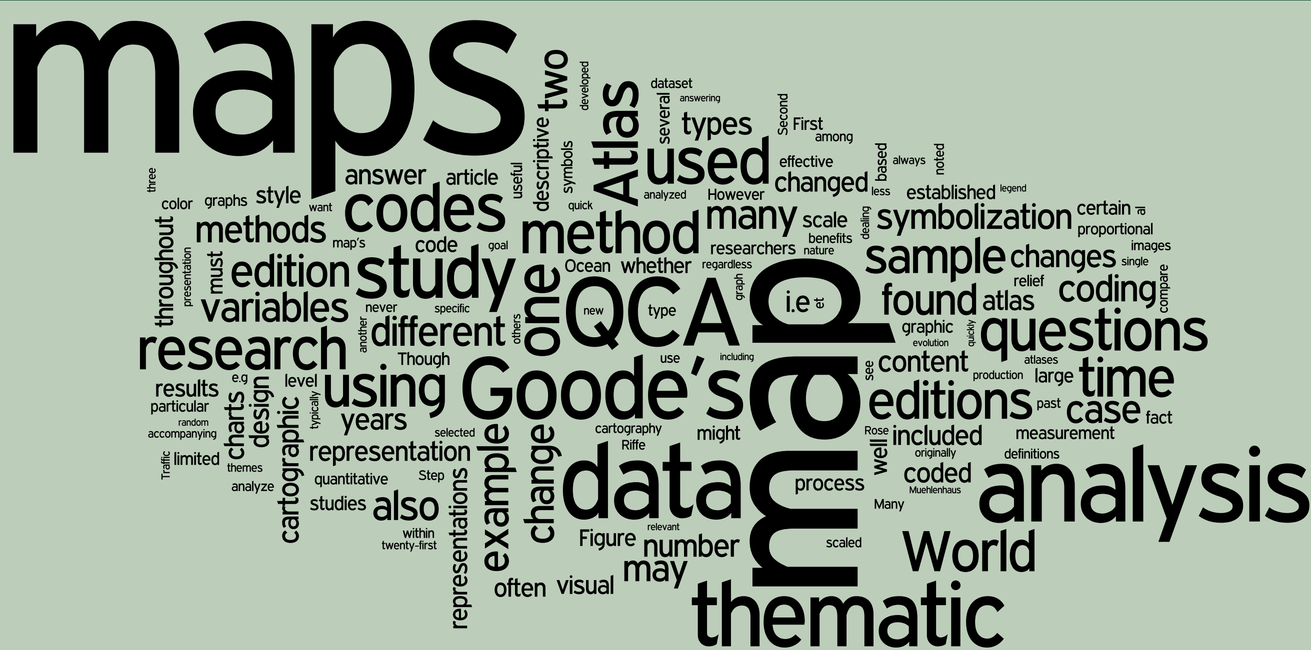
Another Goode Method: How to Use Quantitative Content Analysis to Study Variation in Thematic Map Design

Ian Muehlenhaus | imuehlenhaus@uwlax.edu
University of Wisconsin—La Crosse
Department of Geography and Earth Science



ABSTRACT

Many methods have been embraced to analyze maps and compare them with one another. One method that has not been regularly used to study thematic maps is quantitative content analysis (QCA). QCA is an established scientific method that is exceptional for longitudinal and large sample studies of media images. Using a sample of thematic maps from *Goode's World Atlas* as an example study, this article does two things. First, it demonstrates the benefits and drawbacks of using quantitative content analysis to study the evolution of thematic map design. Thematic maps were selected from the past 80 years of *Goode's World Atlas* and analyzed using QCA to see if and how their thematic and cartographic representations have evolved over time. Second, this article walks the reader through the process of setting up and using QCA to count, measure, and compare cartographic differences and changes in a map sample. Each step of the QCA process is explained, to help readers embrace the method in their own map research. Best practice advice is described throughout the case study. The article concludes with a synopsis of the benefits and pitfalls of using this method.

KEYWORDS: Quantitative content analysis, *Goode's World Atlas*, thematic cartography, methodology

INTRODUCTION

Numerous methods have been embraced over the years to study the history and evolution of thematic map design. Many of these methods have been descriptive. Research on thematic map symbolization in particular is typically episodic and non-cumulative; a single or small sample of maps is often analyzed and summarized in a manner resembling the discussion of fine art. An example of this is Robinson's (1982) empirical overview of the development of thematic cartography. Though insightful and more extensive than many other studies, it is neither systematic in its analysis nor very precise in its conclusions.

One method that has not regularly been used in the study of map history is content analysis. Largely ignored in cartography, *quantitative content analysis* (QCA) is not only a viable method for comparing map design over time (Muehlenhaus 2011), but may prove useful in examining changes in thematic map design. In particular, it is argued that QCA can be used to achieve the following analytical objectives (Muehlenhaus 2010):

1) Count and measure the number of particular data and graphic elements found on a multitude of maps for comparison by publisher;
2) Allow for the relatively quick analysis of a large sample of maps simultaneously;
3) Allow for the quantitative comparison of different compositional traits among maps in a sample; and
4) Allow us to quantitatively measure and compare data longitudinally (e.g., changes in map styles and techniques as they occur throughout time).

Largely ignored in cartography, quantitative content analysis (QCA) is not only a viable method for comparing map design over time (Muehlenhaus 2011), but may prove useful in examining changes in thematic map design

The goal of this article is twofold. First, it will illustrate the usefulness and drawbacks of using this method on a series of thematic maps published over the past 80 years in the *Goode's World Atlas*. Second, it will provide a practical introduction of this method to other researchers who may be interested in using QCA to study their own map sets.

The rest of this article proceeds as follows: first, QCA is defined and its core methodological concepts are reviewed. Then, using this method, the reader is taken step-by-step through an analysis of changes in symbolization and representation found in certain thematic maps from *Goode's World Atlas* throughout the past 80 years. Throughout this case study, care is taken to point out key parts of the methodological process and to highlight several of the potential pitfalls and nuances researchers may come across. The article concludes with a critical review of the benefits, drawbacks, and limitations of using this method for historical map analysis.

WHAT IS QUANTITATIVE CONTENT ANALYSIS?

Content analysis was originally designed to help researchers discern patterns, themes, and repetition within and across numerous text documents. It has since evolved into an established method for analyzing media images, as well.

For example, it has been used by geographers to critically analyze images in *National Geographic Magazine* (see for example Lutz and Collins 1993), iconic maps (Edsall 2007), and the genealogy of persuasive maps (Muehlenhaus 2011). As opposed to other methods of deconstruction, which often concentrate on uncovering different contested meanings and representations in a single or handful of visual image(s), content analysis is useful for answering research questions about the nature of many images at once (Riffe, Lacy, and Fico 1998; Rose 2007). In many cases, it also allows for the statistical analysis of map elements and data types within a dataset.

There are two broad types of content analysis: qualitative and quantitative (Krippendorff 2004). *Qualitative content analysis* is less concerned with counting differences within data samples and more interested in drawing parallels between objects (Rose 2007). In contrast, QCA is a particular method of content analysis primarily used for the analysis of visual media (Riffe et al. 1998). Riffe et al. (1998, 20) summarize QCA as:

> "…the systematic and replicable examination of symbols of communication, which have been assigned numeric value according to valid measurement rules, and the analysis of relationships involving those values using statistical methods…"

Research questions fuel the method in QCA. Before analysis begins, one must know what one is seeking to answer about the data sample (Krippendorff 2004; Riffe et al. 1998). For example, if using QCA on a series of weather maps, researchers need to know what they are looking for on the maps before beginning. If analysts were exploring how weather patterns are represented on maps differently depending on what country a map is published in, they would likely spend time focusing on two key components: (1) each map's country of origin, and (2) what type of map symbolization was used. The importance of determining the country of each map's origin is self-evident. Researchers could not compare one country's maps to another without this information. On the other hand, if the research question is about different weather pattern symbolization, analysts would be foolish to spend time critiquing each map's use of a graticule. Researchers using QCA can limit and specifically define the scope of their analysis via a process called coding.

QCA is dependent upon clearly defined codes (categories). Codes are the operational rules that specify the definitions and intensities of different components in the maps being analyzed. The goal of using codes is twofold: (1) to systematically evaluate and analyze each map in the *exact same manner* so that the results can be compared; and (2) to allow for additional analysis by other researchers in the future. Whereas most qualitative approaches are non-replicable due to the nature of their anecdotal descriptors (e.g., what one person labels "provocative" another may label "tame"), QCA defines, identifies, and quantifies the attributes of nominal data. Essentially, it makes it possible to compare apples to oranges.

For the method to be useful, codes must be explicitly developed and rigorously applied to the maps. Once codes are established, one can go through a series of maps and analyze each one systematically using the same, pre-defined codes. With well-defined codes, anyone trained in the coding should be able to replicate the results of the original analyst. In the end, one can perform quantitative analysis on different images using the codes as the variables of analysis. For example, if a researcher wanted to explore how *Goode's Atlas* symbolized world population on its maps, and whether this symbolization changed at all depending on the edition number, a map symbolization code would be created. This map symbolization code would be defined by established cartographic symbolizations as found in the literature. Then, each map in the sample would be evaluated for its symbolization, and the resulting code for each map would be one of the cartographic symbolizations—such as choropleth, proportional symbol, cartogram, or isopleth.

Though its usefulness in large-sample, comparative studies is well-established, QCA has been critiqued for three perceived shortcomings. First, QCA *is not* capable of answering all of the questions cartographers may want to ask about maps. For example, in the case of map production, QCA focuses on the end product (i.e., the map) and completely disregards analysis of the subjective processes that are involved in the design of a map (i.e., the bias of map producers) and the cognitive steps necessary to interpret the map (i.e., the map readers). Second, regardless of how well one breaks down a map with codes, the image itself cannot be used to determine the communicative intention of the cartographer. Other methods, such as semiotics (Wood and Fels 1992), account for the receptor of the image as well as those designing the map; QCA does not. Third, the method is also incapable of highlighting how effective a map design is or how map readers interpret what is being coded. These limitations aside, however, the strength of QCA rests in the fact that it has the ability to compare, quantitatively, what is found on maps in a large dataset.

The rest of this article will walk the reader through a case study using QCA to explore how particular thematic maps in *Goode's World Atlas* have, or have not, changed throughout time. Due to the fact that *Goode's* has been produced for 80 years and has consistently mapped similar data, this atlas provides an ideal opportunity to explore QCA's usefulness as a method for the longitudinal and comparative study of thematic maps. Each methodological procedure in this case study will be accompanied by an explanation of how things have been done, as well as advice on things to think about when running your own QCA analysis in the future.

STEP 1: DECIDING ON RESEARCH QUESTIONS

Before anything else, you must know what you are trying to answer. Deciding upon your specific research questions is one of the most important decisions you will make in the research process. As will become evident, you cannot easily go back and change the questions you are investigating once you have begun. Because you will be quantifying variables deemed important in answering preselected research questions, you cannot simply use the collected data to infer correlation or causation in other arenas. Be certain that you are asking all of the research questions you want to answer; research questions should never be formulated after your analysis is done.

Assuming you only have weeks or months to devote to this project, not years, coming up with research questions that are limited in scope can be a real time saver. If you are truly interested in only one dimension of map change, you can limit what variables you look for to those dealing with this facet of cartography, saving massive amounts of time and energy.

For this particular case study, two questions were proposed:

1. Did the style and types of thematic representations used in *Goode's World Atlas* change dramatically over eight decades?

2. If so, in what ways and when (i.e., were there any trends among the maps)? If not, which styles and representations remained consistent?

Obviously, if you are investing a large amount of time in the research, or if your dataset is large, you may want to ask more questions than are proposed here. However, given the context of this exploratory project, these two questions were deemed adequate.

This research was originally conducted for a 20-minute presentation at a conference session dealing with the 80th anniversary of *Goode's World Atlas.* Whereas other session presenters were tasked with reviewing the biography of John Paul Goode (the atlas's founder), the complexities of transitioning an atlas from the darkroom to digital databases, and the future of the atlas, my role was to review how map presentation and symbolization have changed in the atlas over the past 80 years. Given the time constraints, both in the amount of time available to complete the study and the brevity of the presentation, I limited the study to the two questions above. As I was not certain what aspects of thematic cartography may have changed in 80-plus years of atlas production, the questions were left vague enough to encompass any variations dealing with thematic symbolization and map presentation—or what I call "style" in the research questions. More specific research questions than these will be preferable in most circumstances.

I also limited my research to thematic maps for several reasons. First, the amount of maps that could be selected from any *Goode's World Atlas* was very large, and the time for presentation limited; I needed to limit the scope of the analysis. Second, after a qualitative assessment of the atlases, it was determined that aside from toponym and border changes, reference maps in *Goode's Atlas* were less prone to dramatic presentation and symbolization change. Of course, in the future, one might conduct a separate study on reference maps in *Goode's World Atlas* and compare the results.

STEP 2: SAMPLING MAPS

Different studies will call for different sampling techniques. Ideally, random samples should be used. However, the ability to select random samples of maps will vary from project to project. Sometimes random samples will not allow you to answer the questions you are exploring. In many cases, convenience samples or selective sampling must be used. This is acceptable, as long as you mention this in your analysis and realize that different types of sampling will have implications on the veracity of your results (Riffe, et al. 1998). It is particularly important to note that if a sample is not randomly selected, it is impossible to infer your results upon a larger population of maps.

As for this case study, there were actually two sampling procedures. First, the selection of atlases was a convenience sample, as not every edition of the atlas was available to me. Thematic maps were selected from the 1923, 1939, and 1950 editions of *Goode's School Atlas,* as well as the tenth (1957), eleventh (1960), thirteenth (1970), fourteenth (1974), sixteenth (1982), nineteenth (1995), twenty-first (2005), and twenty-second (2010) editions of the *Goode's World Atlas.*[1]

Nominal Level of Measurement
North American Vegetation
European Languages
Predominant Economies
Ocean Currents
Interval Level of Measurement
Asia Level of Measurement
World January Temperatures
Ratio Level of Measurement
Import/Export
Wheat
Coffee
Copper
Population Density
Petroleum/Energy/Production
Ocean Traffic

Table 1. Maps that were coded from the different versions of Goode's World Atlas

After analyzing the table of contents from each of these editions, thematic maps were selected for analysis based on whether or not they were found in all, or nearly all, of the editions (i.e., a selective sample). An attempt was also made to find thematic maps that used different levels of measurement—e.g., nominal, interval, and ratio level data. (Ordinal data was excluded due to a lack of thematic maps having data with this level of measurement.) The purpose of choosing maps based on levels of measurement was that different levels of measurement often require different types of symbolization (MacEachren 1994, 1995). As symbolization is one of the key components in my research questions, it was necessary to look at as many types of potential symbolization as possible. The following 13 maps in Table 1 were chosen and analyzed in each atlas that contained them:

Again, a random sample would have been ideal, but that may have also precluded answering my questions. If only nominal or ratio level maps were selected, for example, I would be missing other important varieties of map that use alternative forms of representation.

[1] The atlas was originally entitled *Goode's School Atlas,* but all editions are referred to as *Goode's* or *Goode's World Atlas* throughout the rest of this article.

STEP 3: DEVELOPING ANALYTICAL CODES

Developing codes—i.e., strict definitions of what you will be looking at in your map sample—is the most crucial facet of any content analysis

Developing codes—i.e., strict definitions of what you will be looking at in your map sample—is the most crucial facet of any content analysis. To ensure that the method will help answer the questions being asked, codes must fulfill three obligations (Rose 2007, 64–67). First, the coding must be extensive—any aspect of a map that is relevant to answering the research question should be coded for (Riffe, et al. 1998; Rose 2007). Second, each code must be exclusive (Riffe et al. 1998; Rose 2007). An aspect of a map that has been coded for already cannot be coded for again, or some maps might be counted twice in the final analysis. (This is particularly likely to occur when running cross-tabulations.) Finally, the codes must be enlightening (Rose 2007); they must break down the maps in a manner that is analytically relevant and interesting. Much time and consideration should be put into creating codes that: (a) account for every variable that may play a role in the questions you are hoping to answer; (b) are indigenous from one another; and (c) can actually help you answer your questions.

These codes were developed based off of the researcher's knowledge and previous research in cartographic design. Many of the codes were borrowed or adapted from those developed and tested by Muehlenhaus (2010, 2011) in his comprehensive study of persuasive cartographic manipulations. Other codes were based on what is often considered standard practice in Western atlases. For example, some atlases include data sources with their maps, whereas many do not. Thus, a code was developed to determine whether or not data sources were included with *Goode's* maps, and whether inclusion or exclusion changed by edition. After looking through many editions of *Goode's*, codes specifically relevant to this publication were also developed. For example, comparing the color and layout conformity of many maps to one another within a given edition, it was interesting to notice that title placement and style seemed to vary widely across and within editions. It was assumed, correctly, that coding for title placement and style might highlight specific changes in the large dataset.

Your codes *cannot* be specific enough; you must write down thorough definitions of each to refer to when questions arise during the coding process. (And questions will arise!) Once your analysis begins, strict adherence to the codes' definitions is crucial to the integrity of your study. To make sure that the codes are vigorous enough for large sample coding, it is advisable to conduct several pilot studies. Often a code you create while dreaming up a research project actually does not have any legitimacy or is so poorly defined as to be worthless. By conducting pilot studies, you can easily go back and rectify codes that need reworking, rethinking, or deleting. You can also add new codes that you had not previously thought relevant.

In this case study, I was interested in analyzing the thematic representations and symbolizations of maps in my sample. Thus, the codes I devised (see Table 2) dealt with a variety of data and graphic traits that were found to some degree in each and every map. I tested my codes on a variety of random

Codes	Definitions
Map Edition	The edition number that the map appeared in.
Map Name	The name of the map according to the table of contents.
Map Page Number	The page(s) in the atlas on which the map was found.
Level of Measurement of Data Being Mapped	The level of measurement that the thematic data is provided in. The definitions of these levels are listed below.
Nominal Data	Measurement that involves grouping/categorization of thematic data but no ordering.
Ordinal Data	Measurement that involves both categorization and ordering of thematic data.
Interval Data	Measurement that involves both an ordering of thematic data and a specific numerical difference among categories.
Ratio Data	Measurement that involves an ordering of thematic data, includes a specific numerical difference among categories, and has an absolute zero.
Number of Themes	The number of themes shown on the map, determined by counting the number of themes referred to in the title and/or legend.
Number of Representations	The number of different cartographic representations used on the map. The types of representations accounted for are based on the definitions provided in the front matter of *Goode's Atlas* Editions 10 and 22. The types of representations included in this study were: Area Classification; Dot; Flow; Isoline; Proportional Symbol; Range Graded Symbol; Pie Chart; Choropleth; and Cartogram.
List of Representations Used on Each Map	A list of the types of representations (based on the definitions found in the list above) present on each map.
Number of Visual Variables	The number of visual variables used to actually map the thematic data. The visual variables that count are based on the eight variables commonly referred to in the literature (Slocum et al. 2008).
Type of Visual Variables Used	Each map was coded for which types of visual variables were used to represent the thematic data. The types coded for are defined below.
Color Hue	The use of color hue as defined in Slocum et al. 2008.
Color Lightness	The use of color lightness as defined in Slocum et al. 2008.
Color Saturation	The use of color saturation as defined in Slocum et al. 2008.
Spacing	The use of spacing as defined in Slocum et al. 2008.
Size	The use of spacing as defined in Slocum et al. 2008.
Perspective Height	The use of spacing as defined in Slocum et al. 2008.
Orientation	The use of spacing as defined in Slocum et al. 2008.
Shape	The use of spacing as defined in Slocum et al. 2008.
Arrangement	The use of spacing as defined in Slocum et al. 2008.
Lightness	The use of spacing as defined in Slocum et al. 2008.
Text	The use of text instead of, or in addition to, visual variables to highlight the quantity or category of the thematic data.
Accompanying Charts	If a map has a pie, bar, or any other type of quantitative, graphic representation of data, it is coded as having a chart. If it does not have such an item, it is coded as not having a chart.
Chart Characteristics	
Number of Proportional Symbols	The number of proportional symbol charts accompanying the map.
Number of Pie Charts	The number of pie charts accompanying the map.
Number of Other Charts	The number of other types of charts accompanying the map.
Three-Dimensional Charts?	Yes, if any of the charts are drawn using a three-dimensional perspective. No, if all of the charts accompanying the map are two-dimensional.

Map Scale	
Include a Scale Bar?	Does the map include a graphical scale bar or graticule?
Is a Map Scale Available?	Does the map include a mathematical ratio or word statement scale? Yes or no.
If so, what is it?	List the scale of the map.
Data Source Inclusion	Does the map list a data source for the thematic data being mapped (on the same page or near the same page as the map itself)? Yes, if it does include a data source. No, if no data source is printed with the map.
Legend Inclusion	Is an area clearly devoted to being a legend found on or near the map? If yes, a legend is included. If not, it has no legend.
Title Style	
Caption	Title is a caption.
Headline – Small Type	Title is at the top of the map but does not use type that is the largest text on the page.
Headline – Largest Type	Title is at the top of the map and is at least as large as the rest of the text on the page.
Title in Legend	The map title is inside of the legend or appears to be the title of the legend itself.
No Title	The map has no title associated with it.
Colors	
Number of Colors	Number of different hues used on the map. Hues are limited to the following generic colors: black (80% K or more); gray (79% K or less); blue; brown; green; orange; purple; red; white; yellow; and other.
Colors Included	A list of all the colors found on the entire map, not just the symbolizations of thematic data. The definitions of these colors are based on those above (in Number of Colors).
Base Map Projection	The type of projection used. These projection types are based off of the definitions provided in the 16th edition atlas's front matter. The projections coded for include: Albers Equal-Area; Goode Condensed; Simple Conic; Goode's Full; Lambert Azimuthal Equal Area; Lambert Conformal; Miller; Mollweide; Polyconic; Robinson; Sinusoidal; and Other.
Relief Type	The type of relief on a map was broken down into four types.
Contours	A map has contour relief if it uses isoplethic or isarithmic lines to delineate elevation.
Hachures	A map uses hachures if it represents elevation using line work that is not isoplethic or isarithmic.
Shaded Relief	A map uses shaded relief if it represents elevation using a remotely sensed image or raster shading scheme.
Other	If relief is shown but none of the other codes accurately describe the method, the map is classified as "Other."
None	A map that does not depict relief.
Map Labeling	Labeling was based on an ordinal ranking system following the definitions below.
Extensive	Labeling is common and even across the entire map, including country names, cities, oceans, and more.
Limited	Only reference cities and meridians are labeled. Fewer than 15 countries can be labeled.
Extremely Limited	Labeling of meridians and up to five additional objects only (e.g., cities, seas, islands, etc.). No countries are labeled.
None	No labels whatsoever. Simply a base map with a thematic representation occurring over it.

Table 2. Codes and their definitions

maps collected from different atlases. I quickly discovered which codes I might want to add and which may not be so relevant. For example, I originally did not have any code for map labeling. However, during my preliminary coding tests I soon realized that different thematic maps from different editions used labeling differently.

For the sake of an organized analysis, I broke down the codes into two separate categories—data model variables, and graphic variables—based on what they were identifying in each map. Data model variables are those that are influenced by the geographic nature of, and cartographic decisions made with, the data being mapped. For example, a map's projection, orientation, data level of measurement, and classification scheme would all be data model variables. These have less to do with the graphic representation of the map but are typically manipulations of the data themselves. You do not necessarily need to divide your codes into categories, but for the sake of this write-up and my analysis, I found it helpful to break codes down into these groups by the cartographic traits they were being used to analyze.

GOODE'S WORLD ATLAS DATA MODEL VARIABLES

The first place to start was with each map's projection. Obviously, this was typically Goode's Homolosine Interrupted Projection. Next, each map was coded for whether it included a map scale, either via scale bar, written sentence, or ratio—or two or more of these methods. It was also noted whether each map provided a data source for the data being mapped. The number of themes being shown on each map was counted. For example, if a single map showed both global coffee production areas and cotton production areas, then it was coded as mapping two themes. Along with coding the number of themes, the level of measurement of each theme was also noted (using nominal, ordinal, interval, or ratio). The style of the map's title was coded as one of the following: caption, largest type, prominent but not the largest type, attached to the legend, or no clear title. Finally, the clarity and detail found in accompanying map legends was ranked using a five-point Likert scale (ranging from overly simplified to overly complex). If maps had no legend, this was noted. The specific definitions for each of these codes can be found in Table 2.

GOODE'S WORLD ATLAS GRAPHIC CODES

The maps were also coded for a variety of graphic and visual elements. If a thematic map displayed physical relief, the type of representation was noted (contours, shaded relief, hachures, or other). Place-name labels were also coded for, as well as an ordinal category describing how many were on each map (many, limited, none). In order to decipher change in color over time, colors used on both the base map and in the thematic or referential symbols were coded for. Many maps in *Goode's World Atlas* are accompanied by graphs and charts of various types. Thus, the number of charts accompanying each map was noted, as were the types of charts used (pie charts, bar charts, or other types of charts). In addition to coding for the number of thematic representations found on each map, as discussed earlier, the types of thematic representation were also noted. These codes were based on the basic types found in cartography textbooks—i.e., choropleth, proportional symbol, dot, isarithmic, and area maps (Dent, Torguson, and Hodler 2008; Slocum, McMaster, Kessler, and Howard 2008). Finally, codes were developed for the number and types of visual variables used to map thematic data on each piece. These were counted and the types noted, including: size, shape, orientation, texture, spacing, focus, color hue, color contrast, text, and color saturation. Most of these are considered standard visual variables and are found throughout the literature (Bertin 1983; MacEachren 1995; Slocum, et al. 2008). Codes should typically be based on previously established norms found in scientific literature. For example, I did not devise my own visual variable categories. By using pre-established visual variables, the results of this study can be couched within established cartographic theory. The definitions for the graphic variables can be found in Table 2.

STEP 4: THE CODING PROCESS

Consistency and concentration are the fundamental components of successful coding

The actual process of coding can be a bit mysterious. There is no ideal software for coding or one way of going through the process. Consistency and concentration are the fundamental components of successful coding, and hopefully, if you have conducted several pilot studies, you will quickly become familiar with what setting and method work best—or do not work—for you. Some people prefer to set up a spreadsheet in which to enter their codes. For this study, I created a spreadsheet in SPSS and set up labels, which allowed for quick input and output of the results. Several applications designed for content analysis can also be used (e.g., Atlas.ti). Most of these programs export to SPSS or MS Excel format as well. However, unless you have the time and ability to scan and import the images directly into the Atlas.ti program, it may not be as efficient as merely entering numbers into a spreadsheet. You can, of course, also code your results using paper and pen. Regardless of how you code, you will eventually want to import the data into a statistical software package, so be prepared to enter all of your data into a spreadsheet later on if you do not do so initially.

Once you have your software and setting established, reserve ample time to actually do the coding. Coding is mentally exhausting and is impossible to do well for long periods of time. I found that setting aside two- to four-hour timeslots was ideal. I rarely used the entire four hours, as I often lost the ability to continue after two hours. It is crucial that you remain focused while coding, as the legitimacy of your data depends on it. I have found throughout my experiences in this case study and others (see, for example, Muehlenhaus 2011), that some maps are remarkably easy to code and take no more than a few minutes. Yet others can be completely confounding and require numerous checks of code definitions. In this case, the coding took several weeks to complete. In all, 118 *Goode's* maps were coded. At least 11 thematic maps, and up to 13, from each of the editions were included. In only one case did a thematic map disappear from a newer edition and then reappear—the *Ocean Traffic* map.

Ideally, a QCA has multiple researchers coding exactly the same maps to ensure that the study is replicable. In this case study, I do not. (It should be pointed out, though, that other methods looking at the evolution of map design have had no replicability test whatsoever.) If two or more analysts agree on the codes given to the maps, the study is considered replicable. This is one of the main benefits of content analysis. If discrepancies arise, the coders can then attempt to figure out where and why their interpretations differ. Using only one coder in your study will severely limit the reliability of the results, and at least two coders are strongly recommended. The lack of a second coder is, admittedly, a major shortcoming in this specific case study and prevents me from saying that this study is replicable with any level of certainty. Having two coders would prevent this shortcoming.

STEP 5: DESCRIPTIVE ANALYSIS

After spending weeks doing data entry, one of the most satisfying moments in the entire research process is opening up your spreadsheet to see all of the rows and columns completely filled. Exhilaration can quickly turn to dismay, however, when you realize that you now have thousands of cells of data, and there is no single roadmap showing you how to answer your research questions. Congratulations; you have collected all of the pieces comprising your research puzzle. Now you must figure out how to solve it!

Fortunately, simple introductory statistics will often provide you with a wealth of knowledge about your dataset and give you clues as to where to look for answers. A lot of information can be gleaned from perfunctory descriptive statistics, such as average counts of variables, and frequency of map element occurrence. Sometimes this data proves the most insightful of all the tests you will run. If nothing else, it will quickly tell you which variables are not worth examining any further.

A quick descriptive analysis of the maps sampled from *Goode's World Atlas* shows that they follow predictable cartographic patterns. Most maps illustrated only one spatial theme per map (63% of all maps), though sometimes two themes were placed on the same map together (32% of the time). Two to five visual variables were used to highlight thematic data on 88% of the maps. The use of a scale bar was largely arbitrary (58% of maps did not have one) and generally only used on larger-scaled maps. Legends were a common feature (97% of the maps had one). The style of the titles varied slightly, but by and large it was the largest type near or over the map (46% of the sample), and when not floating by itself, attached to a legend (27%). Interestingly, 87% of the thematic maps did not show physical relief on the base map. Of those that did, more used contour shading methods (8%) than shaded relief (5%).

Labeling on *Goode's* thematic maps is rare. Across all of the years, 90% of the maps had limited, extremely limited, or no map labeling. Offsetting this outcome even more was the fact that relief maps of Asia comprised almost all of the maps with more than limited labeling on them. Surprisingly, only 27%

of maps provided any data reference or source. Also, many of the maps do not change at all from edition to edition—sometimes not even once over the course of 30 years. Lacking data sources, and showing little visible change in the representation of the data, it might be argued that the major change found among different versions of the atlas is the edition number on the binding. However, as will be shown in the next section, stopping analysis here would have missed several interesting evolutions the editions have gone through.

Supplemental information graphics were also a common feature in *Goode's World Atlas,* regardless of the edition. Just over 30% of the maps sampled were accompanied by at least one proportional symbol chart. Such charts were most likely to be found individually or in groups of three (12% of the sample each). Pie charts were less common than proportional symbol charts; pie charts were only found in 14% of the maps. However, when they were used, they were always found in groups of two or more. Other types of charts were even rarer, with only 13% of maps having accompanying figures that were not pie charts or proportional symbols. Of tangential interest is the fact that not a single photograph has been published in a *Goode's World Atlas* to accompany a map, something that has not changed in recent editions, even as other atlas publishers began integrating photos with their map collections (see for example *Perthes World Atlas*).

STEP 6: CROSS-TABULATIONS AND RELATIONSHIP TESTING

Although they often tell us what we need to know about the nature of our dataset, descriptive statistics will sometimes fail to provide enough information for us to explicitly answer our questions. Depending on the nature of your research, whether you are looking for correlation or causation, more refined statistical methods will prove useful. This is what sets QCA apart from previous descriptive methods; not only can we describe what we saw on each map using descriptive statistics, but we can numerically analyze relationships among variables that we might not have noticed via descriptive analysis alone.

In this case study two cross-tabulations were done. First, each map data type (e.g., versions of the coffee production map, versions of Asian land relief, etc.) was cross-tabulated by the cartographic representations used to map the data (e.g., proportional symbols, dots, choropleth, etc.). Second, all of the coded variables were cross-tabulated by the edition numbers of the atlas to test whether and how different editions used design and data techniques differently.

Cross-tabulating the map type variable by thematic representation variable provided count data highlighting how often the thematic representations have changed over the past 80 years. Tellingly, four out of the 13 varieties of maps in this study never evolved thematically; they illustrated the data using exactly the same thematic representation. These included the *European Language* map, the *Economics/Occupations* map, the *North American Vegetation* map, and the *January Temperature* map. *Energy Production* changed the most over 80 years; this data was represented using four different methods: points, flow symbols, proportional symbols, and pie charts. Four maps changed their representations three times: *Imports/Exports*, *Population Density, Ocean Currents,* and *Wheat. Copper* shifted once in the mid-1900s, changing from point data to range-graded symbols. *Ocean Traffic* and *Asian Land Relief* also had one change in their 80 years of representation. The maps dealing with agriculture in this sample shifted from area classification maps to dot maps (i.e., the *Coffee* and *Wheat* maps). Also, several thematic maps were originally designed as proportional symbol maps, but eventually, dynamism was added to these via flow map representation (e.g., *Ocean Traffic* and *Imports/Exports*).

The number of visual variables found on maps, and how this number increases or decreases throughout time, can also be an indicator of change in graphic representation. Thus, the number of visual variables used on each map was cross-tabulated with edition numbers to see if the same data was emphasized differently. The answer was: rarely. Only three maps shifted dramatically in their use of visual variables over time; *Coffee, Energy Production,* and *Import/Export* maps had the most variation (one to five visual variables, depending on the edition). Still, none of these variations were very large, and were only noticeable due to the quantifiable nature of the analysis.

The conclusion: styles and methods of symbolization in *Goode's World Atlas* have not changed dramatically over 80 years. In fact, rather than identifying radical change, QCA was useful at providing evidence that regardless of the edition number, *Goode's World Atlas* frequently illustrates the same data in the same style. However, QCA successfully identified when an edition did go through an evolution. Such changes, though minimal, are highlighted below.

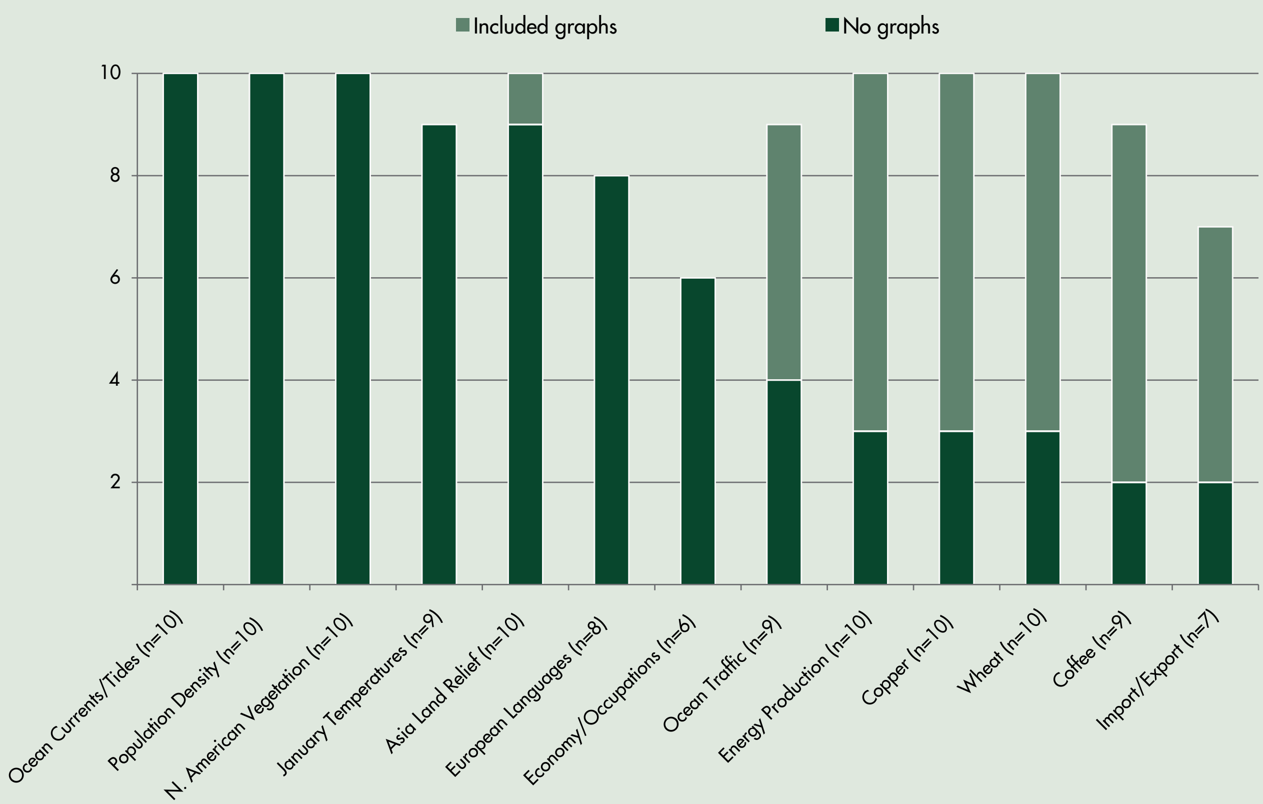


Figure 1. Frequency that each map type included at least one supplemental graph

CHARTS AND GRAPHIC ACCOUTREMENTS

Though *Goode's* thematic maps did not change much in symbolization over 80 years, there were often other graphics included with the maps that did change. Many maps were accompanied by graphs, and each map was coded for a variety of graph variables. These results showed more variability. As Figure 1 highlights, some maps had at least one graph included half the time (e.g., *Ocean Traffic* and *Import/Export*); others, only once (e.g., *Asia Land Relief*); and several, like *Coffee*, nearly always had a graph. Many maps never had an accompanying graph, including: *January Temperatures, Predominant Economies,* and *North American Vegetation*.

Graphs themselves changed via edition too. Beginning in the 1990s, graphs became increasingly three-dimensional. This design decision contravenes best practice guidelines supported by cognitive research: cognitive studies have consistently shown that humans are not very adept at comparing volumes (Ware 2004). Only in 2009 were all graphs redrawn yet again in a strictly two-dimensional form, following editorial deliberation and discussion (Veregin 2009).

The number of graphs included with each map changed depending on the edition (Figure 2). Some maps were simply never accompanied by a graph (e.g., *Ocean Currents, Population Density, January Temperatures,* and *European Languages*). Many maps, however, saw changes in the number of graphs accompanying them (including *Wheat, Ocean Traffic, Copper,* and *Energy).*

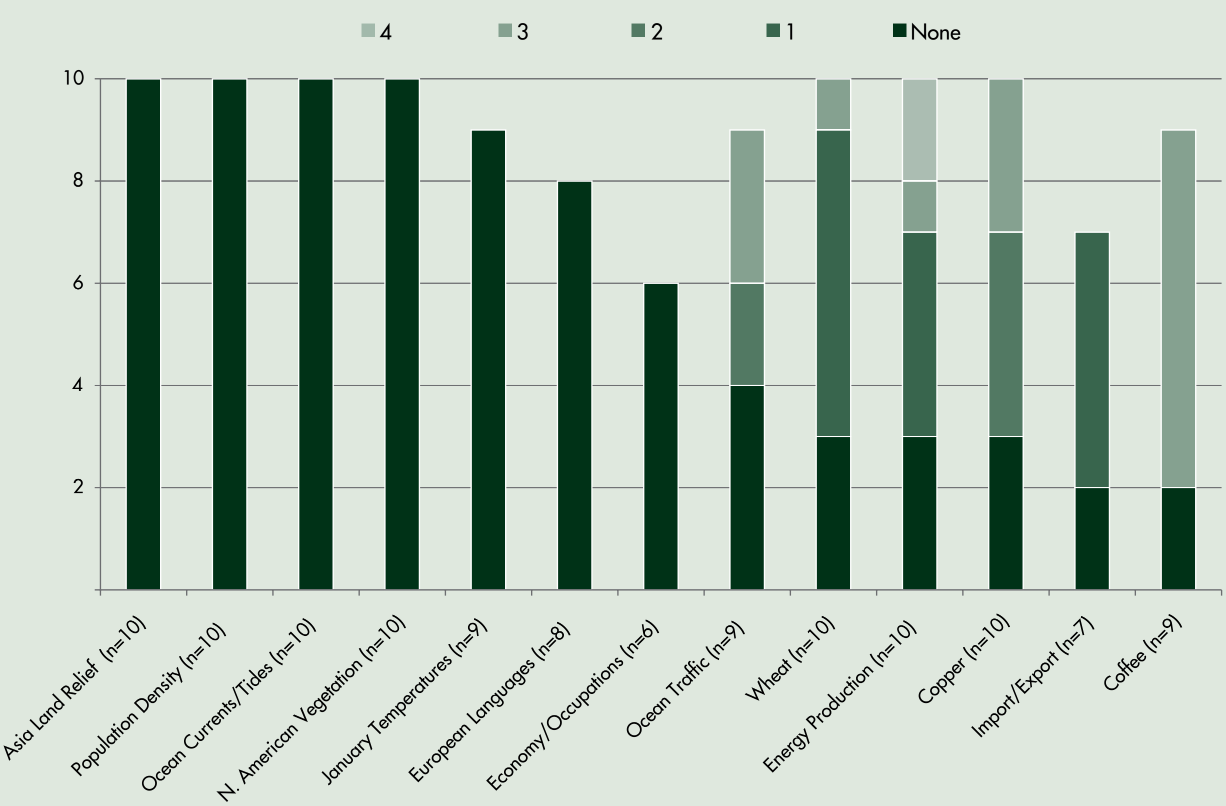


Figure 2. Number of Graphs Accompanying Different Maps

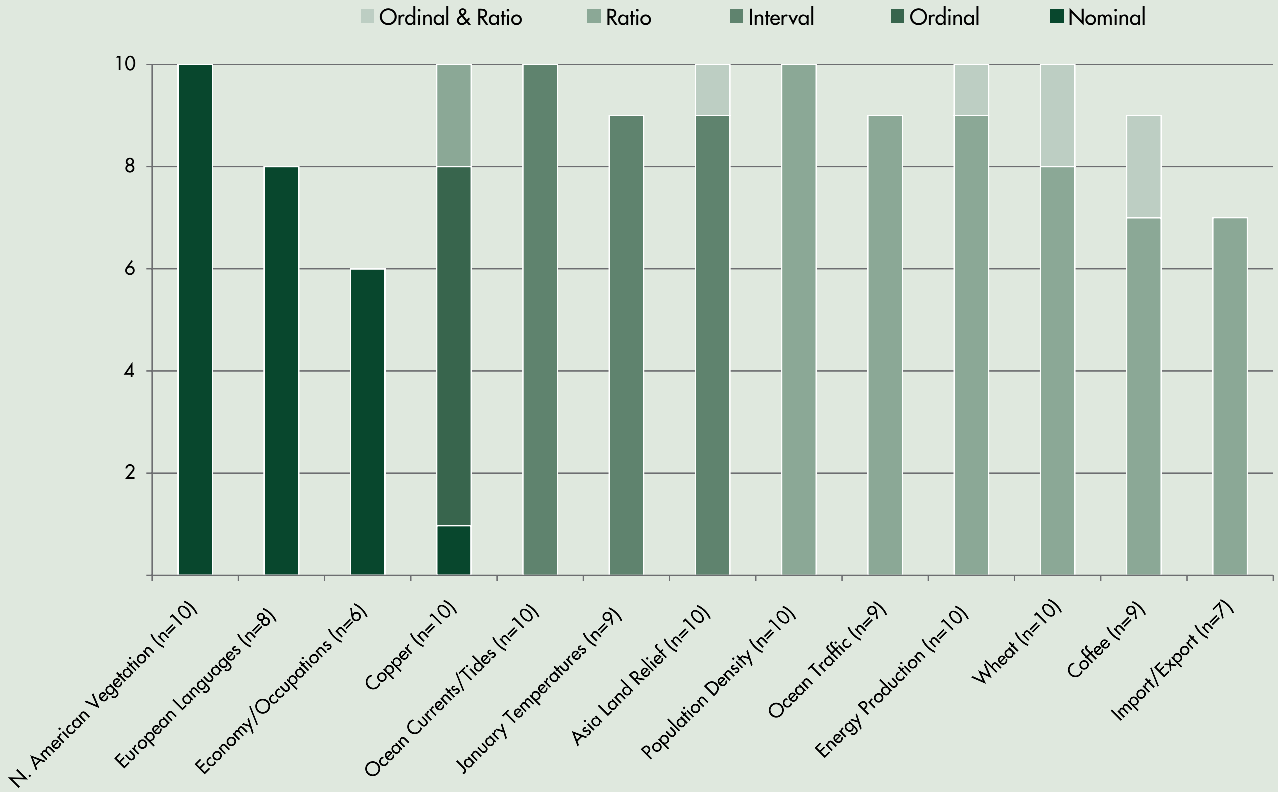


Figure 3. Levels of Measurement Used on Each Map

DATA MODEL VARIATION

How certain data were measured typically did not change throughout the different editions. Most data continued to be mapped at the same level of measurement, regardless of the era; however, there were several exceptions (Figure 3). *Copper* changed the most. Copper data were originally mapped nominally (showing primary areas of copper mining), and eventually evolved into an ordinal level of measurement (showing primary areas of copper mining ranked into three categories based on production).

MAP SCALE

Map scale was rarely included in *Goode's World Atlas,* regardless of the era. Scale was more regularly included on maps in the 1960s and 1970s, but began to disappear again in the 1990s and into the new millennium (Figure 4). Including a map scale on global-scaled maps is often misleading due to map distortion away from the secant lines. Yet, whether a map was global-scaled or not had no relationship with whether a scale was included. Global-scaled maps of *Coffee, Copper,* and *Wheat* never included a map scale, regardless of the edition. Global-scaled maps of *Ocean Currents* and *Population Density* always did. Global-scaled maps of *Ocean Traffic* and *Occupations of Mankind* included a scale more often than they did not.

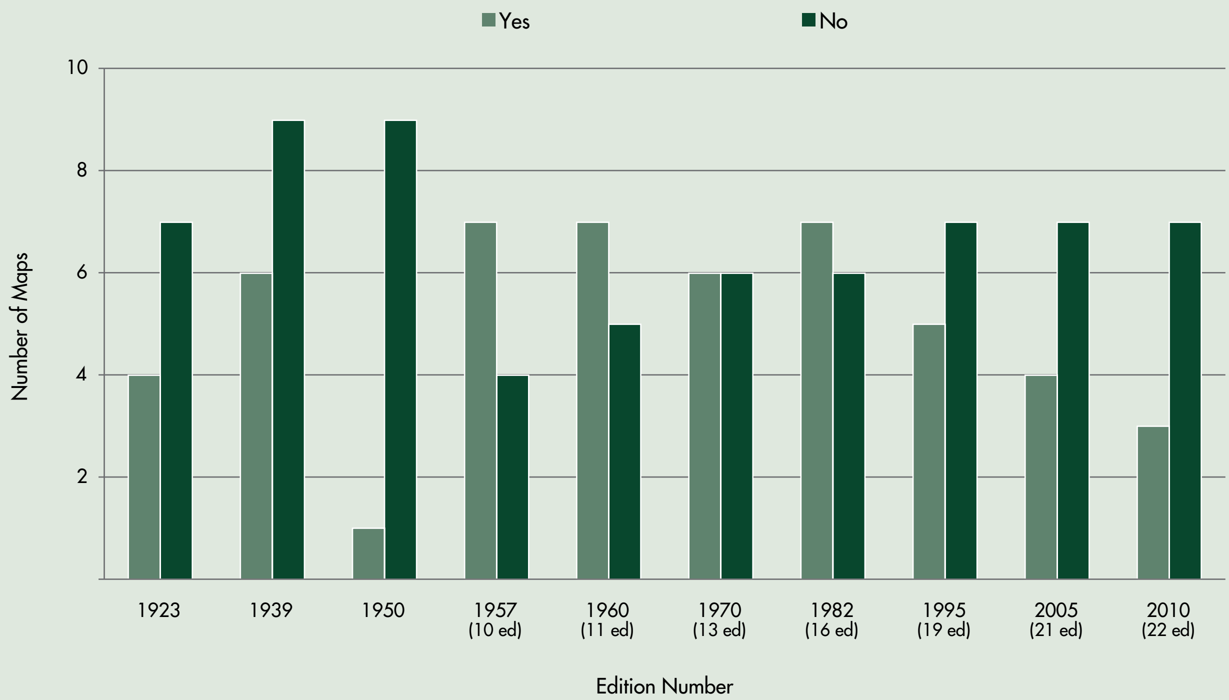


Figure 4. Map Scale Provided with Map

LEGEND INCLUSION

Legends were almost always included with maps (Figure 5). In earlier editions, legends were regularly omitted, but between the sixth and twenty-first editions, only one map had no legend. The newest edition omitted the legend from two of the sampled maps.

DATA SOURCE

The inclusion of a data source with the map varied slightly throughout the different editions, but most of the time data sources were not available to the map reader (Figure 6). Much of the data used in the atlas appears to have been simply republished from edition to edition, with minimal or no change. Over many editions, the same printing plates were simply reused or minimally updated, rather than recreated from scratch, by the publisher (Hudson 2009; Veregin 2009).

LABELING

Throughout all of the editions, a majority of the thematic maps sampled did not have any text labels (Figure 7). In fact, *Goode's World Atlas* maps might be characterized by their uncluttered, label-less appearance.

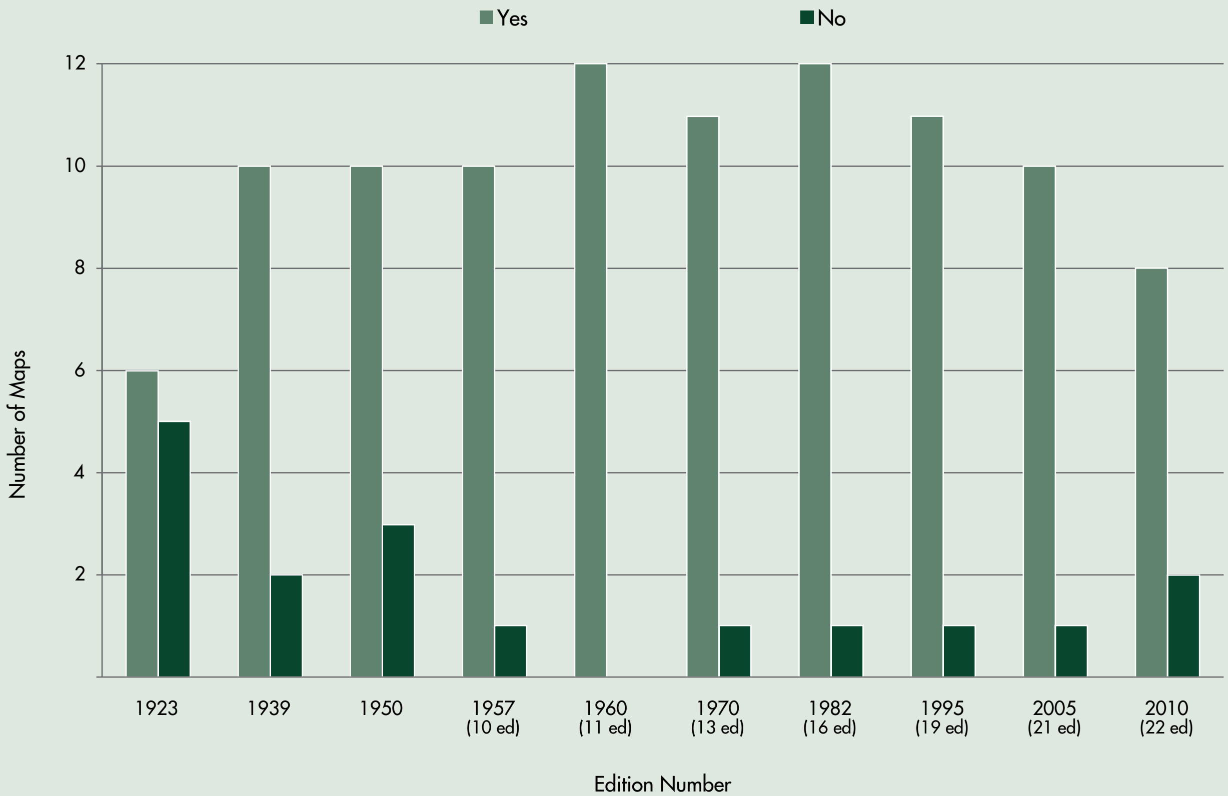


Figure 5. Legend Included with Map

STEP 7: ANSWERING THE RESEARCH QUESTIONS

Once you have analyzed the data, it is time to return to your original research questions. In this case, there were only two questions, but often you will have cause to ask many more depending on what you are researching. Again, it is crucial to think about any and all questions you may want to answer before beginning the coding process.

Did the style and types of thematic representations used in Goode's World Atlas change dramatically over the past eight decades?

Throughout *Goode's* different editions, change has been relatively gradual in graphic symbolization, thematic representation, data model decisions, and style of map accoutrements (i.e., graphs and charts). In fact, from 1960 afterward many of the maps did not change in content at all—merely slight, cosmetic color value differences are used. The biggest noticeable shift in data representation came when certain maps began using shaded relief (the eleventh edition advertises this new development boldly by using shaded relief as its cover illustration).

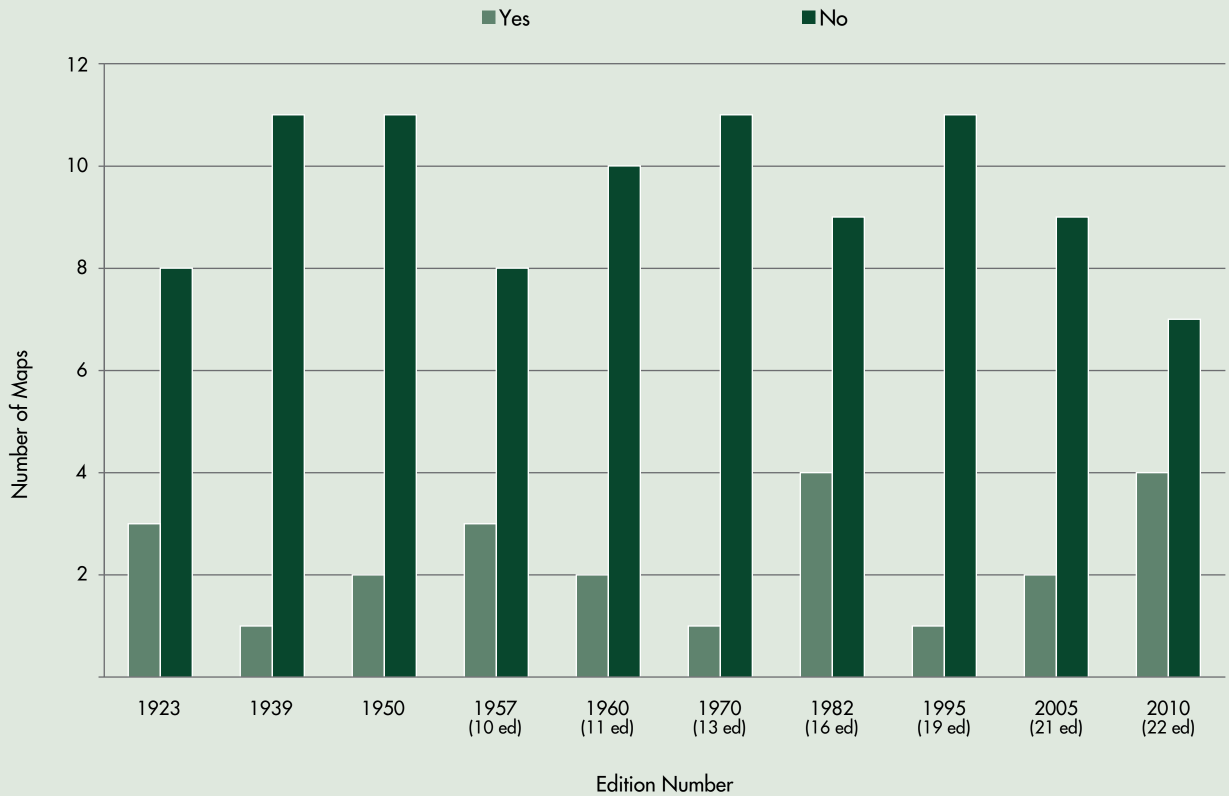


Figure 6. Data Source Included

Figure 7. Use of Map Labels on Thematic Maps

In what ways and when did these changes occur? What styles and representations remained consistent?

The two most recent editions—the twenty-first and twenty-second—show the greatest amount of change in thematic map style from others. The atlas editors have increased the use of satellite imagery. Choropleth maps were never used in the other sampled editions, yet are quite common in the twenty-first and even more regular in the twenty-second edition. These editions also include more cartograms, more contemporary representations (e.g., choro-graduated symbols), and new thematic maps dealing with contemporary issues—including carbon dioxide emissions, sea level change, and network connections. The twenty-first edition incorporated some of these changes, but the twenty-second ushered in the most changes of any edition in this study. Tellingly, the twenty-first edition was designed under a new editor, Howard Veregin.

Though not proposed in the beginning, another question that needs to be asked is whether QCA was effective at revealing changes in the maps themselves. The design of maps in *Goode's* certainly did not change much over time, but QCA was effective at finding miniscule shifts in design and content. An example would be the shifts in color use—there were noticeably more colors used in editions published after the 1950s. This is likely linked to the decreasing cost of printing in color and the evolution of printing technology as a whole. Changes in the number and types of graphs accompanying the maps were also easily identified with this method.

WHY USE QUANTITATIVE CONTENT ANALYSIS?

Unearthing and highlighting idiosyncrasies of thematic representation in different versions of *Goode's World Atlas* was but one goal of this article. The principal goal was to highlight how QCA may prove a useful method for the systematic analysis of many maps at once and to give a primer to cartographers who might be interested in using this method themselves. In this study, QCA successfully allowed for the analysis of trends over time, and variations among representations of the same themes. Once codes were established to answer predefined questions, the coding itself was meticulous, consistent, and relatively quick. Moreover, the results were not episodic; if I wish to add more data to the sample for further comparison at a later date—i.e., if new editions of *Goode's World Atlas* are published—I can. This method allows for continual data accumulation and analysis.

At the beginning of the article, Muehlenhaus's (2010) four methodological benefits of using QCA were summarized. A quick review of how well QCA lived up to these benefits in the *Goode's* case study is in order. First, could QCA be used successfully to count and measure the number of particular data and graphic elements found on maps? The answer is yes; it was very useful for quantifying map attributes that other methods typically only discuss categorically. Second, did QCA allow for a quick analysis of many maps at once? Again, the answer was yes. Though analysis of these maps took roughly 40 hours to complete, this was likely faster than if each of the 118 maps was individually scrutinized and described. Third, did QCA facilitate the systemic comparison of different compositional traits among maps in the sample? Again, the method proved effective at doing this. For example, with the click of a button in SPSS, it was possible to quickly ascertain that certain global-scaled maps included a map scale whereas others did not. We could also determine which maps shared traits and which did not. Finally, did QCA allow for the analysis of how thematic maps have evolved throughout time in *Goode's World Atlas*? Again, it did.

The fact that the maps coded in *Goode's World Atlas* have changed so little over time should not be viewed as indictment on the utility of QCA, although it does signal how slowly developments in thematic cartography can disseminate to the publishers of atlases. QCA was effective at picking up many of the minor map design changes throughout the *Goode's* editions. Such subtleties may have been difficult for small sample methods to pick up on, as the changes occurred across such a long stretch of time. For example, the variation in graph style and type over the course of the different editions was readily apparent using this method, as was the fact that certain global-scaled maps always had a map scale and others never did. If one were to use a less holistic method, details such as these may have been overlooked.

Another advantage of QCA compared to other methods is that it allows researchers to avoid delving into the role of the map reader and the intent of the cartographers. As discussed earlier in the methodology, this is often viewed as a limitation of QCA, but in research dealing solely with map composition—not the contextual forces behind the composition—it can prove useful. Whereas many other forms of map analysis (e.g., semiotics) attempt to analyze a map, its creator's intentions, and how the map is interpreted, QCA focuses solely on the map itself. Maps are analyzed merely as visual compositions to be compared to other maps in the sample.

With the benefits of any research method come certain shortcomings. One disadvantage of QCA here was that coding limited what could be identified and how it could be labeled. This leads to less than inspiring analysis and write-ups compared to more descriptive methods. For example, though QCA caught individual design differences throughout the editions, the resulting analysis was numeric and somewhat mechanized. It might be argued that there is a slight disconnect between the results and the subject matter—frequencies are detailed but may not always be the most effective way to present changes in cartographic style. If a picture is worth a thousand words, how many numbers is a map worth? A mixed method of analysis—for example, using QCA in conjunction with a descriptive overview—would prove more engaging in many circumstances.

CONCLUSION

The goal of this study was twofold. First, it was meant to display the potential effectiveness of using quantitative content analysis for map research. Though there were limitations in the case study presented—including a non-random sample, a single coder, and a dataset that did not vary much over the past 80 years—the method was effective at discerning certain long-term cartographic trends and minor changes with the sample *Goode's* thematic maps. However, it was incapable of providing insight into why certain cartographic decisions were made within the atlas. It also resulted in number-laden analysis that lacked some descriptive qualities that other methods—such as semiotics and deconstruction—might offer. As previously mentioned, QCA may be more effective if used in conjunction with a qualitative approach. Sample size may play a role in the staidness of this analysis as well. Though 118 maps are more than are studied in many pieces of historical map research, it is a relatively small sample size for a QCA. Finally, for the sake of replicability, a minimum of two coders would need to be used. This particular case study has not yet passed this litmus test.

The second goal of this article was to promote the method among other cartographic historians. It is hoped that by describing the analytical process in a step-by-step manner, other researchers can soon adopt and adapt this method for their own research. QCA is already well established in media studies, and as this case study has shown, there is no reason it cannot be employed effectively for the analysis of maps. It is the hope of this author that more researchers begin using QCA to create cumulative datasets that allow for ongoing research rather than anecdotal case studies. That being said, it appears that a mix of quantitative and descriptive methods may be ideal.

ACKNOWLEDGEMENTS

I would like to thank Dr. Fritz Kessler (Frostburg State University) and the anonymous reviewers for their invaluable feedback on earlier versions of this manuscript. I would also like to thank Dr. Robert McMaster (University of Minnesota) for providing me with many of the editions of *Goode's Atlas* used in this study. Many thanks also to Dr. Howard Veregin, the most recent editor of *Goode's World Atlas*.

REFERENCES

Bertin, J. 1983. *Semiology of Graphics*. Translated by W. J. Berg. Madison, Wisconsin: University of Wisconsin Press.

Dent, B. D., J. Torguson, and T. Hodler. 2008. *Cartography: Thematic Map Design*: McGraw-Hill.

Edsall, R. 2007. "Iconic maps in American political discourse." *Cartographica, 42*(4), 335–347.

Hudson, S. 2009. "Rand McNally's Digital World Database for *Goode's World Atlas*." Paper presented at the Association of American Geographers Annual Conference.

Krippendorff, K. 2004. *Content Analysis: An Introduction to Its Methodology* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Lutz, C. A., and J. L. Collins. 1993. *Reading National Geographic*. Chicago: University of Chicago Press.

MacEachren, A. M. 1994. *Some Truth With Maps: A Primer on Symbolization and Design*. Washington, D.C.: Association of American Geographers.

MacEachren, A. M. 1995. *How Maps Work: Representation, Visualization, and Design*. New York: Guilford Press.

Muehlenhaus, I. 2010. "Lost in Visualization: Using Quantitative Content Analysis to Identify, Measure, and Categorize Political Cartographic Manipulations." PhD diss., University of Minnesota, Minneapolis.

Muehlenhaus, I. 2011. Genealogy that counts: using content analysis to explore the evolution of persuasive cartography. *Cartographica, 46*(1), 28–40.

Riffe, D., S. Lacy, and F. Fico. 1998. *Analyzing Media Messages: Using Quantitative Content Analysis in Research*. Mahwah, N.J.: L. Erlbaum.

Robinson, A. H. 1982. *Early Thematic Mapping in the History of Cartography*. Chicago: University of Chicago Press.

Rose, G. 2007. *Visual Methodologies: An Introduction to the Interpretation of Visual Materials* (2nd ed.). SAGE: Thousand Oaks, CA.

Slocum, T. A., R. McMaster, F. Kessler, and H. Howard. 2008. *Thematic Cartography and Geovisualization*: Prentice Hall.

Veregin, H. 2009. "*Goode's World Atlas*: Continuity and Change." Paper presented at the Association of American Geographers Annual Conference.

Ware, C. 2004. *Information Visualization: Perception for Design*. New York: Morgan Kaufmann Publishers.

Wood, D., and J. Fels. 1992. *The Power of Maps*. New York: Guilford Press.