# CHILDREN'S CARTOGRAPHY: WHAT IS A MAP ACCORDING TO CHILDREN?

by

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## DEDICATION

To the children mapmakers who participated in this research, and to all the aspiring cartographers, geographers, and students of the Earth; stay creative and passionate.

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I wish to express great appreciation for the opportunity to work on this research as it is part of a multi-year study originated through the efforts of several students and faculty (Shadi Maleki, Aspen Navarro, Emily Warren, and Dr. Ronald Hagelman III) at Texas State University in partnership with the Meadows Center. The original study was designed to explore children's perception, expressions of and relationship with nature through map-making. I owe a big debt of gratitude to my colleagues at Texas State and of course to the hundreds of children, teachers, and educators who participated in the research.

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# 1. INTRODUCTION

## Introduction

Cartography provides a powerful and creative means to visualize and comprehend the world around us. Beyond the feat of navigation, maps have been tools of war, instruments of education, and mediums for art. Maps matter. But what exactly is a map? Defining the map has been an ongoing challenge in the cartographic community. There is no singular nor standardized definition for what constitutes a map, and there are many types in existence. The near exponential growth in today's technological advancements makes this all the more challenging, blurring the lines between the many forms and functions of maps.

## Purpose Statement and Research Questions

While there is no one true definition of the map, many have attempted to define its form and function over past decades. A quick Google search will provide its inquirer with single-sentence definitions and/or bullet-point lists of common elements of the map from sites like Wikipedia and numerous GIS education websites, reporting overlapping but ultimately unique and subjective descriptions of a map. While leading names in the field such as Monmonier and MacEachren refrain from explicitly defining the map in their work, other major academic contributors to this matter (such as Vasiliev 1990 and Dodge 2014) have turned to governmental departments, bookshelf dictionaries, educational textbooks, and the research of the field to continue the ongoing debate and often-rhetorical feat of objectively and concisely defining the map. However, not many have considered *children* as a population to gain an understanding from of what a map is

in practice.

Rather than seeking to define the map for the field, this research aims rather to explore what a map is to children through the empirical analysis of hand drawn maps. While some have looked to similar populations to better understand how to design maps for children or to explore their spatial development patterns, less if any have asked children what they believe the map to be. While subsequently adding to the general knowledge of how the map can be defined at a fundamental level, this thesis specifically aims to answer from a cartographic point of view the question *"for our child cartographers, what is a map?"*.

Importantly, this thesis does not ask or answer whether or not the drawn maps in this study should or should not be considered maps. Rather, I am interested in what children *materially* create when asked to make a map—the *what* and *how* of the mapmaking process, as compared to how the literature defines the map. When asking *what* the children are mapping, I look at the content children's maps contain, such as whether they are mapping more flora or fauna, natural or built environmental elements, physical or chronological features, etc. When asking *how* the children are mapping, I look to see if they are demonstrating knowledge of cartography, such as use of visual variables (color, size, shape, texture, orientation, etc.), cartographic conventions (north arrow, title, scale, etc.), types of symbology, and the scale and geometric perspective at which they create their maps. In summary, to answer RQ1 (*What is a map according to children?*), I will tackle RQ1A (*What is being mapped*?) and RQ1B (*How is it being mapped*?) separately.

## 2. STUDY BACKGROUND & METHODOLOGY

### Literature Review

#### *What is a Map*

Dating back to at least 6000 B.C., maps of all kinds have proved important to helping people in a multitude of scenarios, from wayfinding and education to legal reports and artful literary features (Liben and Downs 1989, Gerber 1993). However, while ubiquitous and critical, the map is hard to define. Vasiliev et al. (1990) suggest that "map" acts as an umbrella term for various forms, functions and intentions. Furthermore, given the age of technology of the 21st century, maps no longer look like the traditional artifact of yesteryear; rather, developments in modern software and database design continue to "stretch the boundary of what counts as a map" (Dodge 2014). As long as we are connected to the internet, location information is now available at our fingertips, increasing the accessibility, flexibility and efficiency of map use, as well as simultaneously decreasing the quality and trustworthiness of maps, as now anyone can be a mapmaker (Dodge 2014).

Turning to Google to better understand what is a map provides inconsistent advice on what map elements are required, and/or generalized definitional blurbs of the map as a two-dimensional representation of the three-dimensional world. Leaders in the field of cartography, such as MacEachren (2004) and Monmonier (2018), avoid narrowly defining the map, but rather explain its various forms and functions and its primary role to provide information. These scholars express that maps are inherently distorted and complex representations of the Earth; such distortions are found in the subjectivity of the cartographer and his or her culture and society at the time, as well as from the

representational challenges of turning the three-dimensional world two-dimensional. Vasiliev et al. (1990) attempted to synthesize a narrowed definition of the map through an in-depth linguistics analysis of the various definitions that exist in the literature: by comparing definitions from dictionaries, cartography and geography textbooks, and journal articles, he synthesized that the map is, in its most basic sense, "a representation of the earth's surface, or part of it." However, while a standardized definition is useful, its interpretation may vary greatly depending on the person or the map type; therefore, Vasiliev et al. (1990) suggests five categories of map elements/characteristics that make something more "map-like," rather than outright defining the map. From the perspective of defining the map based on what characteristics it should have, Gerber (1981), Wood (1993), Filippakopoulou (2009), Goria and Papadopoulou (2017), and Monmonier (2018) have all found that the cartographic notions of scale, projection and symbology are most prominent to characterizing a map's form.

Beyond the contributions of these prominent scholars, there seems to be a consensus in the literature that in terms of their function and ontology, maps can be seen as representations, as tangible objects, as intangible ideas, and as tools. Vasiliev et al. (1990), as well as others (Liben and Downs 1989, Anderson and Vasconcellos 1995, Dodge 2014) suggests that maps are most commonly seen as graphic representations or geographical pictures, usually on a plane surface, that show earth's surface. Many cartographers pose that maps are more than mere representations or reflections of the world, and should not be degraded to mirrors or miniatures (Liben and Downs 1989, Dodge 2014), for maps are also tools. They are a means to way find, to make territory, or act as a graphical symbol system or technique to visualize our world, as well as help

people of all ages acquire spatial knowledge and mapping skills as teaching aids (Liben and Downs 1989, Filippakopoulou 2009, Dodge 2014).

Beyond being illustrations and instruments, maps in their most basic form are also material artifacts, more or less permanent graphic objects such as scientific documents or archives of information (Wood 1993, Liben and Downs 1989, Dodge 2014). Wood (1993) describes maps as "things that…come tucked inside the pages of National Geographic…things we consult on the walls…things in the newspaper." At the same time, however, maps are intangible in a way that they are a way we think about the world (Dodge 2014). Maps are creative statements, projections of experience, and a "metaphor for the internal representation of knowledge" (Liben and Downs 1989).

Similarly, maps have three primary functions: maps help us understand the world, conceive space, and visually communicate these understandings and conceptions. Ultimately, maps function to aid in the acquisition of geographic knowledge, synthesis of geographic information, and analysis of geographic patterns (Anderson and Vasconcellos 1995, Dodge 2014). Beyond being a means to pose and answer questions, maps enable discovery and appreciation of relationships previously unsuspected, effectively making our world more comprehensible (Liben and Downs 1989). Simultaneously, maps give tangible form to the intangible through representing the experience of space across eras, cultures and contexts; they aid in the perception and construction of space, making the "unperceivable extent of the world at large to perceivable bounds" (Liben and Downs 1989). Maps also function to communicate this perception and understanding, acting as a tool and platform for presentation, discourse, and persuasion alike (Liben and Downs 1989, Wood 1993, Anderson and Vasconcellos 1995).

What this brief overview suggests is that rather than an agreed upon standardized definition, there has been an ongoing discourse in the field surrounding the map's form and function, and a series of definitions of what a map is that vary based on the map's type, intention and audience. Scholars have turned to dictionaries, textbooks, journal articles, and even colleagues to define and understand the map, but far fewer have looked to a population such as children.

*Why Cartographers Should Consider Children*

Beyond the feat of navigation, maps have been tools of war, instruments of education, mediums for art, and are a great avenue to better help people spatially understand the world around them at all scales. Children are no exception to this group, as both map users and spatial thinkers. However, children pose a distinctive challenge to researchers, map designers, and educators alike as their intellectual capabilities, spatial cognition, and exposure to cartographic literacy and geographic education are greatly varied and/or limited (Gerber 1993). Despite these challenges, children offer a unique perspective to cartographers; as such, they have been the target population of many studies over the last forty years in fields such as psychology, geography, education and cartography in an effort to explore their understanding of everything from the environment and perception of space to basic mapping concepts and ability to spatially navigate (Anderson and Vasconcellos 1995, Filippakopoulou 2009, Silva et al. 2019b).

In the field of geographic education, cartographers play a large role in designing maps as teaching aids, in helping to close the gaps in geographic literacy, and in preparing children as the next generation of map users and producers. Given that maps

are generally neglected in modern geographic curricula, at least in the United States, and that map-related pedagogy is not well developed, it makes sense that there is a lack of geographic and cartographic literacy amongst children and adults like (Liben and Downs 1989, Anderson and Vasconcellos 1995, Weigand 2006). Therefore, it should be the aim of the modern cartographer to not only provide effective design of maps and atlases for school textbooks, but also to assist in providing quality geographic education and cartographic training; this will not only equip children with spatial knowledge and skills, but it also prepares them as the next generation of map users and producers while increasing geographic and cartographic literacy (Anderson and Vasconcellos 1995).

Whether for the purpose of improving geographic curriculum or in order to understand how children perceive maps, cartographers must also be cognizant of the children's cognitive development in relation to their spatial abilities and skills (Weigand 2006, Antle 2007). Weigand (2006) explains that research dealing with maps and children should have a foundational understanding of how children come to understand spatial relations in order to take into account their developing spatial perceptions and capabilities. For example, Filippakopoulou et al. (1999) explains that how children read or create maps is a direct reflection of what they are cognitively able to do; a child may fail at applying the cartographic element of scale for no reason other than that until children are of a certain age, they lack understanding of proportionality and metrics. The same can be said for the notions of symbol-reference relationships or certain visual variables such as saturation that young minds are not yet capable of grasping (Filippakopoulou 2009). A number of classic theories in children's general cognitive development can be applied to how children develop their cartographic understanding,

such as the nativist approach, the cognitive perspective, Vygotsky's theory, and especially Piaget's theory, ultimately helping to understand children's spatial capabilities at different ages (Gerber 1981, Filippakopoulou 2009).

Given these considerations, cartographers should recognize the "special case" or unique population that children are due to these developing cognitive capabilities and their evolving educational perspective of geography education and cartographic literacy (Gerber 1993, Filippakopoulou 2009). For example, cognitive cartography has areas within the field dedicated strictly to these notions, such as map-psychology (aiming to understand human perception and cognition) and map-education (aiming to improve education with and about maps) (Montello 2002). Exploring children's perceptions of maps requires an awareness and understanding of how children learn, what they understand and what they make out of (cartographic) symbolism (Sorrell 1974); considering these educational, psychological and cartographic components together is crucial to fully and accurately understanding the world from a child's point of view through their developing minds.

With a holistic consideration to the educational and psychological variables inherent to research with a young population, children are a common focus group in the field of cartography. Leading groups such as the International Cartographic Association (ICA) have also long recognized such research opportunities between children and the map, and the ICA established in the 1990's a formal 'Working Group' entitled Children and Cartography (Anderson and Vasconcellos 1995). Still active today, this group aims to explore the ways cartographers can improve mapping for children. In fruitful contrast, this thesis aims to explore how children can improve mapping for cartographers, as not

many have done before. More often, research involving children and maps are not cartographically motivated, but rather aim to explore children's knowledge of their environment (Liben and Downs 1989, Weigand 2006).

In order to better understand what a map is to children, this study follows similar methods to Blaha (2011), Nieścioruk (2016), Goria and Papadopoulou (2017), and Silva (2019a and 2019b), researchers who analyze hand-drawn sketch maps made by people of various ages. The maps in these studies were used as tools to analyze the "socio-geographic aspects" of space, whereas this thesis considers their content and design elements from cartographic point of view in order to better understand what and how children map. Turning to children to define the map not only expands our knowledge about child cartographers, but also adds to the field's foundational understanding of what a map is.

## Methodology

In exploring what a map is, I offer the perspective of approximately 831 schoolchildren aged 6 to 14 who visited the grounds of the Meadows Center for Water and the Environment, located on the campus of Texas State University in San Marcos, Texas. The children were on school field trips conducted in the second half of 2017. The children who participated in this experiment varied in race, gender, and socio-economic status. They came from different parts of Texas, including rural areas and big cities. Some were familiar with the area, but most were not.

Although demographic and experiential differences are important, we set them aside to concentrate only on the artifacts the children produced, which are analyzed from a map

design perspective.

This research is part of a multi-year study originated through the efforts of several students and faculty (Shadi Maleki, Aspen Navarro, Emily Warren, and Dr. Ronald Hagelman III) at Texas State University in partnership with the Meadows Center with the aim to explore children's perception, expressions of and relationship with nature through map-making. However, in this thesis I separately aim to utilize a subset of the originally collected data to more specifically observe the ways children cartographically express their field trip experience to explore their map-making techniques.

*Site and Situation*

Between July 5, 2017 and December 15, 2017, grade-school students from nearby school districts (Weslaco, Comfort, Roskany, San Antonio, and local home schoolers) participated in a field trip to the Meadows Center for Water and the Environment at Texas State University in San Marcos, Texas. There were 831 student participants composed of elementary schoolers (grades 1st-2nd), middle schoolers (grades 5th-8th), girl scouts (grades 1st-8th), and home-schoolers (grades 3rd-9th). At the end of their guided field trip, the children were prompted to complete a mapping activity that supplies the data for this study. At the end of their visit, these children were asked to draw a map of their field trip experience (see Matthews 1984b on "free recall sketching" / "free recall mapping"). They were provided colored markers and paper to draw their map and describe their map in writing, but no other materials or further instructions were given. The resulting maps were then collected, catalogued, and preserved in paper and/or digital format.

*Data Collection*

Each group of children on the field trips were led by a guide from the Meadows Center who filled out a "Mapping Module Questionnaire for Interpretive Guides" (see Appendix, 2). The questionnaire served to instruct as well as collect information from the group of children as they completed the mapping activity. Over 16 different collection days, 48 groups of children completed the mapping activity, varying in grade level ($5^{th}$ through $9^{th}$) and group size (8 to 23 children per group), for a total of 831 participants from 15 different schools. Altogether, the children created 765 maps (they had the option not to participate). The grade level of each group of children was recorded, with about half of the groups marked as having a range of grade levels (e.g., $6^{th}$-$7^{th}$) rather than a single grade; in practice, this means that groups were composed of children of different ages.

Instructors for this specific mapping activity were given specific training and collection protocol to ensure consistency in data collection (see Appendix, 1), including an instructional script to read to the participants (see Appendix, 2). The children were provided with a sheet of paper with the prompt "draw a map of your field trip" on the front, and the prompt "explain what you included in your map" on the back (see Appendix, 3). No additional instructions were given to the children in regards to what should be included in their work or what it should look like. It is this lack of additional and specific instructions that allow us to answer the research question posited at the end of the previous chapter.

*Data Setup*

This study was originally designed to explore children's expressions of and relationship with nature through map-making. The initial research aimed to specifically investigate what natural and anthropogenic elements were common throughout 765 maps, as well as if cartographic conventions were used. Consistent with the initial research's purpose to explore the children's perception of nature, at this stage the authors utilized visual content and statistical analysis of both the maps and the written descriptions. Separate from the previous research, this thesis more specifically aims to utilize a subset of the 765 maps collected from the original study to observe their content and design elements from a more in-depth cartographic point of view to better understand what a map is to children.

The previous study design involved a list of environmental variables to visually asses for their presence in each individual map, such as flora, fauna, sun, sky, types of bodies of water, buildings, means of transportation, roads, and trails. A singular variable for cartographic conventions was also assessed for whether or not the children used one or any of the following: title, north arrow, scale, legend, symbology. The use of color was also assessed.

In order to more thoroughly understand what and how children map, I reworked and expanded upon the variables previously analyzed to emphasize a more cartographic focus, as seen in Table 1. Utilizing a similar visual content analysis to explore *what* children map, I assessed the topography of every map specifically looking to see whether the children included elements of flora and/or fauna (such as trees, grass, fish, insects, etc.), as well as elements of the natural and built environment (e.g. bodies of water, sun,

wetlands, ground cover, buildings, trails, boats, etc.). To assess *how* the children are mapping their experience, elements of topology (point, line and polygon symbology) were evaluated to better explore how the children are graphically representing the world around them. Similarly, each element of the common cartographic conventions and visual variables were individually assessed in the maps. Other variables such as text, chronology and perspective were also considered in the analysis, for a total of 24 variables in all. The level of uncertainty in map interpretation was also assessed: specifically, I assigned a value on a Likert scale from 1 to 4 (1 as uncertain, 2 as somewhat uncertain, 3 and somewhat certain, and 4 as most certain) to serve as a numerical value to the level of uncertainty in interpretation that I experienced for each map assessment. I will return to this point in the limitations section.

Table 1. List of variables and their associated codes and descriptions. "0" suggests lack of inclusion of the variable on the map, and "1" suggests the presence of the variable, with some exceptions as described above.

| Category | Variable | Code | Description |
|---|---|---|---|
| Topography | Flora | 0 or 1 | Plant life (trees, grass, flowers) |
| | Fauna | 0 or 1 | Animal life (fish, insects) |
| | Natural | 0 or 1 | Natural elements of the environment |
| | Built | 0 or 1 | Built elements of the environment |
| Topology | Points | 0 or 1 | Point symbology |
| | Lines | 0 or 1 | Line symbology |
| | Polygons | 0 or 1 | Polygon symbology |
| Cartographic Conventions | North Arrow | 0 or 1 | North arrow |
| | Title | 0 or 1 | Title |
| | Scale | 0 or 1 | Scale |
| | Legend | 0 or 1 | Legend |
| | Symbology | 1, 2 or 3 | Mimetic (1), Abstract (2), Both (3) |
| Visual Variables | Shape | 0 or 1 | Varying shapes of symbols |
| | Size | 0 or 1 | Varying size of symbols |
| | Orientation | 0 or 1 | Varying orientation of symbols |
| | Texture | 0 or 1 | Use of patterns/repeated individual symbols |
| | Color (Hue) | 0 or 1 | Use of color |
| | # of Colors | # | Number of colors used |
| | Connotation | 0 or 1 | Use of color connotation |
| Other Elements | Text | 0 or 1 | Labels or descriptions |
| | Chronology | 0 or 1 | Evidence of chronological elements or flow |
| | Perspective | 0, 1 or 2 | Oblique (0), Perpendicular (1), Combination (2) |
| | Framed | 0 or 1 | Use of frame or structure to map |
| | Level of Uncertainty | 1, 2, 3 or 4 | Uncertain (1), somewhat uncertain (2), somewhat certain (3), certain (4) |

These variables were chosen based upon a consensus derived from the cartographic literature that suggests the most common elements and characteristics of maps (Bertin 1983, Vasiliev 1990, Wood 1993, Roth 2017, Monmonier 2018). Beyond the children's naturally limited and evolving cognitive functions to grasp certain

cartographic concepts at young ages (see Chapter 2, Section 1), it should be noted that the visual variables of value and saturation were intentionally omitted as the tools the children were supplied with, e.g. basic color markers, do not support the more complex variation of value and saturation, only hue.

*Map Selection*

A vital factor to this study design is ensuring that the children who are drawing the maps do not receive any extraneous influence beyond the strict instruction in the Mapping Module Questionnaire to ensure that the maps are constructed from the children's own idea of what a map is to them. As expressed in the Data Collection Protocol (see Appendix, 1), the guides who are leading the children in the mapping activity are instructed to read the following script exactly to the children to begin the activity:

> "During this next mapping activity, we ask that parents and teachers do not help the students. We are doing a study to learn about how kids like you understand nature and maps. For the next fifteen minutes use the colored markers to draw a map of your field trip today and on the backside, explain what you drew on your map. We would like to use your map for our study. If you don't want to be in the study you can still draw a map but we will not make a copy. Please do not put your name on the map. You will not receive anything in return for drawing a map. If you don't want to be in this study, it is ok to say "no" and nobody will be mad at you."

On the Mapping Module Questionnaire (see Appendix, 2), one of the follow up questions for the guide asks whether or not they followed this script as a "yes" or "no" question. For any of the groups of children who were led by guides that indicated that they did *not* follow this script, or altered it in anyway, I omitted their set of maps and did

not use them for analysis. In addition, another follow up question asked the guides whether or not there were any "extraordinary events that affected the activity." For any of the groups of children who were led by guides that indicated that there *were* extraordinary influences (e.g. the weather was too hot for the kids to focus, there was a large caterpillar distraction, there were language barriers), I also omitted their set of maps and did not use them for analysis. The only maps deemed acceptable to analyze included those that indicated that they followed the script exactly *and* that there were no extraordinary events to the activity or the children, ensuring that the maps analyzed are only those that were created by the children who were left to themselves and had no outside influences.

Of the 47 guides that led groups of the children in the activity, 41 of the them followed the script, whereas only about half (23) of them indicated that there were no extraordinary events that could compromise the activity and therefore the maps. Given these control factors, there were a total of 21 guides who *both* followed the script and stated no outside influence, allowing for 21 useable sets of maps that total to 332 maps; this selection of 332 maps still included children who ranged from kindergarten through the 9$^{th}$ grade. 5 sets of maps were disqualified without doubt (totaling 73 completely unusable maps), where scripts were not followed, and/or there were obvious extraneous events that unequally influenced the activity. The remaining maps collected had subjective outside influences or considerations beyond the above objective control factors that disqualified them for this research.

*Data Analysis*

Each of the 332 maps were individually analyzed using visual content analysis (Rose 2016) to determine the presence (or lack) of each variable listed in Table 1, and were tracked in Microsoft Excel. Most variables were coded with a "0" or a "1" to indicate whether the variable was present ("1") or not ("0") with exception to the following variables: number of colors was coded with a numerical value that ranged from 1 to 11, symbology was coded with "1" (indicating use of mimetic symbols), "2" (abstract symbols), or "3" (both mimetic and abstract), perspective was coded with either a "0" for oblique, "1" for perpendicular and "2" for a combination of the two, and level of uncertainty was coded on a Likert scale of "1-4" as described previously. Once all maps were analyzed, the number of maps (and therefore children) that used each of the 24 variables were summed from the codes, providing a numerical summary (such as percentages or averages) of maps' content and design elements. The written descriptions the children wrote on the back of their maps were not used or analyzed as a part of this thesis.

# 3. RESULTS

## Previous Findings

Initial (2018) results from the previous study (Shadi Maleki, Emily Warren, Ronald Hagelman III and Aspen Navarro, unpublished) indicated that children mapped anthropogenic elements more so than natural elements, and that their overall use of cartographic conventions was limited. The maps varied greatly in terms of scale, detail, and the features of the landscape the children decided to map, as well as how they chose to represent (or not) the relationship between space and time.

## What is Being Mapped

As seen in Table 2, results from this study suggest that just over half of the children (51%) included elements of flora whereas only 25% of children included elements of fauna; 14% included both, and 40% included neither flora nor fauna. Flora elements typically included things such as trees and grass, plants in and around water, and sometimes clouds, the sun, or areas labeled as the "wetlands." Common elements of fauna were most often fish and/or turtles. Nearly all children included elements of either the natural or the built environment (95 and 96% percept respectively), and 93% included both. Elements of the natural environment typically included things such as a body of water, grass and trees, and sometimes a sky. Common built elements of the environment expressed were most often buildings, bridges, sidewalks and/or trails, tables, a parking lot, school buses, cars, and boats. Children would also sometimes draw their friends in their drawings.

Table 2. List of variables and their resulting percentages or averages.

| Category | Variable | Value | Category | Variable | Value |
|---|---|---|---|---|---|
| Topography | Flora | 51% | Visual Variables | Shape | 100% |
| | Fauna | 25% | | Size | 6% |
| | Natural | 95% | | Orientation | 3% |
| | Built | 96% | | Texture | 60% |
| Topology | Points | 95% | | Color (Hue) | 39% |
| | Lines | 54% | | # of Colors | avg. 4.16 |
| | Polygons | 89% | | Color Connotation | 54% |
| Cartographic Conventions | North Arrow | 8% | Other Elements | Text | 73% |
| | Title | 0% | | Chronology | 19% |
| | Scale | 1% | | Oblique View | 8% |
| | Legend | 12% | | Perpendicular View | 63% |
| | Mimetic Symbology | 9% | | Combination View | 29% |
| | Abstract Symbology | 11% | | Framed | 10% |
| | Mimetic & Abstract | 77% | | Level of Uncertainty | avg. 3.69 |

How it is Being Mapped

As it relates to topology, results suggest that nearly half (42%) of the children graphically represent their experience at the Meadows Center using all three types of symbology; very rarely did they use just one type of either points, lines, or polygons alone. Nearly all children utilized points (95%) or polygons (89%), where less utilized lines (54%). More often (42%) children used both points and polygons together, whereas only 9% used the combination of points and lines and only 3% used the combination of polygons and lines.

As it relates to cartographic conventions, less than a quarter (21%) of all children used the north arrow, a title, a scale, and/or a legend. However, while no children put a title on their map and only 3 children (~1%) put a scale, 8% of maps included a north arrow and 12% of maps include a legend. Of the 69 children's maps that included these

cartographic conventions, 7 of them used a combination of conventions, most commonly (5 of the 7 children) the use of both a north arrow and a legend together. As it relates to the types of symbology, most of the children (77%) used both mimetic and abstract symbols; 11% used only abstract, and 9% used only mimetic symbology.

As it relates to the use of visual variables, children most commonly used shape (100%) and texture (60%) compared to size (6%) or orientation (3%). Texture was expressed through pattern creation of repeated individual symbols, most commonly for water or grass. Over a third (39%) of children used more than 1 color (an average of 4.16 different colors were used), and of those who used color, 54% of them expressed their color choice using the same color connotation adults commonly employs, but there were exceptions: for example, while all of these children expressed water as blue and grass as green, sometimes buildings would be pink and trails would be orange.

Nearly three-quarters (73%) of all children used text on their maps, which were most commonly expressed as labels and sometimes descriptive text. 19% of maps showed elements of chronology such as suggested order of events, flow, or marked start and finish locations. While most children (63%) drew their maps from a perpendicular (aerial) perspective, 8% used an oblique perspective and 29% used a combination of perpendicular and oblique. Additionally, some children (10%) had framed their map or had a clear border around the map area. The overall measure of uncertainty in map interpretation averaged 3.69 out of 4.

# 4. DISCUSSION & LIMITATIONS

## Discussion

With a holistic consideration to the educational and psychological variables inherent to research with a young population, these maps not only enable the exploration of what the children found valuable from their field trip experience, but they also provide a window into children's spatial and creative perception of the world around them, at least as concerns their representation via a map. For example, as it relates to the maps subject matter, the children more often mapped things such as plants, trees and grass (flora) compared to wildlife (fauna), most likely because the former is always visible, while the latter, especially in its most uncommon elements, rarely is (in fact, when they are, as is the case for "Edry the Turtle" in Figure 14, children remark on it). They also expressed equally both the natural environment and the built environment, nearly always including things such as Spring Lake (the primary body of water they toured on their field trip), the boats they rode on the lake, the trail, sidewalk and bridge they walked along, and the abundant trees and grasses that surrounded the Meadows Center. The mapping of these things suggest that these are what the children found to be the most remarkable or most valuable to their field trip experience; this also suggests that children commonly express that a map can or should include these primary elements of both the natural and the built environment.

Topologically, nearly all children graphically expressed their field trip using symbols in the form of both points and polygons; the use of lines was also common, as well as the use of all three together or various combinations of two them. For example, given that part of the field trip involved a tour of the Spring Lake, children commonly

represented this body of water using a polygon, whereas fish and boats on the water were typically symbolized using points. The children most often expressed these symbols in both mimetic and abstract means, where in a single map a fish may have been a small referent of the creature itself, whereas the buildings would be simple rectangles; it was rare that a child strictly used either mimetic or abstract symbols alone. Additionally, the field trip also involved the exploration of the grounds of the Meadows Center using sidewalks, bridges, and cleared nature trails that the children graphically represented in various ways: some used lines to denote the linear paths they followed, whereas others used polygons to symbolize the area of the pathways (select examples can be found in Figure 1). While it is known that children's ability in mimetic and abstract point, line and polygon symbology varies with age, the children's varied use of them in these maps suggests a general familiarity with symbolic representation of features (Filippakopoulou 2009); this also suggests that children commonly express that a map is composed of or utilizes points, lines and polygons and mixture of both mimetic and abstract symbology.

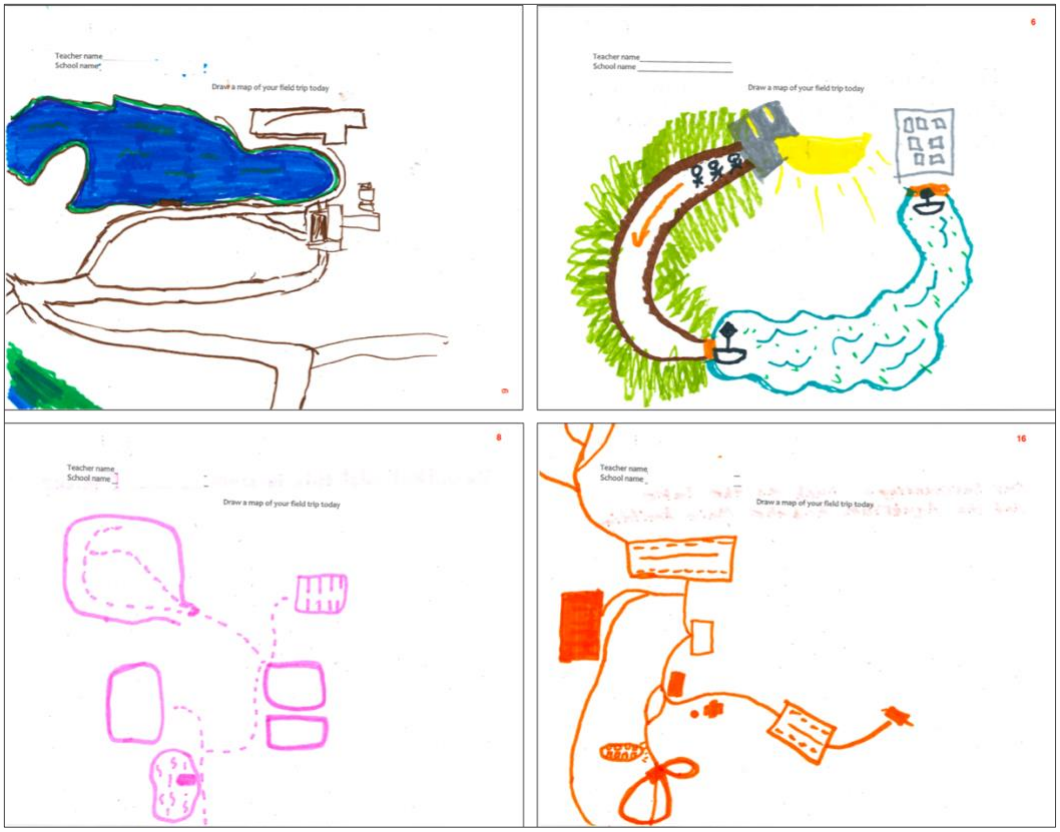


Figure 1. Examples of the use of polygons (top two) and lines (bottom two) for pathways in four maps.

As the basis of symbol design, the use of visual variables from the children varied across the maps; while all children utilized shape, less than 10% used size or orientation. In more than half of the maps, texture was commonly used for graphic expression of water using squiggle lines to create a pattern indicating water, or with repeated small triangles or dashes to indicate grass (Figure 2). As it relates to color, over a third of the children drew their maps with more than 1 color. The children who expressed color used an average of 4.16 different colors on their maps, where more than half these children abided by traditional color connotations; however, while these children did express water as blue and grass as green, many used other various colors that were not associated with color connotations, such as pink tables and orange buildings. While some color choices

didn't always represent reality on their maps, this still suggests that children express that a map can include the use of color, as well as include the use of symbols that will vary in shape and are often used repeatedly to create texture.

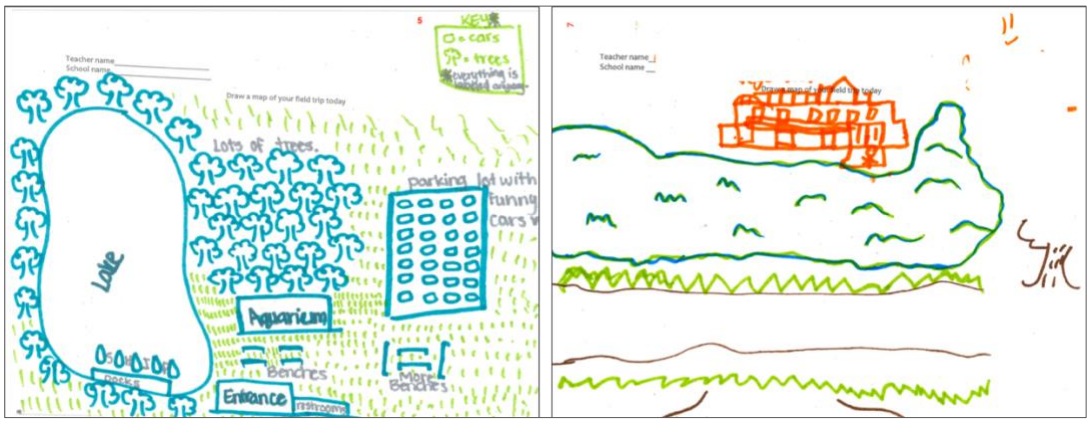



Figure 2. Examples of texture in two maps, such as repeated dashes or triangles for grass.

The overall use of cartographic conventions were very limited: virtually no children included a scale on their map (less than 1%), and none included a title. One reason for the lack of representations of scale might be due to the fact that before a certain age, children struggle with understanding proportionality, which is necessary to understand scale (Filippakopoulou et al. 1999 and 2009). However, the three children who did include a scale (Figure 3) may not have been correct in their measurements and simply included a scale due to past exposure to and experience with maps, associating the notion of a scale with the map itself. Similar is the case with the use of north arrows: roughly 8% included a north arrow on their maps (select examples in Figure 4), but it is inconsistent whether or not the children knew correctly where north was, or whether they associated the notion of a north arrow with a map and included it for such reasons. Legends were the most commonly used cartographic convention (12% of all children included legends on their maps) and were varied in their appearances (select examples in

Figure 5).


Figure 3. Examples of scale in three maps.

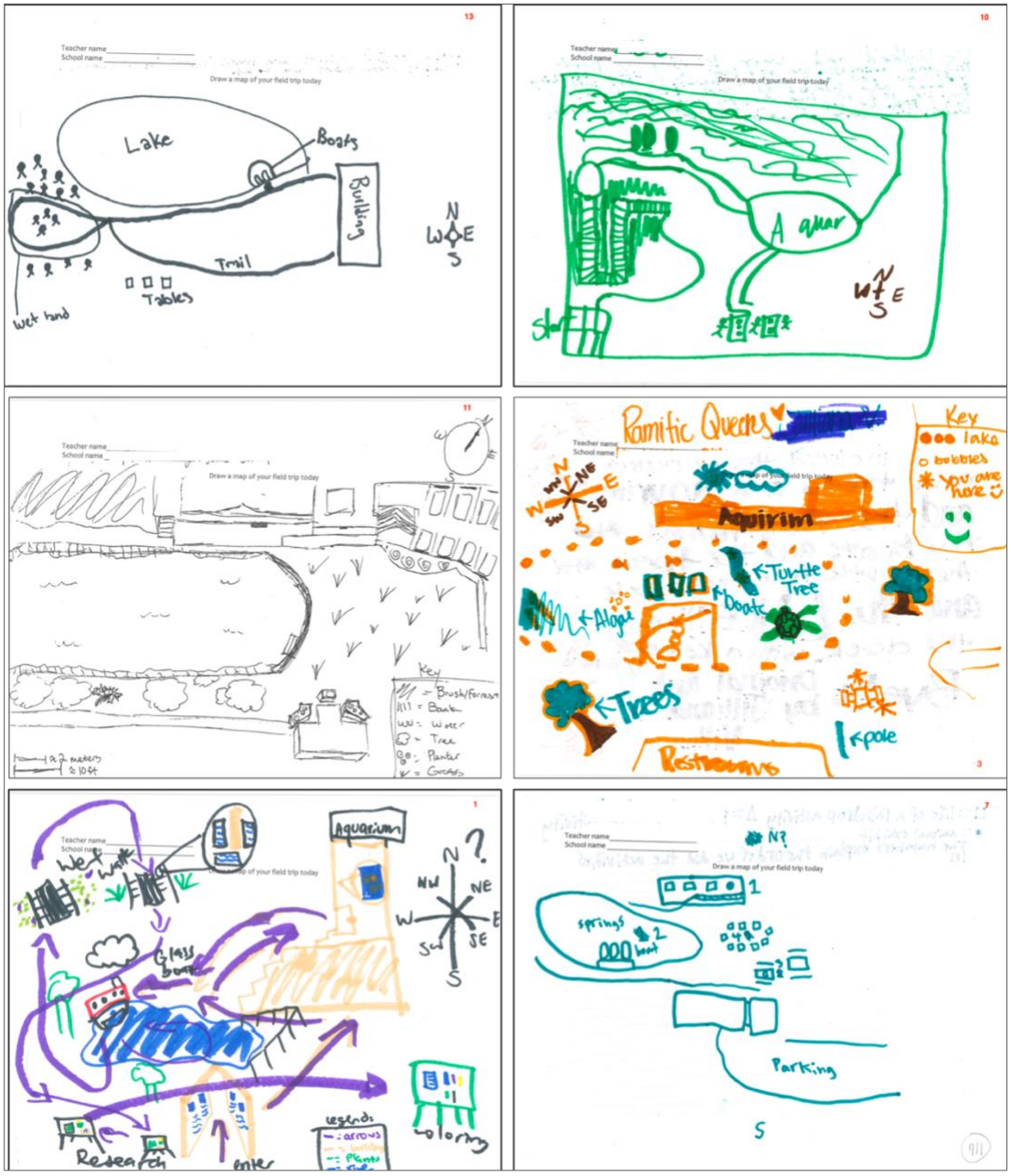



Figure 4. Examples of north arrows in six maps. Compared to the north arrows on the top two maps, the north arrows in the middle two are tilted. The two north arrows on the bottom two maps both include question marks, suggesting uncertainty in correct cardinal direction.


Figure 5. Examples of legends in six maps.

Children commonly included labels on their maps or additional descriptive text that helped convey to the reader a deeper understanding of what they were visually representing. Such text often clarified the various symbols when a legend was not present or provided a way to add more information to the map (Figure 6), and sometimes acted as a form of emotional expression of the children's feelings about their field trip experience (Figure 7). In a small number of cases, children actually used words as a repetitive symbol to denote what and where things are (Figure 8).


Figure 6. Examples of descriptive text in three maps.


Figure 7. Examples of emotional expression with text in two maps.


Figure 8. Examples of repetitive text in three maps.

A little less than a quarter of the children expressed elements of chronological flow through the use of arrows, numbers, or as text to mark ‘start’ and/or ‘end’ locations, such as the examples in Figure 9; representations of such sequence of events is most likely due to the nature of the prompt the students were asked in the activity. Children most often drew their maps from a perpendicular (aerial) perceptive; rarely did they use an oblique perspective, but about a third used a combination of both perpendicular and oblique views as shown in Figure 10. Furthermore, children very infrequently framed their map or used a delineated border around their map area, a couple examples which can be seen in Figure 11.

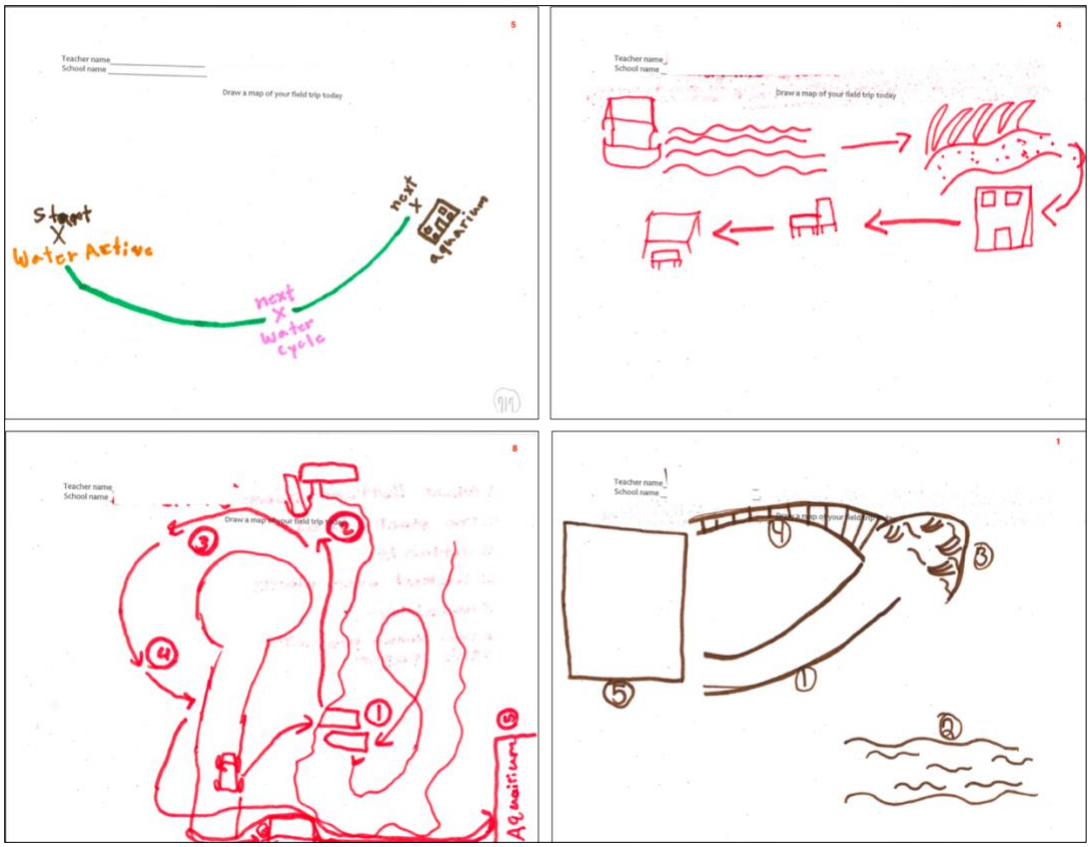



Figure 9. Examples of chronological flow in four maps.

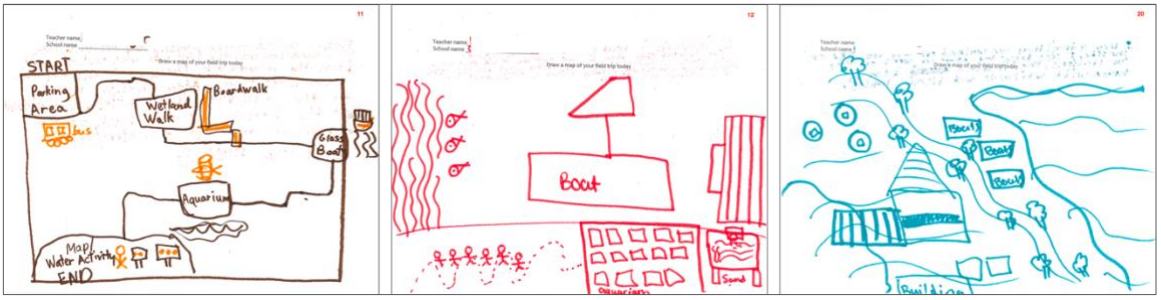



Figure 10. Examples of perpendicular (left), combination (middle) and oblique (right) perspectives.

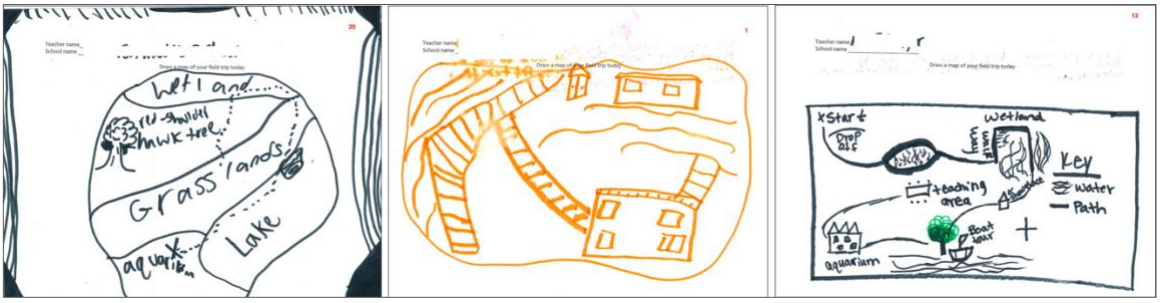



Figure 11. Three examples of framed maps.

*Results Situated Within the Field*

As it relates to the literature, the resulting maps in this thesis look like the prototypical children's map according to Weigand (2006) that is small scale and includes color and conventional symbols; they also express similar styles to the sketch maps of children of various ages in other related studies such as Matthews (1984a), Weigand (2006), Lehman-Frisch (2012), Goria and Papadopoulou (2017), and Silva (2019a and 2019b). Furthermore, this collection of field trip maps are an excellent exemplar corpus reflecting children's spatial representation through the use of pictorial images as established in Matthews' (1984a) evaluation categories of children's maps. Matthews (1984a) suggests that three types of drawings of maps exist between different ages of children, where most children younger than 8 years old tend to draw a *pictorial map* "with elevation views of buildings," most children older than the age of 10 draw maps

using a *plan* (or *plan form*), and children between these ages draw *pictorial plans* or hybrids that "use both forms of representation within the same map" (see examples in Figure 15) (Weigand 2006, Lehman-Frisch et al. 2012).

Additionally, the resulting maps also display expected variations in the levels of sophistication in basic elements such as "symbology, spatial reference systems, scale and direction" as it relates to children's varying ability to represent space (Gerber 1993b, Weigand 2006). The results confirm not only that children often draw their maps "as though they were walking around the area, mentally following the routes they knew," but that maps according to children frequently act as a representation and a means to navigating an area, among other conceptions of the functions of maps as seen by children (Gerber 1993b, Weigand 2006). For example, one child included a "warning" label on their map (Figure 12) that reads "Map may be inaccurate. Do not use to navigate. Thank you" expressing his or her understanding that maps function as a wayfinding tool which requires accuracy. Ultimately, the maps in this study confirm the notion that children's maps are "manifestations of their experience in using maps" and in interacting with their environment, as well as are expressions of what is valuable to them, as children "inject something of themselves in both the process and the product" when they draw maps (Gerber 1993b). In this way, children's maps can sometimes be seen as "egocentric" reflecting the fact that younger children, according to Piaget, tend to "perceive, understand and interpret the world only in terms of themselves," as the map in Figure 13 shows an example of (Gerber 1981a, Weigand 2006).

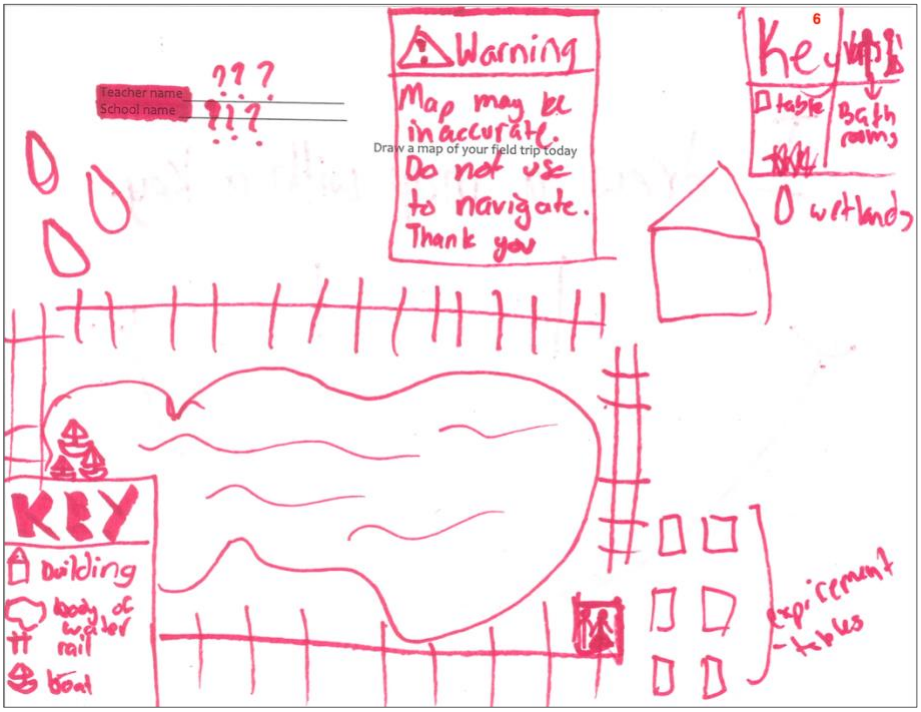



Figure 12. Example of a child's expression of the function of a map using descriptive text in a "warning" label about map accuracy.

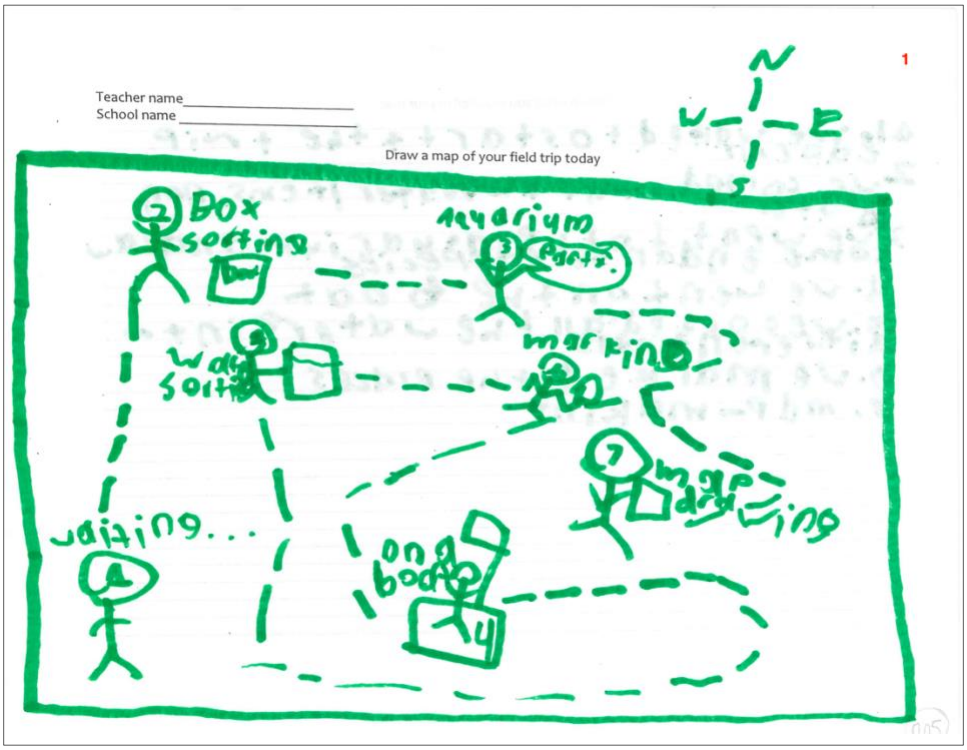



Figure 13. Example of a child's expression of self in a map as seen by drawing him or herself at every point on the map.

While confirming that free recall sketching of maps is a rich graphic method for exploring children's cartography, this thesis is unique in that while most studies who use this method inquire about children's mapping of their neighborhood or their journey from home to school (Matthews 1984b, Weigand 2006, Lehman-Frisch 2012, Goria and Papadopoulou 2017, Silva 2019a and 2019b), I investigate children's visual expression of a geographic area that have just experienced for the first time, which allows for a more controlled comparison of the content and ways in which they cartographically represent their experience (Matthews 1984a). Additionally, these studies investigate children's cartography with a sample population size ranging between 20 and 70, whereas this thesis analyzes maps made by 332 children, allowing for the analysis of a larger sample of maps created in a controlled environment and with little prompt from adults.

Furthermore, the content of the maps made from the children's field trips confirm the suggested clustering of children's common map elements and content as posed by Silva (2019a), including: a) orientation elements which act as landmarks (new buildings or remarkable places that help with wayfinding); b) cultural personalization (personal associations, emotional links); c) infrastructure (urban built environment); and, d) natural landscape (sea, sun, trees, gardens, etc.). These four groups can be clearly seen within the content of the children's map within this thesis, where elements of both the natural and built environment were abundantly present, and places such as the aquarium, Spring Lake and bathroom facilities commonly functioned as orientation elements; emotional or personal attachments to various places and things also appeared on the maps, as, for example, the exciting experience of seeing a turtle that a group of children saw on a tour of the lake in which they named "Edry" and made to sure include on their map (Figure

14). In addition to this clustering of common map content, the maps in this thesis also include children's expressions of chronological elements (Figure 9).


Figure 14. Examples of emotional expression/personal attachment in three maps. These maps all include the turtle some children collectively named "Edry" from their exciting encounter with turtles on the lake.

Additionally, this content also provides a window into the children's field trip experience at the Meadows Center, which is an important part to understanding the big picture and context of these maps in question. Field trips are an excellent educational pillar of a child's well-rounded 21st century skillset that utilize interactive and engaging learning experiences in a real-world context, as supported by inquiry-based learning (IBL) and Vygotskian theory, that inspires critical thinking and challenges children's assumptions of the world (Layen and Hattingh 2020, Peterson et al. 2020, Krantz and

Downey 2021). For example, the exploration of the Meadows Center allows children to collaborate and co-construct knowledge through interaction with their environment and discussion with their peers, engaging their senses, emotions, and perceptions beyond their personal worldviews that are reflected in the maps they produced in the mapping activity following their field trip; by prompting the children to visually and graphically represent their experience, not only do they exercise their creative and critical thinking skills, but the resulting maps also provide great insight as to how children perceive the world, and subsequently, how they conceive maps (Layen and Hattingh 2020, Peterson et al. 2020, Krantz and Downey 2021).

In regards to *how* children map, the resulting maps show that children most often use both abstract and mimetic symbology, most likely due to the fact that younger children typically use a mixture of the two and older children rely "almost wholly on abstract ones" (Gerber 1993, Weigand 2006). The varied use of points, lines and polygons in these maps reflect what Filippakopoulou et al. (1999) explains in that children's ability in "pictorial [mimetic] and abstract line, point and area symbol identification" varies with age. Similar is the case with the children's expression of color in the maps in this thesis: children of different ages vary in their awareness of the range of hues and in their general gravitation towards certain hues or saturations, as, for example, children generally dislike "dull unattractive" colors such as brown or gray, and therefore such colors were not abundantly seen in these maps (Sorrell 1974). This may explain the cases where children's use of color connotation was similar to the adult's, with exceptions already noted: while all children who applied the rules of color connotation used blue for water and green for grass, often times sidewalks or bridges,

which are normally shades of brown or gray in reality, were expressed with pink or orange (arguably seen as less "dull or unattractive" colors comparatively).

As it relates to cartographic conventions and perspective, variations in the application of scale and viewing perspective varied across the maps, confirming what Liben and Downs (1989) and Weigand (2006) explain as how children commonly stretch some parts of the map while shrinking others; understanding scale requires a child to understand proportionality and the ability to estimate distance on the ground, which is difficult for children until the age of 11 (Filippakopoulou et al. 1999, Weigand 2006). The majority of children in these maps utilized a perpendicular view or aerial perspective, as Liben and Downs (1989), Vasiliev et al. (1990), Gerber (1993), and Weigand (2006) all found to be common in children's drawing of maps. However, while these studies discuss how children use and draw conclusions from maps that have a perpendicular perspective, less common is the exploration as to what type of perspective children tend to use when making a map of their own, as this thesis uniquely provides.

While the majority of maps lacked the inclusion of a legend, Nieścioruk (2016) suggests this may not be surprising due to the nature of sketch maps which include symbols that are often "limited and self-explanatory." Furthermore, given that the children were also asked to include a written description of their map on the back, data which was not included in the analysis of this thesis, this description often acted a place where children explained their symbology which may have indirectly tempted them not to include such explanations via a legend on the map itself. Although the use of a north arrow was also limited, those who did include one typically oriented north at the top, which follows the persistent false notion that north is always at the top of the map

(Weigand 2006); this could suggest, however, that these children have seen or worked with maps prior to this mapping activity.

*Interpretation and Application*

Given the range of ages of the children who participated in the mapping activity, as well as differences in what each child remembered, found valuable and could visually represent, there is an expected variation in map design throughout the children's maps. As related to Matthews' (1984a) classifications or grades of children's map drawings, there was a clear range of pictorial to plan form maps that varied in levels of sophistication in basic elements. For example, Figure 15 shows two examples each of a pictorial, a pictorial plan, and a plan. Additionally, children also expressed map drawings of certain objects, events or landscapes that they found remarkable from their field trip experience (see Figure 16). These maps also varied in levels of abstraction, ranging from circumventing linear expressions to minimalistic colored polygons (see Figure 17).

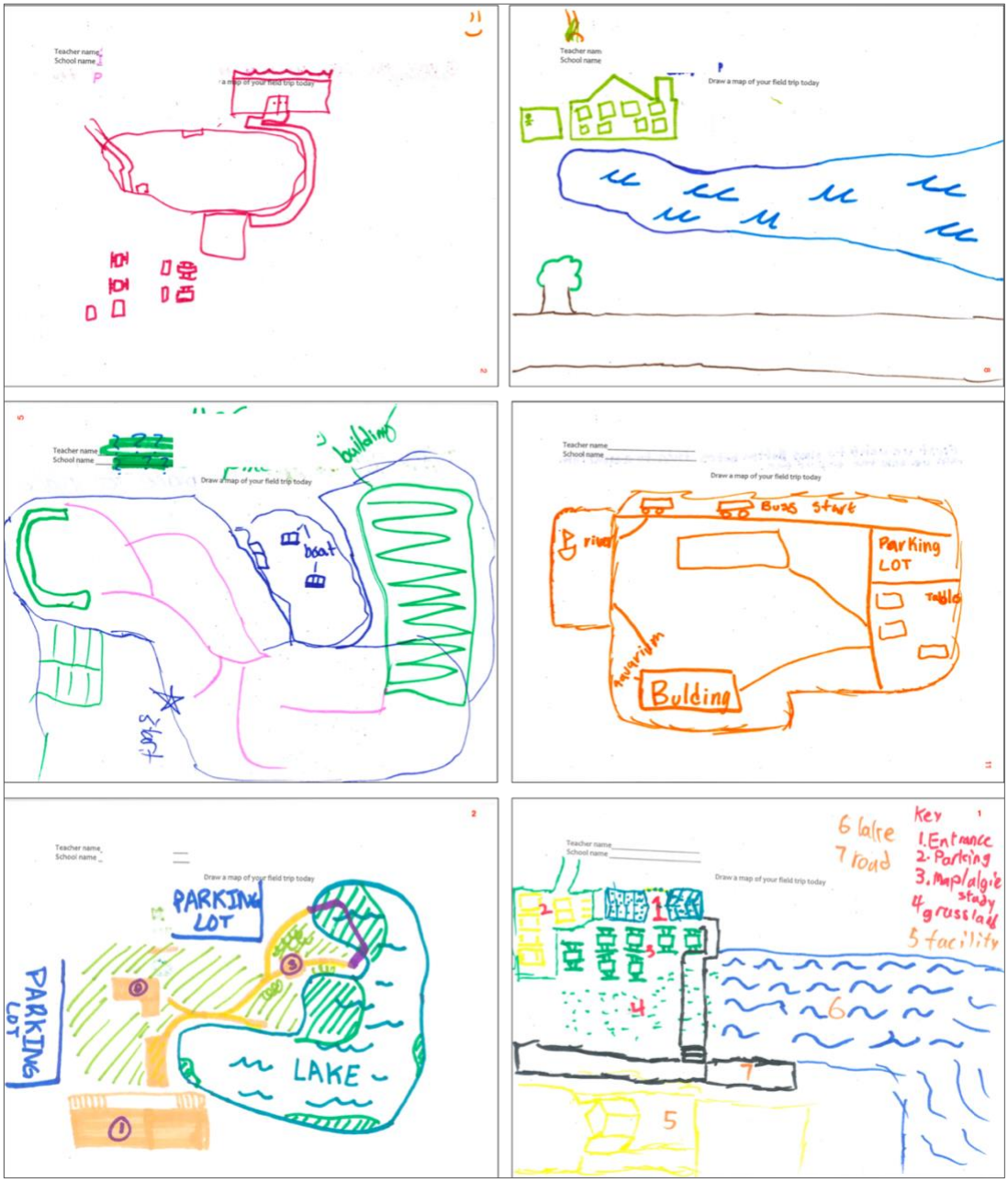



Figure 15. The top two maps are examples of pictorial maps, the middle two maps are examples of pictorial plans, and the bottom two are examples of plan forms according to Matthews' (1984a) classification.


Figure 16. Four examples of children's expressions of objects (top left), events such as the boat ride (top right), and landscapes (bottom left and right) that they found significant to map.

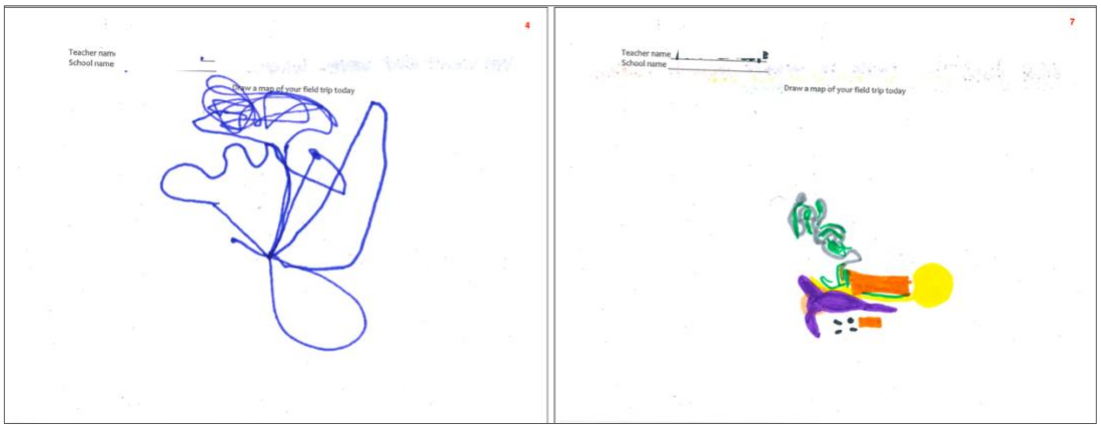



Figure 17. Two examples of the varying levels of abstraction ranging from circumventing linear expressions (left) or minimalist abstract polygons (right).

The children's maps also varied, although rarely, in scale. While most maps were drawn at a geographic scale that spanned the general area of the Meadows Center, a small number of children "zoomed in" and graphically expressed small portions of the Center, where as others "zoomed out" and either included businesses or cities they explored outside the Meadows Center or included an inset map of the world (Figure 18).

As it relates to map content specifically, the most common built environmental elements across the maps were buildings such as the aquarium or bathroom facilities, as well as sidewalks and bridges they walked on as part of their tour; they also included many natural environmental elements of significance, such as Spring Lake or the abundance of trees surrounding it. In relation to Silva's (2019a) interpretation themes of children's map content, this suggests that the children focused their maps around orientation elements, i.e., places or things that acted as landmarks that ultimately helped them navigate their experience on their field trip. They also included things like specific creatures they found on their walk that they enjoyed seeing, such as the turtle Edry (see Figure 14), thus expressing emotional connections they built throughout their experience. This suggests that children often see maps as a representative means for way-finding or emotional expression.

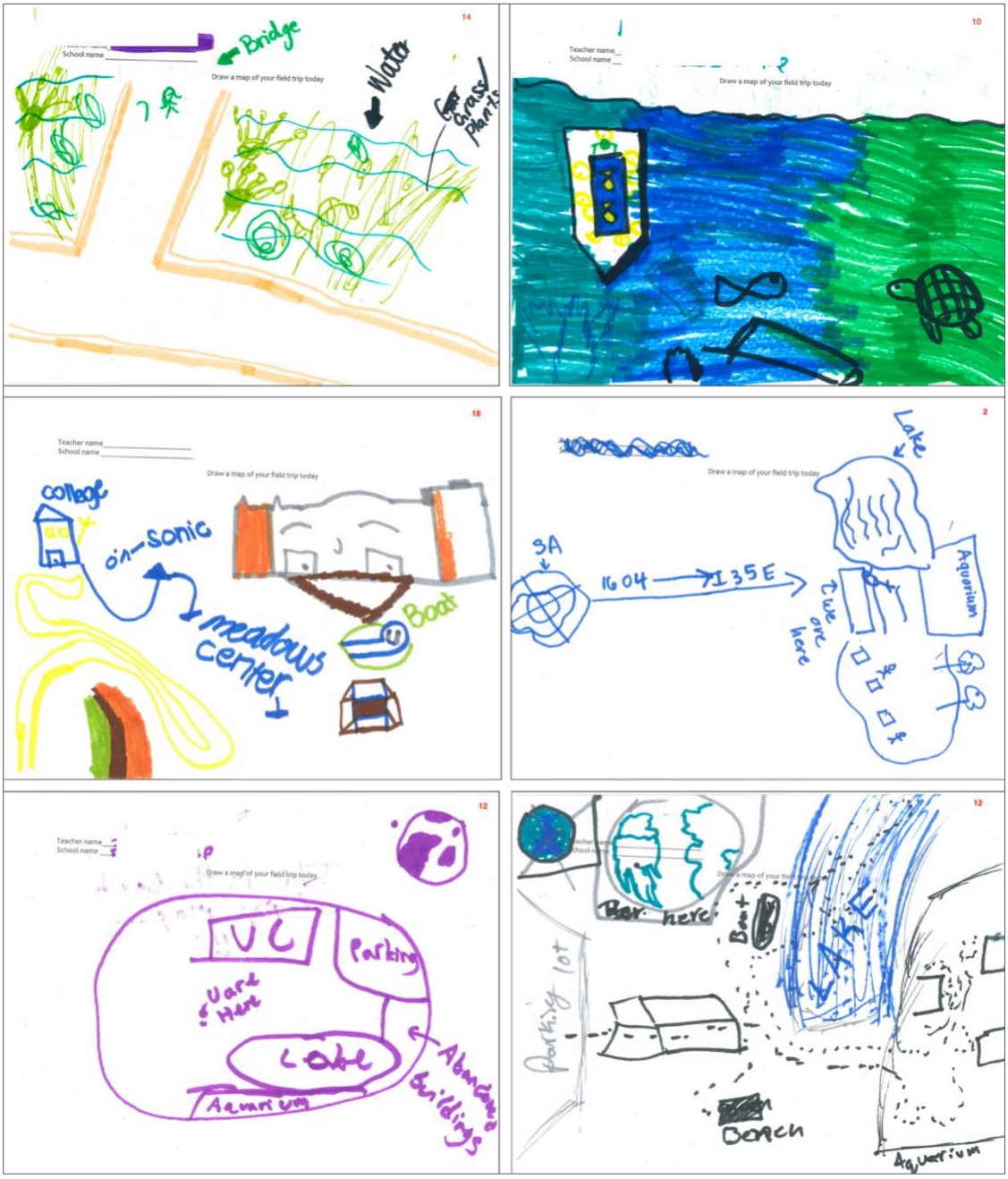



Figure 18. Six examples of varying scale of maps: the top two are the most "zoomed in," the middle two show places or cities ("SA" being San Antonio and "1604, I35E" being highways in the map on the right) zooming outside of the Meadows Center, and the bottom two include inset maps of the world.

With respect to their evolving minds and variation in education and experiences, it can be said that a map according to a child typically involves a graphic representation of their experience that is composed of points, lines and polygons and a mixture of both mimetic and abstract symbology to represent both the natural and the built environment. These symbols vary in shape, are often used repeatedly to create texture or patterns, and can vary in color that sometimes abide to traditional color connotations. While none of the cartographic conventions were used significantly besides color, this suggests that children who did include things like a scale, legend or north arrow may have experience with maps before either in school or in everyday life. The abundant used of written labels or descriptive words on their maps suggest that children commonly express a map that includes text. The results also suggest that children commonly expressed maps from a perpendicular perspective. Other elements such as chronology of maps were not used significantly but do suggests that children express that maps can be a means to show chronological flow.

Overall, the content and design of these 332 maps provide great cartographic insight as to what children believe a map should include and how a map should look in its most basic form. Given a sheet of paper, some colored markers and limited instruction, the children of this research enable a deeper understanding of what a map is through comparison and analysis of their maps on the basis of what the children mapped and how they mapped it.

## Limitations

Due to the nature of the population of this study, and specifically their age, there is an inevitable level of uncertainty and subjectivity that goes into the interpretation of children's handwriting and drawings. For example, without written labels, a legend or well-drawn mimetic symbology, an orange blob/dot in the middle of a body of water drawn by a child could be interpreted as a fish, a boat, plant life, or something else. Similarly, while it was common to see children represent grass with large green rectangles, other children drew similar green rectangles and labeled them as a building. As it relates to interpreting mimetic versus abstract symbology, often times it was unclear whether the child was attempting to draw an abstract symbol or if they made a vague attempt to draw a mimetic one. Therefore, during the analysis of each map, I assigned a value on a Likert scale from 1 to 4 (1 as uncertain, 2 as somewhat uncertain, 3 as somewhat certain, and 4 as most certain) that serves as a numerical value to the level of uncertainty in interpretation that I experienced for each map. At the end of the analysis, the average level of uncertainty was 3.69.

Additionally, the educational background of the children is unknown. While this is not a factor that is directly limiting, it is important to consider when discussing the findings. For example, a child's level of experience with or education of maps may significantly vary from other children who were homeschooled or in Girl or Boy Scouts, compared to those solely from a public-school education, in addition to the expected variation in school curriculums and grade levels.

The mapping activity the children participated in that supplied the maps for this thesis was set up to allow for the children to draw maps from their own intuition rather

than acquired knowledge, at least as it pertains to their time spent at the Meadows Center. With awareness and consideration to the fact that we do not know what cartographic knowledge (or lack of knowledge) the children are bringing to the mapping activity, there is a limit to the conclusions that can be drawn from analyzing these maps as it relates to how children map. For example, in the case where a child included a north arrow on their map, we cannot be sure whether they included the north arrow because they think that maps require a north arrow to orient the map and included one in the correct manner (where north faces the true cardinal direction in relation to reality), or because, due to previous knowledge of maps, they associate the notion of a north arrow as being a part of a map, and included it symbolically. The same could be said regarding the inclusion of a legend, scale, or title, or the use of visual variables or various types of symbology. Similarly, the lack of a north arrow (or any cartographic convention or variable for that matter) does not always necessarily suggest a child's cartographic ignorance, rather it could be reflective of a child's natural cognitive limitations to understanding underlying concepts that enable the use of such things, such as understanding proportionality and the use of a scale as previously discussed. Weigand (2006) also reminds us that the analysis of children's sketch maps is more fruitful to understand how children cognitively map rather than how children draw cartographic maps.

This research also includes a number of uncontrollable variables, such as a child's possible physical or mental disabilities (broken arm, color blindness, etc.), natural creativity, drawing skills, spatial awareness, language barriers, or even not having enough blue markers for everyone, all playing a role in the children's ability to graphically represent their experience on paper (Bell 2011, Castner 2000).

As stated in Chapter 2 Section II, this thesis reworks and builds upon a previous multi-year study. Through the excellent efforts of the students and faculty involved, they formed the structure, protocol, collection process and type of the data collected to fit their research aim to explore children's perception, expressions of and relationship with nature through map-making. Specifically, the grades of the children were documented in ranges rather than individual grade levels (e.g. $5^{th}$-$7^{th}$ rather than just $5^{th}$ grade) for each set of maps, limiting the conclusions that can be drawn from the analysis as it relates to age related patterns in cartographic performance. Consequently, this thesis is limited to the careful adaptations and reworkings of the previously collected data and study design to fit a more cartographically focused research interest.

# 5. CONCLUSION & FUTURE WORK

## Conclusion

Ultimately, the 332 maps created by the children on their field trips are manifestations of their experience in interacting with their environment and in using maps, essentially expressing what is valuable to them in both content and design. With respect to their evolving minds and variation in education and experiences, this thesis finds that a map according to children can be defined as a graphic representation of a child's experience that is expressed with considerable use of symbology, text and design variations to represent both the natural and the built environment composed from a perpendicular perspective. Although this definition is subject to the nature of the prompt the children were given reflecting their experience of their field trips, it implies that children's maps are uniquely composed compared to maps in general. These children's maps are experiential in that they use variations in cartographic elements and design to ultimately express the paths they followed and the events they enjoyed throughout their fieldtrip. Comparatively, a map made by a teacher or adult member from the same field trip groups may graphically express the map in a visually similar manner in their use of cartographic conventions and elements, whereas children are unique in the structure of their maps with their varied use of perpendicular and oblique perspectives and mixture of mimetic and abstract symbology as it relates to their various ages and experiences with maps.

This thesis provides an excellent and extensive collection of what children materially create when asked to make a map, reflecting their varied approaches in spatial representations of their experience. Through a cartographic analysis, this work provides

insight as to *how* children map and *what* they map, ultimately expressing their overall inherent understanding of what a map is. Through considerations of the topographic, topologic, and cartographic characteristics of maps, this analysis inspires results that, with holistic considerations of the cognitive and educational development of the children, ultimately contribute to the field's foundational understanding of the map.

## Future Work

This study is intended to lay the initial groundwork not only to better understand what a map is to children, but also to open the door to future investigations related to children's geographic education, environmental relations, psychology and the development of spatial cognition, and cartographic literacy. Specifically, future work could deal in exploring how the children's socio-geography (school district, zip code) impacts their cartographic understanding and practice. To better understand the great variations expressed in cartographic content and design, a grade level analysis would be greatly beneficial from a geographic education perspective. Additionally, and as it relates to mitigating for the specific limitations of the children's unknown educational background, future work can involve gathering information for each child's education type, such as public school, private school, or homeschool, or even their personal experiences related to map use, such as traveling.

As it relates to children and the environment, further analysis could focus on the terms children used to call the body of water they toured (as it often ranged from terms like pond to ocean), looking into how the time of day or time of year impacted the content represented in the maps, and exploring the child-nature relationships as expressed

via the map. Other elements such as presence of place names, social elements, or emotional expressions would also be fruitful for investigation. As it relates to a deeper cartographic analysis, future investigations could include comparing the amount of white space used, the locational placement of the various cartographic conventions on the map, the number of mapped elements, the specific colors used, primary map content or subject matter, map accuracy, representation of chronology, or the level of detail or range of sophistication from map to map.

Additionally, an analysis of the written descriptions the children included on the back of these maps could provide insight into all of the above future considerations through a textual analysis using Corpus Linguistics (CL) (Moretti 2000, Knowles et al. 2021); paired with the visual content analysis this thesis provides of how and what children map, a textual analysis would enable an investigation into how children describe the map in words.

# APPENDIX SECTION

## 1. Data Collection Protocol

**Data Collection Protocol**

**I. Summary of the project and Data Collection Plan**

The purpose of this study is to examine children's perceptions of nature and the spatio-temporal characteristics of maps. The participants of this research will be k-12 children who signed up for a field trip at the Meadows Center for Water and the Environment at Texas State University in San Marcos, Texas. The estimated number of participants is 300. The investigators formulated this study based on an extensive literature review on utilizing sketch map method for understanding children's perceptions of nature. This study will be designed based on previous research experience with a small sample.

**II. Collection of Data: Before, During and After collection**

**Tour Coordinator Training.** Investigators will train Meadows Center tour coordinators to ensure that appropriate information is collected from, and provided to, teachers prior to their arrival at the Center. Tour coordinators are Meadows Center staff who interfaces with teachers and books all the field trip tours.

In the weeks prior to field trip bookings, estimated to occur in April 2017, investigators will train tour coordinators on the research goals, meaning of non-identifiable data collection, and an overview of the importance of following the data collection protocol.

**Tour Coordinator Data Collection Protocol.**

1. When teachers contact the Meadows Center to schedule a field trip, the tour coordinator will collect information on whether teacher self-selected the mapping module or whether it was included as an add-on (i.e., did not request, but will be included at the end of the field trip).
2. If teacher did not self-select the mapping module, the tour coordinator will ask whether the teacher would be willing to add-on the mapping module to the end of the field trip.
3. Tour coordinators document selection in existing Meadows Center registration logs.
4. For those teachers that agree to include the mapping module, tour coordinators will provide teacher with modified tour booking forms that include required language as part of researcher data collection IRB requirements.

**Interpretive Guide Training.** In the weeks prior to field trips where data are collected, investigators will train Meadows Center's interpretive guides, estimated to occur in April 2017. Interpretive guides are Meadows Center employees who deliver the educational modules during field trips and are typically Texas State University undergraduate students. The training session will include:

1. 15 minute training session with all interpretive tour guides on data collection protocol. The training will include a description of the research goals, non-identifiable data collection, and an overview of the importance of following the data collection protocol for quality research.
2. 15 minute demonstration of data collection protocol and timing, including:
   a. 10 minutes for map: "For the next few minutes use the colored markers to draw a map of your field trip today on the sheet provided." (See appendix 1, mapping sheet)
   b. 5 minutes for explanation: "Now take a few minutes to write down what you included in your map on the back of the sheet provided."
   c. During a & b above, interpretive guides will fill out Mapping Module Questionnaire for Interpretive Guides questions 1-8. (See appendix 2)
   d. Collect the maps
   e. 5-10 minutes for interpretive guide-led discussion and questions about mapping and cartography using the Mapping Module Questionnaire for Interpretive Guides.
   f. After each mapping module, interpretive guide will clip all maps collected from each group to the Mapping Module Questionnaire for Interpretive Guides form and store them in the Meadows Center's Ticket kiosk.

**Interpretive Guide Data Collection Protocol.**

1. Interpretive Guide will gather students and pass out clipboards with mapping sheet (See appendix 1).
   a. "For the next few minutes use the colored markers to draw a map of your field trip today on the sheet provided." Allow 10 minutes for maps.
   b. "Now take a few minutes to write down what you included in your map on the back of the sheet provided." Allow 5 minutes for explanation.
2. During 1a & 1b above, interpretive guides will fill out Mapping Module Questionnaire for Interpretive Guides questions 1-8. (See appendix 2)
3. Interpretive guides then Collect the mapping sheet.
4. Interpretive guides will next lead students in a 5 -10-minute discussion and question session about mapping and cartography using the Mapping Module Questionnaire for Interpretive Guides.

## 2. Mapping Module Questionnaire for Interpretive Guides

**Mapping Module Questionnaire for Interpretive Guides**

**Read**

"During this next mapping activity we ask that parents and teachers do not help the students. We are doing a study to learn about how kids like you understand nature and maps. **For the next fifteen minutes use the colored markers to draw a map of your field trip today and on the backside, explain what you drew on your map.** We would like to use your map for our study. If you don't want to be in the study you can still draw a map but we will not make a copy. Please do not put your name on the map. You will not receive anything in return for drawing a map. If you don't want to be in this study, it is ok to say "no" and nobody will be mad at you."

**Complete this section while students are drawing their maps.**

1. Name of School_____
2. Name of Teacher_____
3. Grade_____
4. Name of Guide_____
5. Date/Time_____
6. Place of the mapping activity_____
7. Number of Students_____
8. What activities did you do today (check all that apply)?

☐ Boat ☐ Bug Picking ☐ Wetlands ☐ Aquarium ☐ All the water in the World ☐ Water Conservation Game

☐ Journey of a Water Drop ☐ Competition in Spring Lake ☐ Foodweb ☐ Bingo ☐ _____ Fill in ☐ _____ Fill in

9. Does the teacher prefer to receive a digital copy of the students' maps? Yes or No

   If yes, teacher's email address_____

10. Did kids talk to each other? Yes or No
11. Other observations?

*Last modified July 17, 2017*

**This section includes suggestions for what to discuss/teach about maps after you collect the maps.**

Collect the maps from the students. Then show them examples of the maps. Then tell them maps have:

- Key
- Scale
- Compass/north arrow
- Some have Grids

Ask students to "raise your hand if your map has..." this:

1. A compass or a North arrow? Write down number of hands.
2. Is it an aerial view? Write down number of hands.
3. Did you include a scale? Write down number of hands.
4. Have you drawn a map before? Write down number of hands.

Ask students what did they included in their map? Write examples.

**After Activity follow-up questions for the interpretive guides**

1. Did you follow the script? Yes or No

   If No, then explanation_____

2. Was the time expected correct? Yes or No

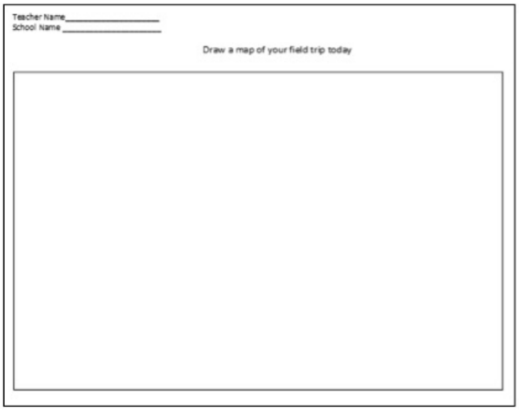
   If No, then explanation_____

3. Were there any extraordinary events that affected the activity? (Examples: sick kid, rain, etc...)

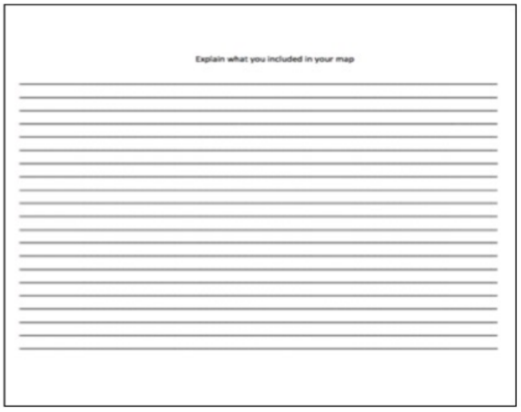
*Last modified July 17, 2017*

3. Data Collection Sheet

Front 8.5 x 11




Back 8.5 x 11



## LITERATURE CITED


Anderson, J. M., & Vasconcellos, R. 1995. Maps for and by children: possible contributions by cartographers. In *17th International Cartographic Conference*, Barcelona, Spain, ICA.

Antle, A. N. 2007. Designing tangibles for children: what designers need to know. In *CHI'07 Extended Abstracts on Human Factors in Computing Systems*, 2243-2248.

Bell, S., & Archibald, J. 2011. Sketch Mapping and Geographie Knowledge: What Role for Drawing Ability?. In *Understanding and Processing Sketch Maps@ COSIT*, 1-10.

Bertin, J. 1983. Semiology of Graphics (translated by William J. Berg). *Madison, Wisconsin: The University.*

Bláha, J.D., Hátle, J., Hudeck, T., Kynclová, M., Novotná, K., Pastuchová-Nováková, T., & Sákrová, M. 2011. Cartographic research of mental maps at Charles University in Prague. In *The 25th International Cartographic Conference,* 3-8.

Castner, H. W. 2000. The Nature of Creativity in Cartographic Design with Special Reference to the Barbara Petchenik Map Design Competition. *Cartographic Perspectives*, (36), 12-22.

Dodge, M. 2014. 24 Mapping and Geovisualization. *Approaches to human geography: Philosophies, theories, people and practices*, 289.

Filippakopoulou, V., Michaelidou, E., & Nakos, B. 1999. The use of primary graphic elements in map design by first and second grade students. *Proceedings: Discovering Basic Concepts, ICA*, Montreal, Canada, 58-63.

Filippakapoulou. 2009. Children and Mapping. In Kitchin R, Thrift N (eds) *International Encyclopedia of Human Geography*, Volume 1, 50–57.

Gerber, R. 1981. Young children's understanding of the elements of maps. *Teaching Geography*, 6(3), 128-133.

Gerber, R. 1993. Map design for children. *The Cartographic Journal*, 30(2), 154-158.

Gerber, R. 1984. Factors affecting the competence and performance in cartographic language for children at the concrete level of map reasoning. *Cartography*, 13:205–13.

Goria, S., & Papadopoulou, M. 2017. Icons versus symbols: investigating preschoolers' cartographic design. *Meta-carto-semiotics*, 5(1), 1-18.

Knowles, A. K., Jaskot, P. B., Cole, T., & Giordano, A. (2021). Mind the gap: Reading across the Holocaust testimonial archive. In *The Holocaust in the 21st Century: Relevance and Challenges in the Digital Age: Lessons and Legacies Volume XIV*, 216-241. Northwestern University Press.

Krantz, A., & Downey, S. 2021. Thinking About Art: The Role of Single-Visit Art Museum Field Trip Programs in Visual Arts Education. *Art Education*, 74(3), 37-42.

Layen, S., & Hattingh, L. 2020. Supporting students' development through collaborative reflection: interrogating cultural practices and perceptions of good practice in the context of a field trip. *Early Years*, 40(3), 306-318.

Lehman-Frisch, S., Authier, J. Y., & Dufaux, F. 2012. 'Draw me your neighbourhood': a gentrified Paris neighbourhood through its children's eyes. *Children's Geographies*, 10(1), 17-34.

Liben, L. S., & Downs, R. M. 1989. Understanding maps as symbols: The development of map concepts in children. *Advances in child development and behavior*, 22, 145-201.

MacEachren, A. M. 2004. How maps work: representation, visualization, and design. *Guilford Press*.

Matthews, M. H. 1984a. Cognitive mapping abilities of young boys and girls. *Geography*, 327-336.

Matthews, M. H. 1984b. Cognitive maps: a comparison of graphic and iconic techniques. *Area*, 33-40.

Monmonier, M. 2018. How to lie with maps. *University of Chicago Press*.

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.

Moretti, F. (2000). Conjectures on world literature. *New left review*, 1, 54.

Nieścioruk, K. 2016. The use of mental and sketch maps as a tool to evaluate cartography teaching effectiveness. *The Cartographic Journal*, 53(2), 186-196.

Petersen, G. B., Klingenberg, S., Mayer, R. E., & Makransky, G. 2020. The virtual field trip: Investigating how to optimize immersive virtual learning in climate change education. *British Journal of Educational Technology*, 51(6), 2099-2115.

Rose, G. 2016. *Visual methodologies: An introduction to researching with visual materials*. Sage.

Roth, R. E. 2017. Visual variables. *International encyclopedia of geography: People, the earth, environment and technology*, 1-11.

Silva, C., Prandi, C., Ferreira, M., Nisi, V., & Nunes, N. J. 2019a. Towards Locative Systems for, and by, Children: A Cognitive Map Study of Children's Perceptions and Design Suggestions. In *Proceedings of the 2019 on Creativity and Cognition*, 382-395.

Silva, C., Prandi, C., Ferreira, M., Nisi, V., & Nunes, N. J. 2019b. See the World Through the Eyes of a Child: Learning from children's cognitive maps for the design of child-targeted locative systems. In *Proceedings of the 2019 on Designing Interactive Systems Conference*, 763-776.

Sorrell, P. 1974. Map design—with the young in mind. *The Cartographic Journal*, 11(2), 82-90.

Vasiliev, I., Freundschuh, S., Mark, D. M., Theisen, G. D., & McAvoy, J. 1990. What is a map?. *The Cartographic Journal*, 27(2), 119-123.

Wiegand, P. 2006. Learning and teaching with maps. *Routledge*.

Wood, D. 1993. What makes a map a map?. Cartographica: *The International Journal for Geographic Information and Geovisualization*, 30(2-3), 81-86.