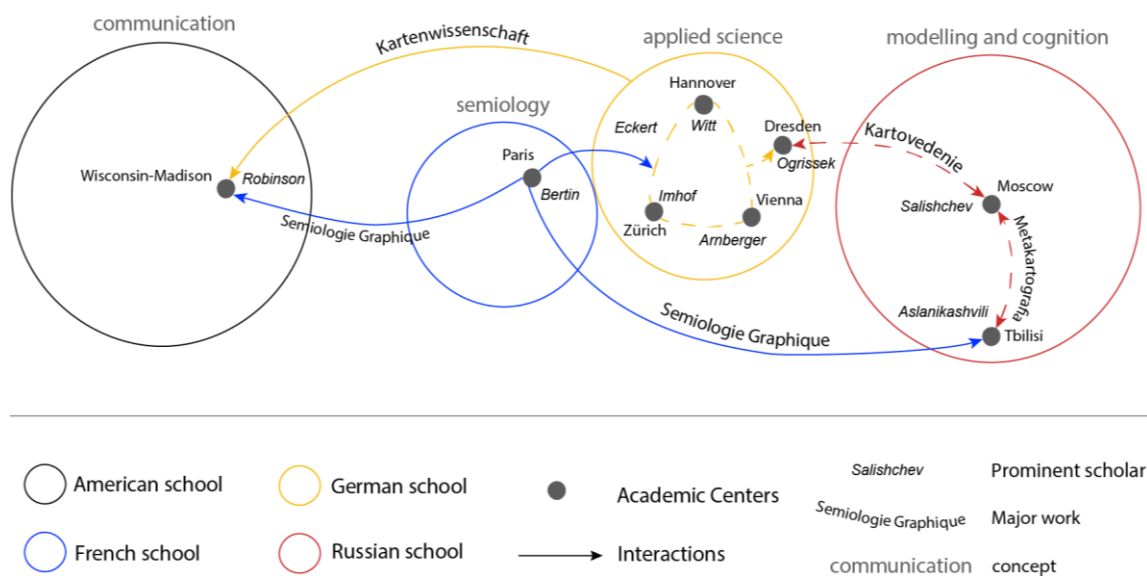


Figure 39. The interactions between schools of cartographic thought in 1960-1990

At the end of the 20th century, new developments appeared – the prominent examples are the geovisualization of MacEachren, the mixed concept of Freitag – they were the mixture of different concepts of the previous period, such as semiotics, communication, and cognition.

This proves that process of integration has started at that time – in the background of the World integration with the end of the Cold War. However, the integration did not mean unification, e. g. the German school, the developments of East Germany became a secret and therefore were not integrated with the Western into one school. Cartographers from Eastern Germany, in the end, were forced to adapt their school to the Western paradigm. The Russian school, in turn, has not adopted the development from the West, except the concept of semiotics, as it was mentioned earlier.

The main difference between the Russian and Western schools is in the understanding of cognition. Nowadays, cognitive research in cartography is one of the main directions, but the meaning/interpretation of cognition is not the same everywhere. In the American, French, and German schools of cartographic thought, it is aiming to answer how people cognize maps or cartographic visualizations. This concept is rooted in the tradition to see the map in the communicational framework, where the map is a message that should be understandable in the right way. From this perspective, the methods from psychology, such as eye-tracking, or measuring the time of map reading, are applied in cartographic research in these countries. Another reason for concentrating on the visualization concept is that in the USA, with the emergence of GIS, the analytical part of cartography is considered to be part of the GIS domain, and by some even cartography is considered to be a part of GIS.

In Russian university school cognition refers to the purpose of the map – a scientist, usually a geographer, uses a map to analyze the spatial data, to perceive the knowledge about the real world, and this knowledge is generated because of a combination of spatial information. The map itself is a secondary thing – the perception of map symbols and other studies on map cognition are not included in the scientific part of the cartographic domain. Cartographic science is not concentrated on developing successful methods of communication of spatial information, but on the spatial analysis of geographic phenomena. Here, cartography and GIS together with remote sensing are merged into one domain because they aim to answer the same research questions and objectives related to geography.

In Figure 40, the interaction between schools in the contemporary period is shown. The grey ellipse is uniting three different schools in one multiplicity of cognitive research, which is common for these three schools. The paradigm of geovisualization emerged in the US at the Penn-State University influencing cartographers worldwide. At the same time, the discipline of visual analytics made an impact. The user-experience studies continue the tradition of American and German cartographers, who followed the communicational paradigm. However, Russian cartography is more conservative, and the paradigm of cartographic modeling and cognition has not adopted the above-listed paradigms.

The role of leaders in cartography is less significant, because of social and technological development – these better ways of interaction make the ideas of any scholar available for the international audience in real-time. Before, scholars had to be recognized by fellow scientists, and only then they might have a chance to share their ideas with the world – those, who did not follow the common thinking, the school of thought of a particular leader – had no chance to be heard.

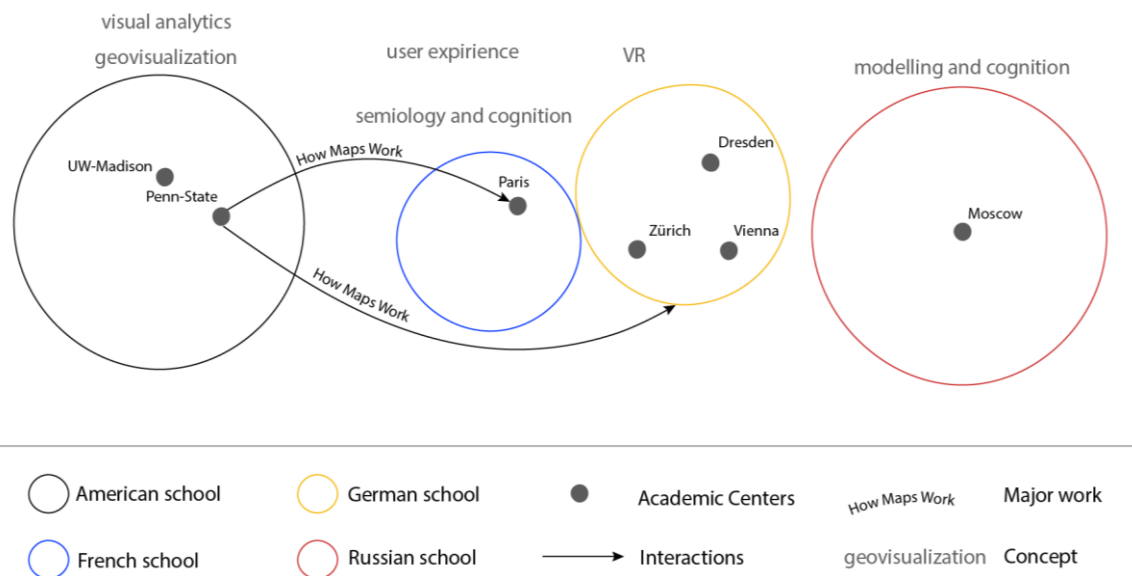


Figure 40. The interactions between schools of cartographic thought in contemporary time

The scholars from different countries cooperate in the ICA events and remotely – the ICA commissions and research groups are open for everyone. Scholars create groups of interest and collaborate, regardless of the language or nationality. The research of Kraak and Fabrikant (2017) shows, that there are more countries involved in the ICA, than ever before, although Europeans and Americans still dominate in the association. As it was noted in the interview analysis, language barriers are influencing international cooperation less, but still, the requirements for English proficiency are high, and the scholars from the non-English-speaking countries face higher efforts.

Technological development transforms schools of cartographic thought. The maps are now visualizations of spatial information in a digital form – interactive maps on the internet, VR, AR, and multi-dimensional. The new concepts, such as geographic information science, geovisualization and visual analytics, digital earth, volunteered geographic information, location-based services, emerged from cartography, geography, and computer science can be considered interdisciplinary. Cartography has always been an interdisciplinary domain, but this trend has only increased with the advancements of technologies. The ‘hype’ technologies define the future cartographic trends, which are reflected in the curricula – all scope of digital cartography disciplines. The ‘hype’ technologies and topics are reflected in the names of ICA commissions and research groups, as Kraak and Fabrikant (2017) noticed. Cartographers often visit conferences in computer science, and it was noted in the interview, that there are more computer science specialists active in the cartographic domain.

However, this does not mean that the schools of cartographic thought are dead because the differences in education and the research in the different language areas continue to be. It is suggested that schools of cartographic thought nowadays are a kind of cultural lenses – the word tradition, gathered from the survey, describes them best. French cartographers are still looking at cartography through the lens of semiotics. German cartographers – through the lens of communication – see the map as an interface. American cartographers look through the lens of communication and cognition. Russian cartographers the lens of modeling reality that serves the geographer’s needs.

A critical concept in cartography is different, it is related to the non-representational paradigm of cartography and could be considered as a kind of school of cartographic thought, but does not share the same criteria, defined in this work. It was initiated by J. B. Harley in the second half of the 20th century, but nowadays the school developed into different streams such as feminist cartography, and it includes scholars from different countries. The trend to humanism requires maps to become an inclusive practice and this became possible with the trends to open-source programs and collaborative mapping. This trend influences the academic world, some of the conversational partners noted that cartography should be seen from the different cultural perspectives – so far it was traditionally seen from the European and American perspectives. The scholars and their schools discussed here – are the most prominent in the history of cartography, but because this history was written by the people with European culture. The critical concept, although it was started as a kind of a school of thought, breaks the person-oriented idea of a school of thought as if cartography will be the open practice for everyone and there will be no authority – the schools of thought will stop existing.

Chapter 7 Conclusion and Reflections

The objective and research questions of the thesis were answered using the hybrid methodological approach. The criteria, describing the cartographic school, characteristics of the Russian, American, German, and French schools, and their interactions were discovered using the survey and interview, which were processed with the qualitative approach related to the critical philosophy of research.

A school of cartographic thought is a group of scholars who share the same ideas about the core of cartographic knowledge, education, and practice. It has three criteria of a theoretical concept, people – prominent scholars, and cartographic education. Nowadays, Western schools (German, French, American) share the cognitive-semiotic concept, but each school preserves the legacy of the previous generation. Russian school is different in a sense of research methodology – it does not study the interactions between map and human, but the modeling of geographic phenomena – a materialistic approach to cartography is preserved. There is more interaction between schools nowadays and the language barrier influence less, therefore cartographic schools of thought tend to be intermixed nowadays, and new approaches that emerge do not depend on the language and physical barriers.

The schools' developments over time were analyzed by studying the university curricula, which is related to the positivist approach. At this stage, it was discovered that technological advancements influence curricula. There is a trend of diminishing cartography subjects in the favor of GIS subjects. Theoretical subjects include the concept which is typical for the school.

Four stages of literature review, survey, interviews, and university curricula analysis helped to understand the schools of cartographic thought through the history, individual stories, and the experience of the people, involved in these schools and the formal material of curricula – the documents of schools' developments. Together, these stages give an in-depth and in-breadth overview of schools of cartographic thought in four different language areas.

Of course, these four schools were chosen as examples, and there are many schools of cartographic thought – British, Spanish, Czech, Polish, Hungarian, Chinese, etc. – in each language area. Moreover, there is also an indigenous understanding of cartography and mapmaking practice, which is still to be discovered. In that sense, the choice of schools in the thesis is Eurocentric and there is a lot of potential in discovering and describing all cartographic schools of thought in the world.

The author of the thesis is a native Russian speaker, and it was decided to give a detailed literature overview on the Russian school because most of the Russian cartographic literature has not been translated to English or other foreign languages. The literature overview of German and French schools was based on the sources in English – therefore they give a general overview, which is not comprehensive. During the interviews and surveys, more information on schools was gathered, and therefore the complete overview of schools consists of three chapters of background, survey, and interview.

The intended number of conversational partners in an ideal case should be equal from each school. However, in practice, the feedback on the invitations was different – and therefore more people from the US were willing to participate in the interview, than from any other country. Nevertheless, citations from each interview were included, but only those related to the research objective and questions. Of course, a large part of the interviews was left, and sometimes, here are more topics and questions were discussed.

The interview transcripts will be the further reading for anyone, who wants to study the different views and opinions of cartographers from a different country. It is a collection of stories, and more ideas and insights could be discovered – and everyone is welcomed to do so. Anonymization of the interviews was done with the ethical concerns in mind – some stories could be sensitive, but at the same time there was no purpose to anonymize everything, especially the information related to the country, university, the people who are person work or study with – this is the important parts of the story. Therefore, conversational partners could be recognizable by their colleagues, but hardly by the general public. All of the conversational partners gave oral permission to be recorded for research purposes.

The choice of study programs for curricula analysis was depended on the old curricula availability – they were mainly obtained through the contacts of universities staff. Numerous requests were made for the different universities, but the curricula represented are the result of these attempts. Some of the curricula, though, were discovered using an internet archive service.

The different curricula have different units of measurement of the subjects' laboriousness. The conversions made to standardize the units over time – are based on the assumptions and therefore not exact. The level of detail of each curriculum differs as well and therefore grouping subjects into categories was performed. The names of subjects can reflect different things and the subject can include different content, and the relations of the subjects to the different categories were also based on the assumptions and could not be exact. However, the research on the subjects' meaning was performed where it was possible.

Theses, research projects, and internships are an important part of the curricula, and they could add more credits to the specialization disciplines. However, the topics are often chosen by a student, in the case of theses and projects, as well as the internship could be related to the different disciplines, not necessarily to cartography. Because this part of the curriculum is individual, it is impossible to relate it to any discipline, and, therefore, it was not analyzed. However, the analysis of the subjects in the curriculum helps to understand the core of the knowledge and therefore the character of the school.

The future work on this topic might be broader and deeper research on the different schools of cartographic thought. The broader – in the global sense, and the deeper – in studying the schools' 'dialects' – centers of cartographic research and education in a different school. Further advancement will be studying cartographic techniques, which are typical for the school. Therefore, the fourth criteria of cartographic production will be added to the defined criteria of a school of cartographic thought. However, then one might operate another terminology because it will be related not only to theory but to the practice – how concepts and paradigms are reflected in mapmaking.

The main reason for studying the different schools of cartographic thought – is to facilitate the awareness of different approaches in cartography and stimulate the exchange the ideas between cartographers of the world.

References

- Alvesgaspar. (2007). *English: Waldo Tobler in front of Newberry Library, Chicago (USA)*. Own work. https://commons.wikimedia.org/wiki/File:Waldo_Tobler_2007.jpg
- Azócar, P., & Buchroithner, M. (2014). *Paradigms in Cartography*. Springer Berlin Heidelberg. <https://doi.org/10.1007/978-3-642-38893-4>
- Batuev, A. R., Kotova, T., Postnikov, A. V., & Snytko, V. (2019). I. P. Zarutskaya's contribution to cartographic research in Russia: To the 110th anniversary of her birth. *Geodesy and Cartography*, 943, 156–164. <https://doi.org/10.22389/0016-7126-2019-943-1-156-164>
- Berlyant A. M. (n.d.). Geography Faculty MSU. Retrieved August 26, 2021, from http://www.geogr.msu.ru/about/rank/element.php?IBLOCK_ID=4&SECTION_ID=0&ELEMENT_ID=837
- Berlyant Alexander Mikhaylovich. (n.d.). Letopis' Moskovskogo Universiteta. Retrieved July 19, 2021, from <http://letopis.msu.ru/peoples/4681>
- Berlyant, A. M. (n.d.-a). *Salishchev K. A.* Geography Faculty MSU. Retrieved July 19, 2021, from http://www.geogr.msu.ru/about/rank/element.php?IBLOCK_ID=4&SECTION_ID=0&ELEMENT_ID=952
- Berlyant, A. M. (n.d.-b). *Zarutskaya I. P.* Geography Faculty MSU. Retrieved July 19, 2021, from http://www.geogr.msu.ru/about/rank/element.php?IBLOCK_ID=4&SECTION_ID=0&ELEMENT_ID=937
- Berlyant, A. M. (1994). Theoretical Concepts in Cartography. *Mapping Sciences and Remote Sensing*, 31(4), 279–287. <https://doi.org/10.1080/07493878.1994.10641973>
- Berlyant, A. M., Lurie, I. K., Tutubalina, O. V. & Chalova E. R. (2009). A Concept of Innovative University Education in Geographical Cartography. *Vestnik Moskovskogo universiteta. Seriya 5, Geografija.*, 6-12. <https://cyberleninka.ru/article/n/kontseptsiya-universitetskogo-innovatsionnogo-geografo-kartograficheskogo-obrazovaniya>
- Brunet, R. (1986). La carte-modèle et les chorèmes. *Mappemonde*, 86(4), 2–6.
- Cartography and Geographic Information Systems, B.S.* (n.d.). University of Wisconsin-Madison. Retrieved September 1, 2021, from <https://guide.wisc.edu/undergraduate/letters-science/geography/cartography-geographic-information-systems-bs/>
- Cartography and Geographic Information Systems, M.S.* (n.d.). University of Wisconsin-Madison. Retrieved September 1, 2021, from <https://guide.wisc.edu/graduate/geography/cartography-geographic-information-systems-ms/>
- Cartography and Geoinformation (Master)*. (n.d.). University of Vienna. Retrieved September 1, 2021, from <https://studieren.univie.ac.at/en/degree-programmes/master-programmes/cartography-and-geoinformation-master/>
- COGIT Laboratory. (2018, November 16). ENSG, the School of Geomatics. <https://www.ensg.eu/COGIT-Laboratory>
- DiBiase, D., DeMers, M., Johnson, A., Kemp, K., Luck, A. T., Plewe, B., & Wentz, E. (Eds.). (2006). *Geographic information science and technology body of knowledge* (1st ed). Association of American Geographers.

- Fabrikant, S. I. (2003). Commentary on “A History of Twentieth-Century American Academic Cartography” by Robert McMaster and Susanna McMaster. *Cartography and Geographic Information Science*, 30(1), 81–84. <https://doi.org/10.1559/152304003100010965>
- Fairbairn, D. (2014). Issues in Cartographic Education: How and How Many? In *Cartography from pole to pole* (pp. 461–470). Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-32618-9_33
- Fairbairn, D. (2018). Creating a Body of Knowledge for cartography. *Proceedings of the ICA*, 1, 35. <https://doi.org/10.5194/ica-proc-1-35-2018>
- Fraser, D., Zentai, L., & Brandalize, M. (2011). *The Changing Face of Cartographic Education and Training*. Proceedings of the 25th International Cartographic Conference, Paris. https://icaci.org/files/documents/ICC_proceedings/ICC2011/Oral%20Presentation%20PDF/B2-Education%20and%20training/CO-113.pdf
- Freitag, U. (1989). The state of cartography in the Federal Republic of Germany. *Cartography Past, Present and Future: A Festschrift for FJ Ormeling*, p. 65–77.
- Freitag, U. (1993). 1993 Jaques Bertin. *Deutsche Gesellschaft für Kartographie e.V.* <https://www.dgfk.net/1993-jaques-bertin/>
- ICA Working Group. (2021). *Terms of Reference*. Cartographic Body of Knowledge. <https://bok.cartography.no/sample-page/>
- In Memoriam – Kira B. Shingareva. (2013, September 17). ICA Commission on Planetary Cartography. <https://planetcarto.wordpress.com/2013/09/17/in-memoriam-dr-kira-b-shingareva/>
- van den Hoonaard, W. C. (2013, September 17). Kira B. Shingareva (1938–2013). *International Cartographic Association*. <https://icaci.org/kira-b-shingareva-1938-2013/>
- Kitchin, R., Perkins, C., & Dodge, M. (2011). Thinking about maps. In *Rethinking Maps* (pp. 19–43). Routledge. <https://doi.org/10.4324/9780203876848-7>
- Koch, W. G. (2013). Training Paths in Cartography and Geomatics in Germany, Austria and Switzerland. *KN - Journal of Cartography and Geographic Information*, 63(3), 181–187. <https://doi.org/10.1007/BF03546132>
- Konecny, Ormeling, & Tikunov. (2005, November 20). Centenary of the birth of Konstantin Alexeevich Salishchev (1905–1988). *International Cartographic Association*. <https://icaci.org/centenary-of-the-birth-of-konstantin-alexeevich-salishchev-1905-1988/>
- Kraak, M.-J. (2018, May 21). Cartographic Body of Knowledge International Cartographic Association. *International Cartographic Association*. <https://icaci.org/presidents-blog-cartographic-body-of-knowledge/>
- Kraak, M.-J., & Fabrikant, S. I. (2017). Of maps, cartography and the geography of the International Cartographic Association. *International Journal of Cartography*, 3(sup1), 9–31. <https://doi.org/10.1080/23729333.2017.1288535>
- Lurie, I. K. (2011). Innovations in cartography from Lomonosov to the present (In Russian; English abstract). *Vestnik Moskovskogo universiteta. Serija 5, Geografija.*, 55–60.
- Lurie, I. K. & Prasolova, A. I. (2017). University cartographic education in an era of change (In Russian; English abstract). *Geodesy and Cartography*, 4–15. DOI: 10.22389/0016-7126-2017-4-15
- MacEachren, A. M. (2013). Cartography as an Academic Field: A Lost Opportunity or a New Beginning? *The Cartographic Journal*, 50(2), 166–170. <https://doi.org/10.1179/0008704113Z.000000000083>

- Master parcours Carthago* (fr). (2021, July 20). Offre de formation - Université Paris 1 Panthéon-Sorbonne. <https://formations.panthéonsorbonne.fr/fr/catalogue-des-formations/master-M/master-geographie-KBUW66GE/master-parcours-carthago-KBUW66XE.html>
- McMaster, R., & McMaster, S. (2002). A History of Twentieth-Century American Academic Cartography. *Cartography and Geographic Information Science*, 29(3), 305–321. <https://doi.org/10.1559/152304002782008486>
- Montello, D. R. (2002). Cognitive Map-Design Research in the Twentieth Century: Theoretical and Empirical Approaches. *Cartography and Geographic Information Science*, 29(3), 283–304. <https://doi.org/10.1559/152304002782008503>
- Muller, J. C. (1996). Cartographic curriculum and trends in German universities: What they are and what they could be. *Cartographica*, 33(3), 15.
- Ormeling, F. (2015). Academic Cartography in Europe. In M. Monmonier (Ed.), *The History of Cartography* (Vol. 6, pp. 6-13). The University of Chicago Press. https://press.uchicago.edu/books/HOC/HOC_V6/Volume6.html
- Ormeling, F. (2008). Mapping the Changes in Cartographic Education in the Last 50 Years. *KN - Journal of Cartography and Geographic Information*, 58(4), 178–185. <https://doi.org/10.1007/BF03543984>
- Ormeling, F. J. (1986, December 31). Eduard Imhof (1895–1986). *International Cartographic Association*. <https://icaci.org/eduard-imhof-1895-1986/>
- Ormeling, F. J. (1992). Brunet and the revival of French geography and cartography. *The Cartographic Journal*, 29(1), 20–24. <https://doi.org/10.1179/caj.1992.29.1.20>
- Otogi. (2021). *English: Professor Alexander Aslanikashvili*. Own work. https://commons.wikimedia.org/wiki/File:Alexander_Aslanikashvili.jpg
- Palsky, G. (2011). *Map Design vs. Semiology Graphique. Reflections on Two Currents of Cartographic Theory*. Proceedings of the 25th International Cartographic Conference, Paris. https://icaci.org/files/documents/ICC_proceedings/ICC2011/Oral%20Presentation%20PDF/A4-Jacques%20Bertin%20and%20graphic%20semiology%202/CO-056.pdf
- Palsky, G. (2019). Jacques Bertin, from classical training to systematic thinking of graphic signs. *Cartography and Geographic Information Science*, 46(2), 189–193. <https://doi.org/10.1080/15230406.2018.1523026>
- Paradigm. (2021a). In *Merriam-Webster.com*. Retrieved June 17, 2021, from <https://www.merriam-webster.com/dictionary/paradigm>
- Paradigm. (2021b). In *Cambridge Dictionary*. Retrieved September 3, 2021, from <https://dictionary.cambridge.org/dictionary/english/paradigm>
- Peters, S., Krisp, J., & Meng, L. (2009, November 21). *Development of an International Master Program in Cartography and Geoinformatics*. ICC – 24th International Cartographic Conference, Santiago de Chile.
- Reimagining Maps*. (n.d.). ESRI. Retrieved September 1, 2021, from <https://www.esri.com/news/arcuser/1010/lookofmaps.html>
- Rubin, H., & Rubin, I. (2005). *Qualitative Interviewing (2nd ed.): The Art of Hearing Data*. SAGE Publications, Inc. <https://doi.org/10.4135/9781452226651>
- Rubin, H. & Rubin, I. (2012) *Qualitative Interviewing: The Art of Hearing Data. 3rd Edition*, Sage Publications, Thousand Oaks.
- Salishchev Konstantin Alexeevich*. (n.d.). Letopis' Moskovskogo Universiteta. Retrieved July 19, 2021, from <http://letopis.msu.ru/peoples/3556>
-

- Scharfe, W. (1986). Max Eckert's "Kartenwissenschaft". The Turning Point in German Cartography. *Imago Mundi*, 38, 61–66.
- Schewtschenko, V., Strauhmanis, J., & Wolodtschenko, A. (2017). Über die kartographischen Traditionen an den Universitäten in Dresden, Kyiv und Riga: Eine vergleichende Analyse (1991-2011). *Meta-Carto-Semiotics*, 5(1), iii–vi.
- Schmelhaus, F. (1922). *Imhof, Eduard (1895-1986)* [Fotografie: Silbergelatine-Abzug]. ETH Library. [https://commons.wikimedia.org/wiki/File:ETH-BIB-Imhof, Eduard \(1895-1986\)-Portr_00154.tif](https://commons.wikimedia.org/wiki/File:ETH-BIB-Imhof,_Eduard_(1895-1986)-Portr_00154.tif)
- Schmidt, M. (2015, August 26). ICA Awards Ceremony #icc2015rio. *International Cartographic Association*. <https://icaci.org/ica-awards-ceremony-icc2015rio/>
- School. (2018, December 2). ENSG, the School of Geomatics. <https://www.ensg.eu/School>
- School. (2021a). In *Cambridge Dictionary*. Retrieved April 9, 2021. <https://dictionary.cambridge.org/us/dictionary/english/school>
- School. (2021b). In *Merriam-Webster.com*. Retrieved June 17, 2021, from <https://www.merriam-webster.com/dictionary/school>
- School of thought. (2021). In *Cambridge Dictionary*. Retrieved April 9, 2021. <https://dictionary.cambridge.org/us/dictionary/english/school-of-thought>
- UCGIS. (n.d.). *Welcome to the GIS&T Body of Knowledge!* GIS&T Body of Knowledge. Retrieved June 29, 2021, from <https://gistbok.ucgis.org/bok-basic-page/welcome-gist-body-knowledge>
- Vladimir Sergeevich Tikunov. (n.d.). Geodesy and Cartography. Retrieved July 19, 2021, from https://geocartography.ru/en/editorial_board/vladimir-sergeevich-tikunov
- White, T. M. (2018). View of The George F. Jenks Map Collection. *Cartographic Perspectives*, 91, 114–121. <https://doi.org/10.14714/CP91.1516>
- Wikle, T. A., & Sinton, D. S. (2021). Where have the cartographers gone? The status of cartography instruction within U.S. geography departments and programs. *Cartography and Geographic Information Science*, 48(2), 140–150. <https://doi.org/10.1080/15230406.2020.1852971>
- Wolodtschenko, A. (2017). Quo vadis classic cartosemiotics & quo vadis theoretical cartography? *Meta-Carto-Semiotics*, 4(1), 26–43.
- Zarutskaya Irina Pavlovna. (n.d.). Centr geodezii, kartografii i infrastruktury prostranstvennykh dannych. Retrieved July 19, 2021, from <https://cgkipd.ru/75-years-day-of-Victory/posle-voini/zarutskaya/>

Appendix 1

SURVEY:

https://kartoweb.itc.nl/msc-carto-thesis/materials/olesia_ignateva/

Appendix 2

Interview outline

The sample list of interview topics

1. The features of the school of thought that you belong to
 - ☐ Scholars influenced you at the beginning of your scientific career and now
 - ☐ The role of critical cartography in creation of better maps
 - ☐ The curricula for cartography higher education you would design

2. Interactions with the other cartographic schools of thought
 - ☐ Awareness of different approaches in cartography in other countries
 - ☐ Scientific cooperation with colleagues from different countries
 - ☐ Global trends that influence cartographic teaching and research

Appendix 3

INTERVIEW TRANSCRIPTS:

https://kartoweb.itc.nl/msc-carto-thesis/materials/olesia_ignateva/

Appendix 4

CURRICULA AND CHARTS:

https://kartoweb.itc.nl/msc-carto-thesis/materials/olesia_ignateva/