ARTICLE

What Do Children Draw When Asked to Draw a Map? Results of a Mental Map Experiment

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RÉSUMÉ

Que dessinent les enfants, quand on leur demande de dessiner une carte reflétant leur expérience ? Les auteur·es tentent de répondre à cette question à travers le regard d'enfants âgés de 6 à 14 ans qui ont visité le Meadows Center for Water and the Environment, sur le campus de la Texas State University, en étudiant 332 cartes dessinées par les enfants à la suite de leur visite. Les résultats indiquent que, pour les enfants, une carte peut être comprise qualitativement comme une représentation graphique de leur expérience qui comprend des personnes et des animaux, des lieux et des évènements, ainsi que des environnements naturels et bâtis. Les enfants utilisent à la fois des symboles mimétiques et abstraits, caractérisés par une forme variable, leur emploi souvent répété pour créer des textures ou des motifs, et des couleurs variables qui respectent en général – mais pas toujours – les dénotations habituelles des couleurs. Les échelles cartographiques, les légendes ou les flèches vers le nord sont rarement utilisées. L'utilisation abondante d'étiquettes textuelles ou de mots descriptifs sur leurs cartes suggère que les enfants comprennent les cartes comme une forme expressive qui mélange les symboles et le texte. Dans le but d'alimenter la réflexion sur ce qui fait, ultimement, qu'une carte est une carte, cette étude fournit des arguments empiriques solides pour soutenir que le contenu et le fonctionnement des processus de création de cartes des enfants se concentrent sur les conventions et les éléments cartographiques traditionnels.

Mots clés : cartographie, cartographie par des enfants, conception de cartes, cartes mentales

ABSTRACT

When asked to draw a map reflecting on their experience, what do children draw? The authors offer possible answers through the eyes of children aged 6 to 14 who visited the Meadows Center for Water and the Environment on the campus of Texas State University; the 332 maps children were asked to draw after their visit are the focus. Results indicate that according to children, a map can be qualitatively understood as a graphic representation of the child's experience that includes people and animals, places, and events, and natural and built environments. Children use both mimetic and abstract symbols that vary in shape, are often used repeatedly to create texture or patterns, and can vary in colour that often—but not always—abide by traditional colour denotations. Cartographic scales, legends, or north arrows are rarely used. The abundant use of written labels or descriptive words on their maps suggests that children understand maps as an expressive form that blends symbols and text. In efforts to contribute to the ultimate questioning of what makes a map a map, this study provides a strong empirical case for the what and how of children's map-making processes concentrating on traditional cartographic conventions and elements.

Keywords: cartography, children's cartography, map design, mental maps

Introduction

What is a map? As a quick Google search will reveal, answering this question often returns bullet-point lists of elements all maps supposedly share. Interestingly, academic cartographers have generally restrained from answering this question explicitly, with notable exceptions (see, for example, Vasiliev and others [1990] and Dodge

[2014]). In this article, we offer insights into this question from a children's perspective through an empirical analysis of hand-drawn maps created by children varying in age from 6 to 14. Thus, we are not interested here in establishing whether the drawn maps in this study should or should not be considered maps but rather in what children *materially* create when they are asked to make a map—the *what* and the *how* of the map-making process, as compared to how the *literature* defines the map. When asking *what* the children are mapping, we look at the content of the maps, such as whether they are mapping flora or fauna, natural or built environmental elements, physical or chronological features, and so on. When asking *how* the children are mapping, we seek to examine if they are demonstrating any level of cartographic design principles, such as the use of visual variables (colour, size, shape, texture, orientation, etc.), cartographic conventions (north arrow, title, scale, etc.), types of symbols, and the scale and geometric perspective at which they create their maps. In summary, to answer the question, "What is a map according to children aged 6 to 14?" we look at "What is being mapped?" and "How is it being mapped?" separately.

Study Background

WHAT IS A MAP

While ubiquitous and helpful in a multitude of scenarios, from wayfinding and education to legal reports and artful literary features (Liben and Downs 1989; Gerber 1993), maps are hard to define. Map-making in "theory, praxis and technology" has and continues to experience great changes and advancements, especially as it relates to seeing maps as representations or reflections of reality/nature; where maps were once considered representations of truth and (social) constructions, a critical cartography approach to defining the map reframes this thinking with post-representational ontologies, suggesting that maps are more so "inscriptions, propositions, immutable mobiles and actants, and practices" (Wood and Krygier 2009; Kitchin, Perkins, and Dodge 2011). In this light, there is no singular "right way" to make or define a map, with respect to the methods and people(s) (both professional and non-professional map-makers) behind its creation. John Pickles (and other critical [cartographic] thinkers such as Brian Harley, David Harvey, and Denis Wood) advocate that maps go beyond describing and explaining our world, acting to shape our understanding of it and the interplay of ourselves within it, from a more hermeneutic approach that combines the connotative and denotative context of the map (Wood and Krygier 2009; Kitchin, Perkins, and Dodge 2011).

Furthermore, two leading cartography scholars, MacEachren (2004) and Monmonier (2018), describe the map in terms of its form and function as well as its primary role to provide information: they explain that maps are inherently distorted and complex representations of the Earth that derive from the fact that the act of map-making is inextricably rooted in the cartographer's own culture, society, and times, as well as from the representational challenges of turning the three-dimensional world two-dimensional. For their part, Vasiliev and others (1990, 120) synthesized 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, they write that the map is, in its most basic sense, "a representation of the Earth's surface, or part of it." They proceed to define what makes a map a map, rather than defining what a map is, an approach followed by other scholars: in particular, Gerber (1981), Wood (1993), Filippakopoulou and Noros (2009), Goria and Papadopoulou (2017), and Monmonier (2018) all agree that scale, projection, and symbology are most prominent to characterizing a map's form.

A consensus also emerges that in terms of their function and ontology, maps can be seen as representations, tangible objects, intangible ideas, and tools. Vasiliev and others (1990), as well as others (Liben and Downs 1989; Anderson and Vasconcellos 1995; Dodge 2014), suggest that maps are most commonly seen as graphic representations or geographical pictures, usually on a plane surface, that show Earth's surface. Many cartographers posit 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 wayfind, 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 and Noros 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, 83) 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, 149).

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 the 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 by 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, 148). 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).

CHILDREN AND THE MAP

When it comes to map users and spatial thinkers, children are no exception, but they often pose a distinctive challenge to researchers, map designers, psychologists, and educators alike as their intellectual capabilities, spatial cognition, and exposure to cartographic literacy and geographic education greatly vary and/or are limited (Gerber 1993). Despite these challenges, children offer a unique perspective to cartographers given their innate creativity and unique conceptualization of space socially, culturally, and environmentally. "All children have an urge to explore the landscape around them, to learn it, to give order to it, and to invest in it with meaning" (Hart 1979, 3). In this way, children provide a fresh perspective to researchers through young and imaginative eyes as they are just beginning to experience the world. While their perspective could be considered "unbiased" or "unadulterated" given their young age and lack of (or still-developing) geographic and cartographic literacy, we must also consider their socialization in "Western" society (and "Western" mapping conventions, given that our sample population takes place in North America, specifically Texas) and exposure to maps in general (e.g., web maps; Blaut and Stea 1971). Despite preliteracy and the "ignorance" or "naivety" of young age, children "can deal with map-like representations and display immense pleasure in doing so"; geographic learning beings very early and often before entering school (Blaut and Stea 1971, 392). As such, they have been the target population of several studies over the last 40 years in fields such as psychology, geography, geographic education, and cartography (Blaut and Stea 1971; Hart 1979; Gerber 1993; Anderson and Vasconcellos 1995; Filippakopoulou and Noros 2009; Silva and others 2019b).

In the field of geographic education, cartographers play a large role in designing maps as teaching aids, helping to close the gaps in geographic literacy, and preparing children as the next generation of map users and producers. Given that cartography as a subject is 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 among children and adults alike (Liben and Downs 1989; Anderson and Vasconcellos 1995; Weigand 2006). 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). For example, Filippakopoulou, Michaelidou, and Nakos (1999) note that 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 an 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 and Noros 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 and Noros 2009). Given these considerations, cartographers should recognize the "special case" or unique population that children are (Gerber 1993; Filippakopoulou and Noros 2009). 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).

To this point, children have been and continue to be a common focus group, especially in the field of cartography. Current scholarly efforts generally aim to explore the ways cartographers can improve mapping for children and turn to the map as a means of understanding them. In contrast, the work we present here aims to explore how children can improve mapping for cartographers, where we turn to the children to understand the map. To do so, we follow similar methods as Bláha and others (2011), Nieścioruk (2016), Goria and Papadopoulou (2017), and Silva (2019a, 2019b), researchers who have analysed hand-drawn sketch maps made by people of various ages. The maps in these studies were used as tools to analyse the "socio-geographic aspects" of space, whereas this article focuses more explicitly on cartographic design elements in order to better understand what and how children map.

Turning to children to qualitatively understand the map not only expands our knowledge about child cartographers but also adds to the field's foundational understanding of what a map is from a perspective that the literature lacks. Given their well-established presence within the literature as a target population for geographers, psychologists, educators, and cartographers alike, this study provides an opportunity to demonstrate further that children play a critical role in providing insightful accounts of their creative representations/interpretations of their experiences and environment. Their unique conceptualization and visual representation of space have much to offer in efforts to expand our understanding of maps and the

map-making process. Therefore, in an effort to contribute to the ultimate questioning of what makes a map a map, this study provides a strong empirical case for the what and how of children's map-making processes concentrating on traditional cartographic conventions and elements.

DATA AND METHODS

The maps examined in this article were collected as part of an internal review board–approved multi-year study conducted at a research and education center, the Meadows Center for Water and the Environment (referred to as the Meadows Center), located on the campus of Texas State University in San Marcos, Texas. The objective of the study was to explore children's perception, expressions of, and relationship with, nature through map-making. The maps we examined for this article were created by schoolchildren aged 6 to 14 who visited the grounds of the Meadows Center on field trips conducted in the second half of 2017. Over 16 different collection days, 48 groups of children completed the activity, varying in grade level (1st through 9th), group size (8 to 23 children per group), race, gender, and socio-economic status, for a total of 831 participants from fifteen different schools located in big cities (e.g., San Antonio) and rural areas (Kendall, Bastrop, and Hidalgo) across the state. Some were familiar with the area, but most were not. The groups contained children of different ages and grades. Altogether, they created 765 maps (they had the option not to participate). The maps we studied for this article are a subset of the 765.

The map activity was an integral part of the field trip. Each group of children was led by a guide from the Meadows Center who filled out a "Mapping Module Questionnaire for Interpretive Guides" (see Appendix 1). The questionnaire served to instruct as well as collect information from the group of children as they completed the mapping activity. Instructors for this specific mapping activity were given specific training and collection protocol to ensure consistency in data collection (see Appendix 2), including an instructional script to read to the participants (see Appendix 1). The children were provided with a sheet of paper with the prompt "draw a map of your field trip" on the front (see Matthews [1984b] on "free recall sketching/free recall mapping"), and the prompt "explain what you included in your map" on the back (see Appendix 3). No additional instructions were given to the children. It is this lack of additional and specific instructions that allows us to answer the research question posited at the end of the Introduction.

In order to more thoroughly understand what and how children map, we used the variables listed in Table 1. In order to explore *what* children map, we observed 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 map their experience, we looked at the shape of cartographic symbols (point, line, and polygon symbology) to ascertain how they graphically represent 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 (see Table 1). The level of uncertainty in map interpretation was also assessed: specifically, we 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*) to serve as a numerical value to the level of uncertainty in interpretation that we experienced for each map assessment. We will return to this point in the Limitations section.

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, it should be noted that the visual variables of value and saturation were intentionally omitted as the tools the children were supplied with, for example, basic colour markers, do not support the more complex variation of value and saturation, only hue.

Vital to this study design is to be certain that the children who are drawing the maps did not receive any extraneous influence beyond the instructions provided in the Mapping Module Questionnaire. This is to ensure that the maps are constructed from the children's own idea of what a map is to them. For this reason, we excluded all maps for which the guide indicated that they did *not* follow the script provided or altered it in any way. We also excluded maps if the guide indicated that extraordinary influences affected the trip (e.g., the weather was too hot for the kids to focus, there was a large caterpillar distraction, there were language barriers). Of the 47 guides, 41 followed the script, but only about half (23) indicated that there were no extraordinary events that could compromise the activity and therefore the maps. Overall, a total of 21 guides both followed the script and stated that there were no outside influences: this reduced the set of usable maps from 765 to 332. Each of the 332 maps was individually analysed using visual content analysis (Rose 2016) to determine the presence (or lack) of each variable listed in Table 1; as theorized by Gillian Rose (2016), visual content analysis provides the framework in which this study uses to consistently analyse our maps in a systematic and quantitative way.

Most variables were coded with a "0" or a "1" to indicate whether the variable was present (1) or not (0). Exceptions included the following: (a) the number of colours was coded with a numerical value that ranged from 1 to 11; (b) symbology was coded with "1" (indicating use of mimetic symbols), "2" (abstract symbols), or "3" (both mimetic and abstract);

Table 1. List of variables and their associated codes and descriptions. "0" suggests a lack of inclusion of the variable on the map, and "1" suggests the presence of the variable. Explanations in the text

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
Geometry	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
	Colour (Hue)	0 or 1	Use of colour
	# of Colours	#	Number of colours used
	Denotation	0 or 1	Use of colour denotation
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)

(c) perspective was coded with "0" for oblique, "1" for perpendicular, and "2" for a combination of the two; (d) level of uncertainty was coded on a Likert scale of 1 to 4 as described previously. Once all maps were analysed, the number of maps (and therefore children) that used each of the 24 variables were summarized from the codes. The written descriptions the children wrote on the back of their maps were not analysed for this article.

Results

These maps provide a window into children's spatial and creative perception of the world around them, at least as it concerns their representation via a map. As seen in Table 2, results suggest that just over half of the children (51 percent) included elements of flora—typically, trees and grass and plants in and around water—whereas only 25 percent included elements of fauna. Fourteen percent included both, and 40 percent drew neither flora nor fauna. Common elements of fauna were most often fish and/or turtles. A possible reason why children more often mapped flora rather than fauna is that while the former is always visible, the latter, especially 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).

Nearly all children included elements of either the natural or the built environment (95 percent and 96 percent, respectively), and 93 percent included both. 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 surround the Meadows Center were almost always included in their drawings. The sky, too, was sometimes included, as were clouds, the sun, or areas labelled as "wetlands." Common built elements of the environment mapped were most often buildings, bridges, sidewalks and/or trails, tables, the Meadow Center's parking lot, school buses, cars, and boats. Children would also sometimes draw their friends in their drawings.

As it relates to the symbols' geometry, nearly all children utilized points (95 percent) or polygons (89 percent), whereas fewer utilized lines (54 percent). More often (42 percent)

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

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

children used both points and polygons together, whereas only 9 percent used the combination of points and lines, and only 3 percent used the combination of polygons and lines. For example, given that part of the field trip involved a tour of the lake, children commonly represented this body of water using a polygon, whereas fish and boats on the water were typically symbolized using points. Of the children, 77 percent expressed these symbols in both mimetic and abstract means. Thus, 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 used either mimetic (9 percent) or abstract symbols (11 percent) alone. The field trip 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 (Figure 1). While it is known that children's abilities in mimetic and abstract point, line, and polygon symbology vary with age, the children's use of them in these maps suggests a general familiarity with the symbolic representation of features (Filippakopoulou and Noros 2009); this also suggests that children commonly express that a map is composed of or utilizes points, lines, and polygons and a mixture of both mimetic and abstract symbology.

As concerns the visual variables, all children utilized shape, 60 percent used texture, and only a few used size (6 percent) and orientation (3 percent). 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). Over a third (39 percent) of children used more than one colour hue (on average, 4.16), and of those who used colour, 54 percent of them chose hues we expected, but there were exceptions; for example, while all children drew water blue and grass green, sometimes buildings would be yellow and trails would be orange.

Very few (less than 1 percent) children included a scale on their map, 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 and others 1999, 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 percent included a north arrow on their maps (select examples in Figure 4), but it is inconsistent whether 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 percent of all children used them) and were varied in their appearances (select examples in Figure 5). Overall, of the 69 maps that included the cartographic design elements mentioned earlier, 7 used them in combination, most commonly (5 of 7) a north arrow and a legend.

Nearly three-quarters (73 percent) of all children used text on their maps, most commonly as labels but sometimes also as descriptive text. 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 served as a form of emotional expression of the children's feelings (such as words like "*eww*" and "*ugh*" in Figure 7) and emotional/personal attachment to certain things or events from their field trip experience, such as the naming of a specific turtle as "*Edry*" (Figure 7 and 14). In a few cases, children actually used words as a repetitive symbol to denote what and where things are (Figure 8).

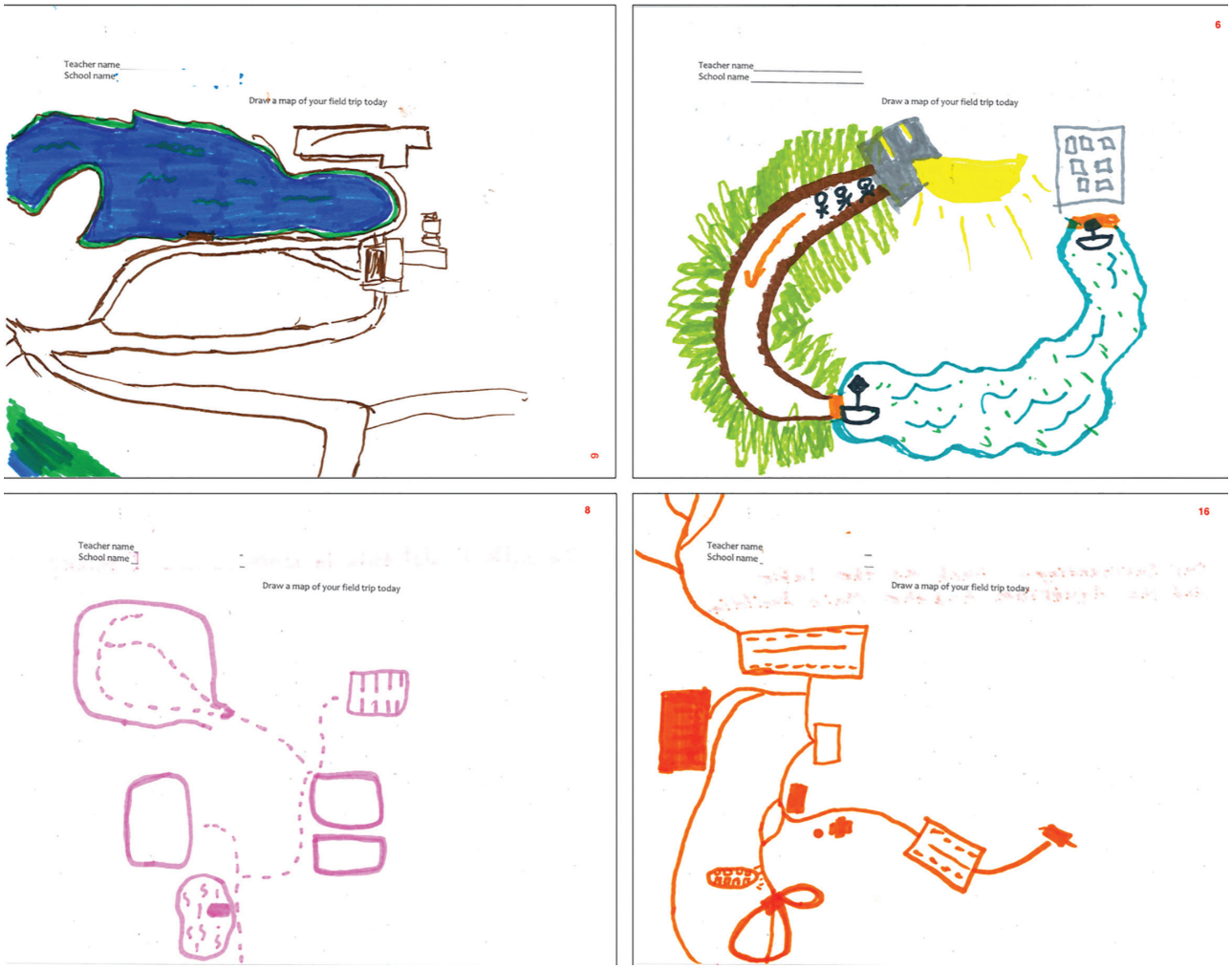

Figure 1. Examples of the use of polygons (top two) and lines (bottom two) for pathways
Source: Study participants' illustrations

Figure 2. Examples of texture, such as repeated dashes or triangles for grass
Source: Study participants' illustrations

Figure 3. Examples of scale
Source: Study participants' illustrations

Nineteen percent of maps showed elements of chronology, such as a suggested order of events, a flow or by marking start and finish locations (Figure 9). Most children (63 percent) drew their maps from a perpendicular perspective, but 8 percent used an oblique perspective, and 29 percent used a combination of the two. Additionally, some children (10 percent) framed their map or had a clear border around the map area (Figure 11).

Discussion

As it relates to the literature, the children in our study drew maps that do not differ substantially from what was found by Weigand (2006), Matthews (1984a), Lehman-Frisch (2012), Goria and Papadopoulou (2017), and Silva (2019a, 2019b). Matthews (1984a) suggests that three types of drawings of maps exist between different ages of children, where children younger than 8 years old tend to draw a *pictorial map* "with elevation views of buildings," 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." All such forms are present in our maps (see examples in Figure 11).

Additionally, our 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 1993; Weigand 2006). The results confirm that not only do 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 1993; Weigand 2006, 52). 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 their understanding that maps function as a wayfinding tool that requires accuracy. Ultimately, the maps in this study confirm the notion that

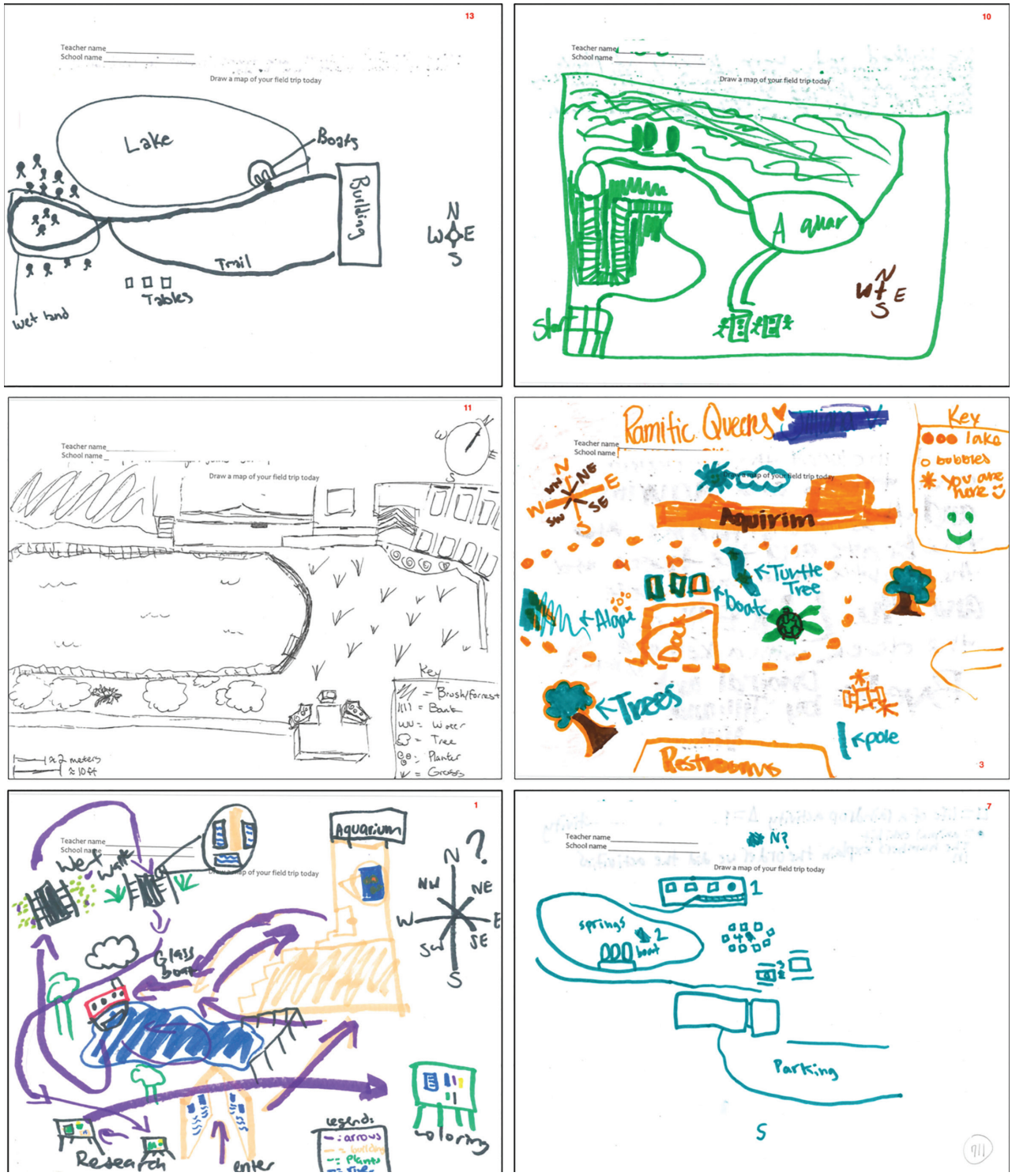

Figure 4. Examples of the use of the north arrow. Compared to the north arrows on the top two maps, the north arrows in the middle two are tilted. The north arrows on the bottom two maps both include question marks, suggesting uncertainty about the correct cardinal direction
Source: Study participants' illustrations

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 1993). 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

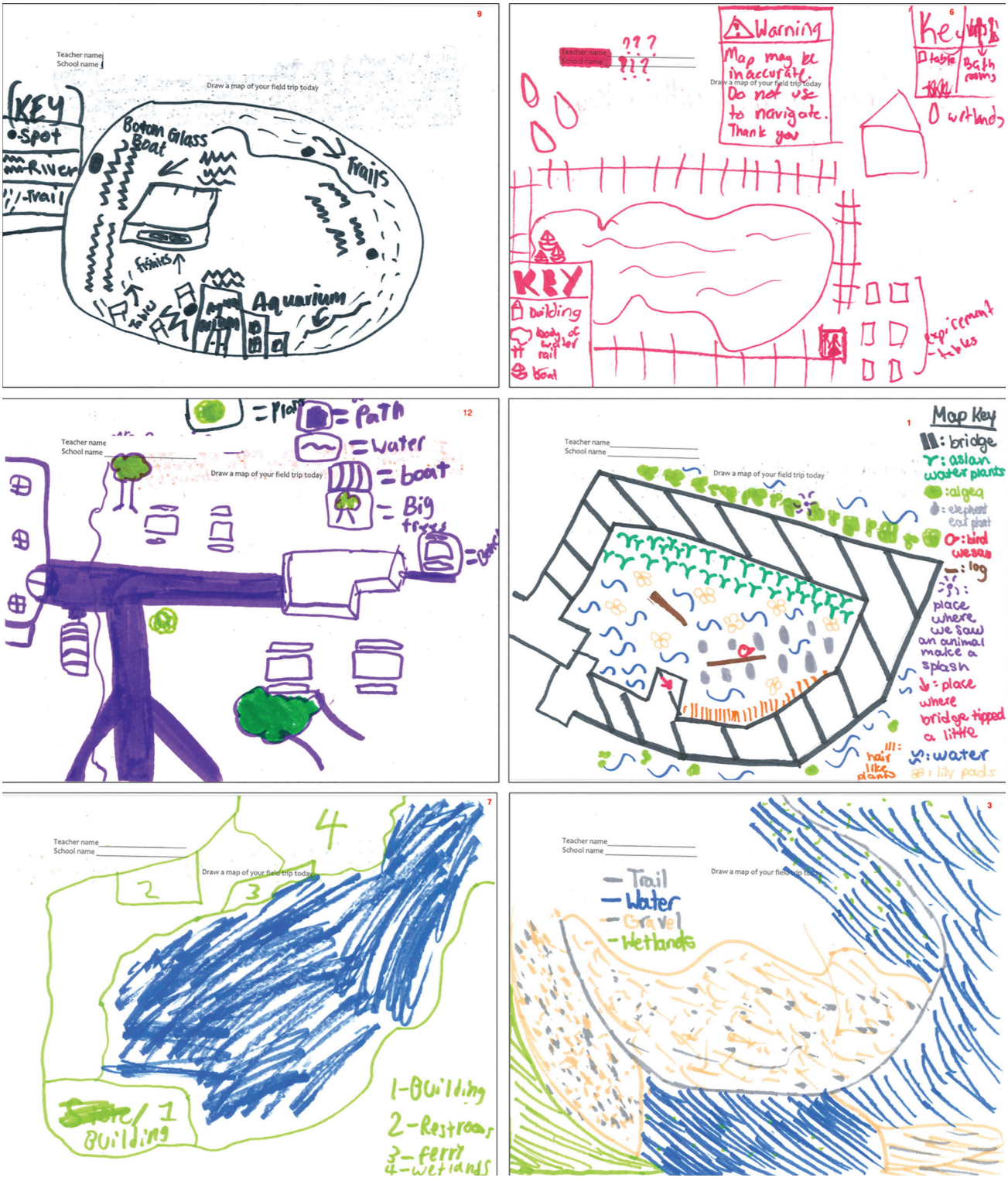

Figure 5. Examples of legends
Source: Study participants' illustrations

world only in terms of themselves," as the map in Figure 13 shows an example of (Gerber 1981a; Weigand 2006, 14).

While substantially confirming previous findings in the literature, our study is quite unique in that while in most studies children are asked to draw maps of their neighbourhood or their journey from home to school (Matthews 1984b; Weigand 2006; Lehman-Frisch 2012; Goria and Papadopoulou 2017; Silva 2019a, 2019b), here we are

Figure 6. Examples of descriptive text
Source: Study participants' illustrations

studying maps of a place almost all children are experiencing for the first time, and this allows for a more controlled comparison of the content and ways in which they cartographically represent their experience (Matthews 1984a). Additionally, while the studies we have found have a relatively small sample size (between 20 and 70 individuals), we have maps from 332 children in a controlled environment, with strict rules, and relatively little prompt from adults.

Furthermore, the content of the maps made from the children's field trips confirms the suggested clustering of children's common map elements and content as posed by Silva (2019a), including (a) orientation elements that 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 in our study, where elements of both the natural and built environment were abundantly present, and places such as the aquarium, the lake and bathroom facilities commonly functioned as orientation elements; emotional or personal attachments to various places and things also appeared on the maps, as is the case when the children saw a turtle they named "*Edry*," making sure to include it on their map (Figure 14). In addition to Silva's clustering of common map content, the maps in our study also included children's expressions of chronology (Figure 9).

Additionally, this content also provides a window into the children's field trip experience at the Meadows Center, which is an important part of understanding the big picture and context of these maps in question. Field trips are an excellent educational pillar of a child's well-rounded twenty-first-century skill set that utilizes interactive and engaging learning experiences in a real-world context, inspires critical thinking, and challenges children's assumptions of the world (Layen and Hattingh 2020; Peterson and others 2020; Krantz and Downey 2021). By exploring the grounds of the Meadows Center, children collaborate and co-construct knowledge through interaction with their

Figure 7. Examples of emotional expression with text
Source: Study participants' illustrations

environment and discussion with their peers. Not only is this knowledge reflected in the maps they produced, but, in turn, the maps also provide insight into how children perceive the world and, subsequently, how they conceive maps (Layen and Hattingh 2020; Peterson and others 2020; Krantz and Downey 2021).

Regarding *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, 54). The varied use of points, lines, and polygons in these maps reflects what Filippakopoulou and others (1999, 59) explain that children's abilities in "pictorial [mimetic] and abstract line, point and area symbol identification" varies with age. Similar is the case with the children's expression of colour in the maps in this thesis: children of different ages vary in their awareness of the range of hues and in their general gravitation toward certain hues or saturations, as, for example, children generally dislike "dull unattractive" colours such as brown or gray, and therefore such colours were not abundantly seen in these maps (Sorrell 1974). 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 and others 1999; Weigand 2006). The majority of children in these maps utilized a perpendicular view or aerial perspective, as Liben and Downs (1989), Vasiliev and others (1990), Gerber (1993), and Weigand (2006) also found in their research (Figure 15). 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 our study uniquely provides.

Figure 8. Examples of repetitive text
Source: Study participants' illustrations

As noted, the majority of our maps did not include a legend, which Nieścioruk (2016) suggests may not be surprising due to the nature of sketch maps that include symbols that are often "limited and self-explanatory." In the case of our study, children were also asked to include a written description of their map on the back: this gave children the opportunity to explain their symbol choice, which they did in several cases, thus reducing the need for a legend on the map itself. Although the use of a north arrow was also limited, those who did include one typically oriented it with north at the top, regardless of the actual orientation of the Meadows Center grounds. This may suggest that these children have seen or worked with maps prior to this mapping activity.

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. 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 (Figure 16). These maps also varied in levels of abstraction, ranging from circumventing linear expressions to minimalistic coloured polygons (Figure 17). 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 Meadows Center, while others "zoomed out" and either included businesses or cities they explored outside of the Meadows Center or included an inset map of the world (Figure 18).

Conclusion

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

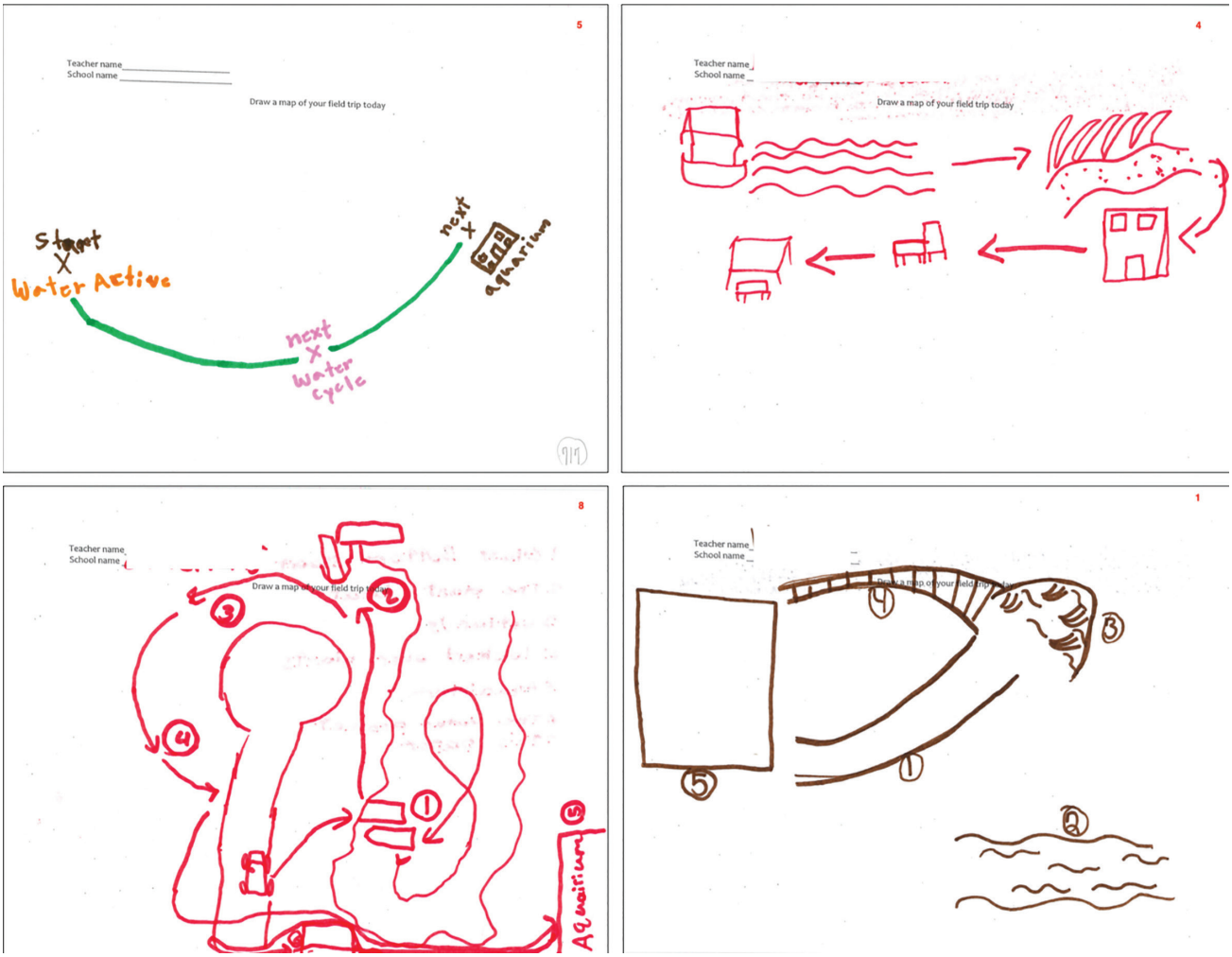

Figure 9. Examples of chronological flow
Source: Study participants' illustrations

Figure 10. Examples of framed maps
Source: Study participants' illustrations

expressing what is valuable to them in both content and design. With respect to their evolving minds and variation in education and experiences, according to children aged 6 to 14, a map can be qualitatively understood as a graphic representation of the child's 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 colour that often—but not always—abide by traditional colour denotations. While none of the cartographic design elements was used significantly besides

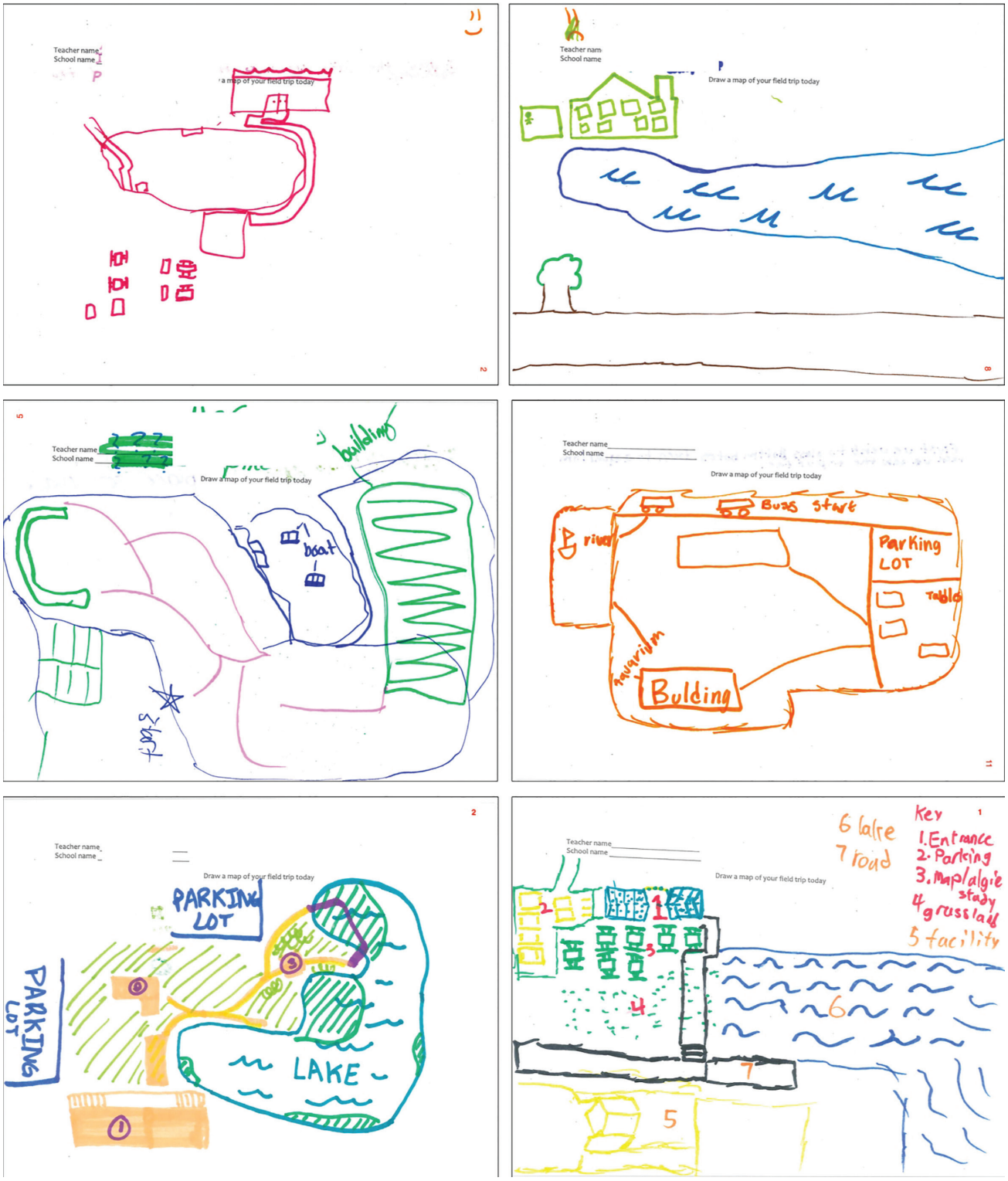

Figure 11. The top two maps are examples of pictorial maps, the middle two are examples of pictorial plans, and the bottom two are examples of plan forms according to Matthews's (1984a) classification
Source: Study participants' illustrations

colour, this suggests that children who did include things like a scale, legend, or north arrow may have had experience with maps before either in school or in everyday life. The abundant use of written labels or descriptive words on their maps suggests that children commonly express a map that includes text. The results also suggest that

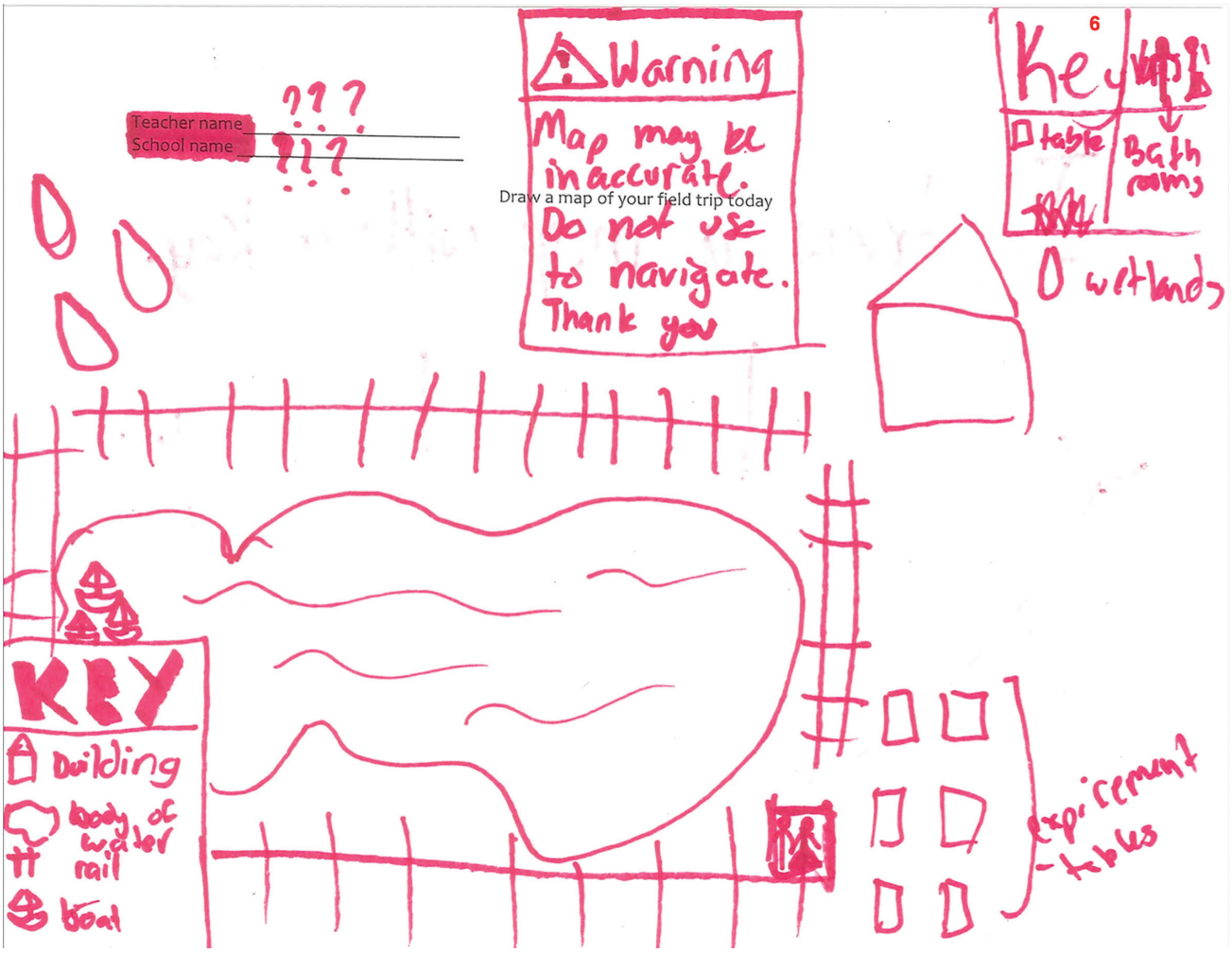

Figure 12. Example of a child's expression of the function of a map using descriptive text in a "warning" label about map accuracy
Source: Study participants' illustrations

children commonly expressed maps from a perpendicular perspective. Other elements such as a chronology of maps were not used significantly but do suggest that children see maps as a means to show chronological flow.

It is also apparent 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 field trip experience. The nature of this research is also subject to the inherent modality of the study where children are asked to hand-draw maps with coloured marks and paper, subsequently resulting in a collection of mental maps. While the terms *sketch maps*, *mental maps*, *cognitive maps*, and *perceptual maps* have been used interchangeably throughout the literature, Boschmann and Cubbon (2014, 237–38) have distinguished that sketch maps are "cartographic representations of individual or group spatial experiences, commonly produced by placing locational marking onto geographically referenced base maps," whereas mental maps are "paper-and-pencil free-form spatial drawings on blank paper," which is it what our data set is composed of.

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 coloured 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. Maps created by children tend to mix perspectives, are less bounded by colour conventions, and are generally devoid of cartographic design elements such as a legend, a north arrow, and a scale. Crucially, the maps depict not only the geography of the place they are visiting but also the events that took place during the field trip and the chronology of the visit. The children often express their emotions as well

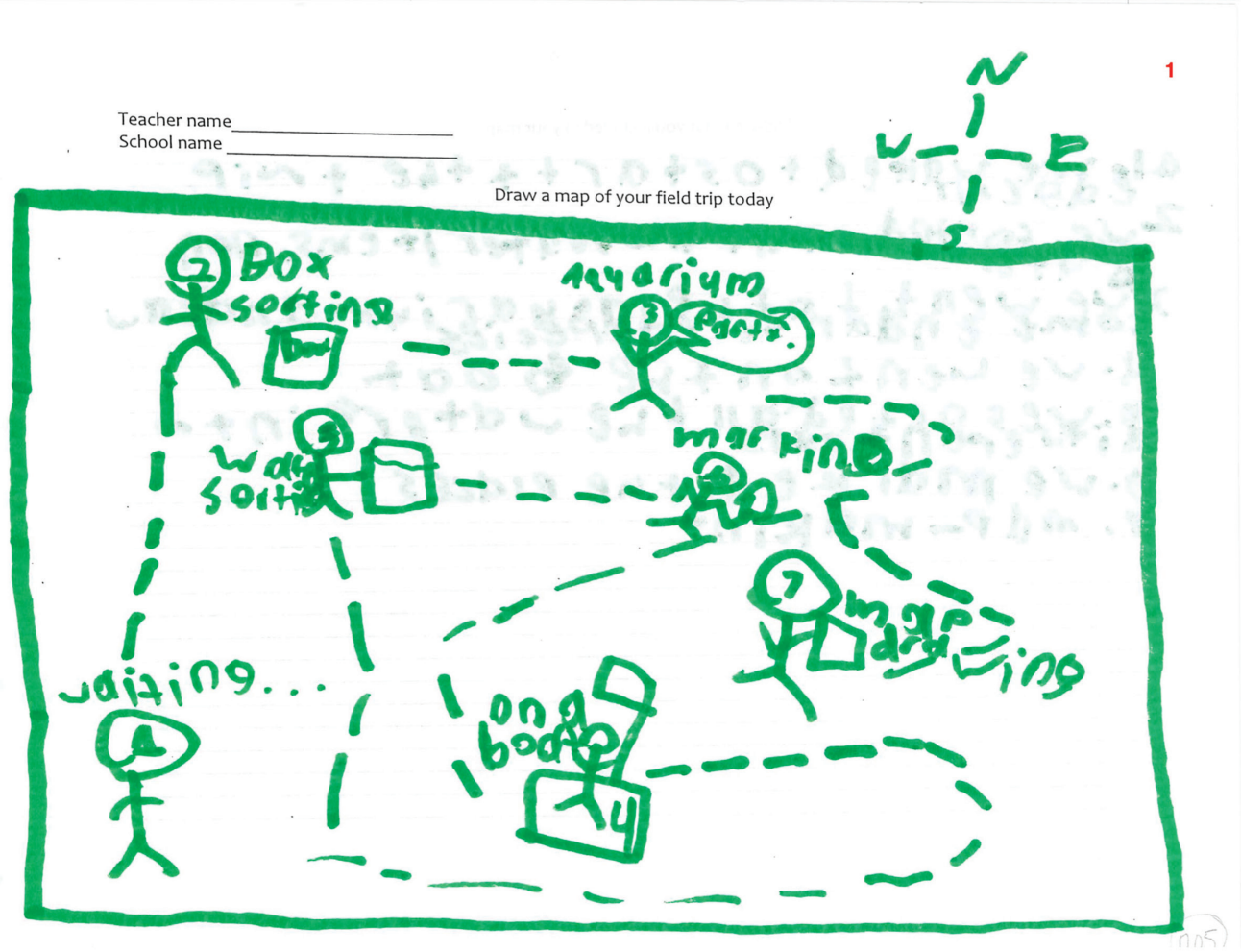

Figure 13. Example of a child's expression of self as seen by drawing them at every meaningful location on the map
Source: Study participants' illustrations

and note unusual sights (*"Edry* the Turtle") with vividness. Relations with others (a "friend") are also portrayed.

Limitations

Our study has important 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 labelled them as buildings. As it relates to interpreting mimetic versus abstract symbology, oftentimes, 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. To account for these occurrences, we 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*) to self-assess how confident we were in interpreting the maps the children drew (see Table 1). Overall, we averaged a score of 3.69 out of 4, and we are therefore confident in the results of the analysis.

One other limitation of this study is that the maps were produced by children ranging in age from approximately 6 to 14, who, of course, have a range of different cognitive abilities, knowledge, and skills; while this study is limited to qualitatively analyzing the entire age span of the participants, we address this in our future work and intended purpose of this study. Additionally, this study is limited to the modality of the use of mental maps used as data. The general criticism of such hand-drawn maps is that the method relies too heavily on the participants' "inevitably varied drawing skills" as well as their spatial ability, spatial memory, and geographic knowledge; however, this does not negate the validity of the use of mental maps as a lens into the world of children's spatial perceptions and

Figure 14. Examples of emotional expression/personal attachment. These maps all include the turtle some children collectively named "Edry" from their exciting encounter with turtles on the lake
Source: Study participants' illustrations

mapping behaviors (Kitchin and Freundschuh 2000; Bell and Archibald 2011; Gieseking 2013; Boschmann and Cubbon 2014). Additionally, conclusions drawn in this study should consider that findings (such as the fact that children prefer the perpendicular perspective when making [mental] maps) apply to children's mental mapping process specifically as compared to mapping practices in general.

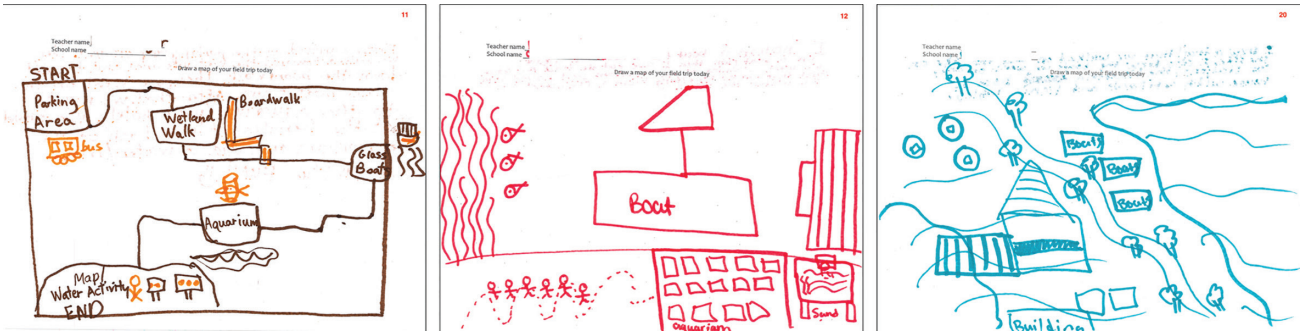

Figure 15. Examples of perpendicular (left), combination (middle) and oblique (right) perspectives
Source: Study participants' illustrations

Figure 16. 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 enough to be mapped
Source: Study participants' illustrations

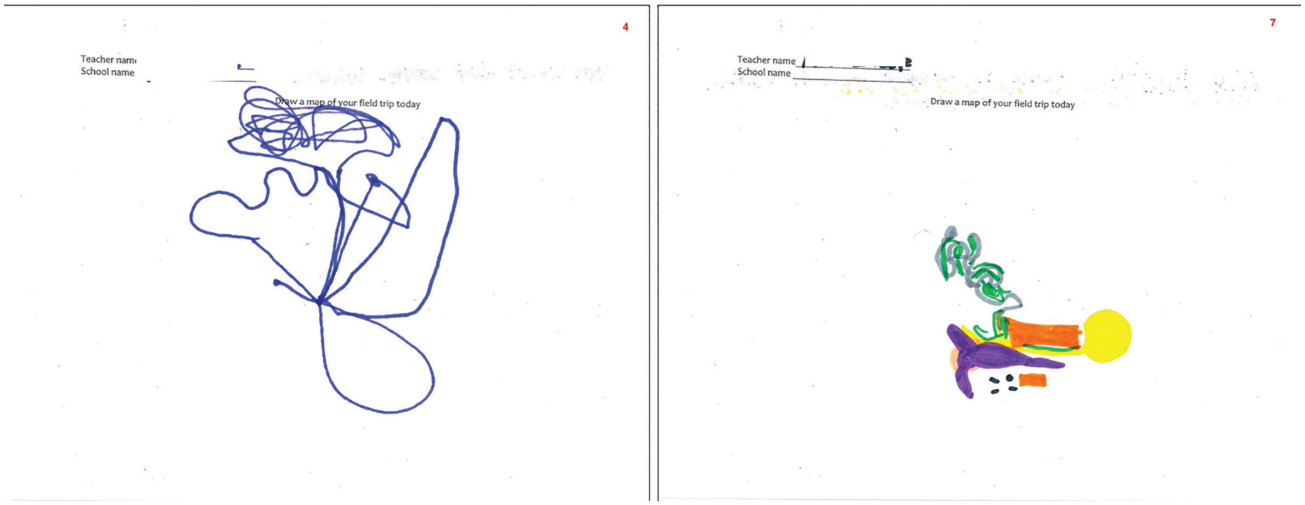

Figure 17. Examples of varying levels of abstraction, ranging from circumventing linear expressions (left) to minimalist abstract polygons (right)
Source: Study participants' illustrations

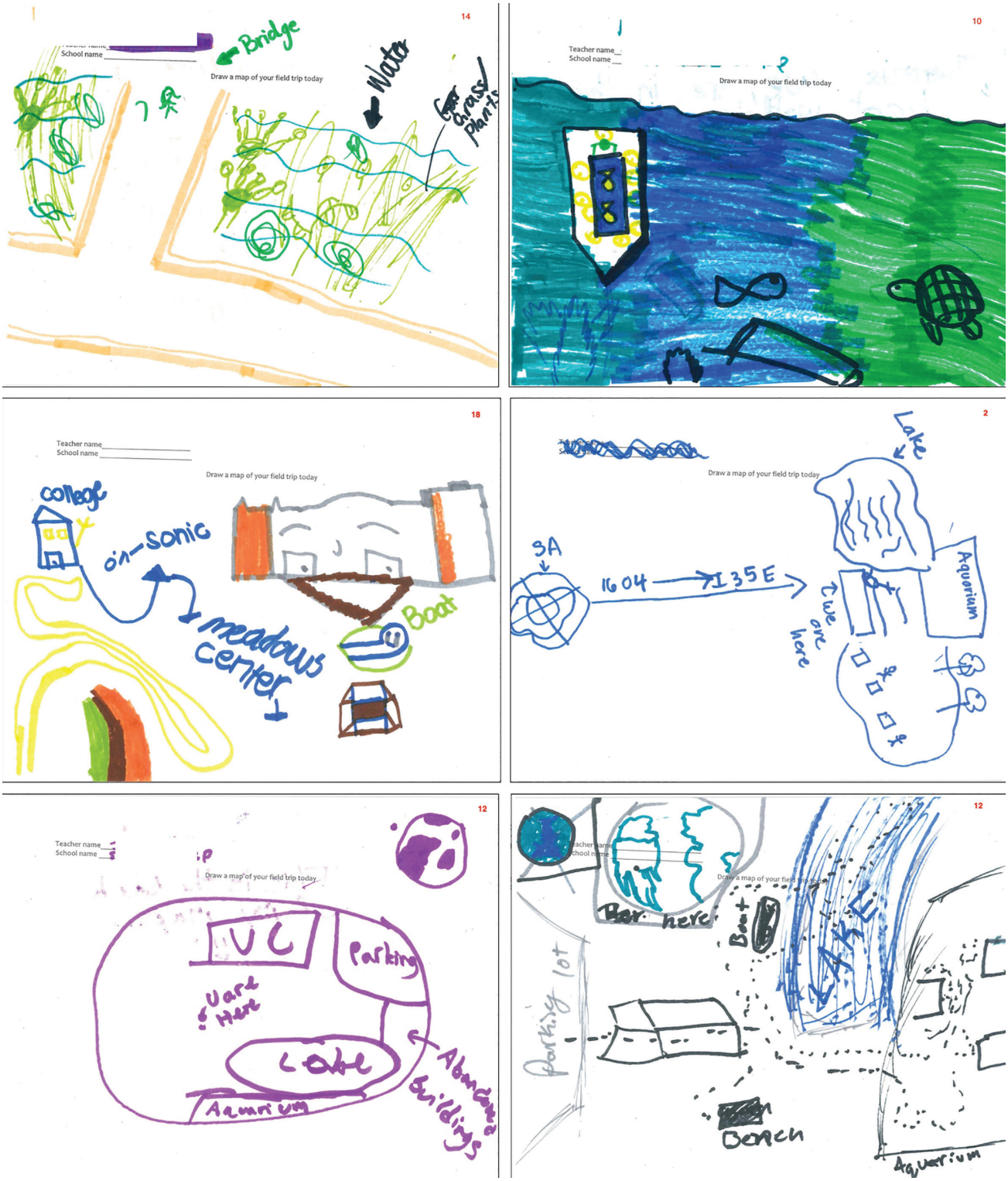

Figure 18. Examples of increasingly smaller scales of representation: the top two maps are the most "zoomed in," the middle two show places or cities ("SA" being San Antonio and "1604, I35E" being highways in the map on the right) outside of the Meadows Center, and the bottom two include inset maps of the world
Source: Study participants' illustrations

We also do not know the educational background of the children or their level of exposition to maps (e.g., web maps). While we believe these factors do not invalidate our study and prevent us from answering the research question in the Introduction, which defined the children as being ages 6 to 14, this limitation needs to be considered when discussing the findings. For example, a child's level of experience with or education of maps may vary depending on whether they were home-schooled or went to a public or a private school or if they are in the Girl or Boy Scouts. Additionally, it is probable that the children have experienced a level of socialization to "Western" society and "Western" maps given our geography and society. Subsequently, 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 with the correct cardinality 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 purely as a symbol. 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.

This research also includes a number of uncontrollable variables, such as a child's possible physical or mental disabilities (broken arm, colour 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).

Future Work

Importantly, this study is intended to lay the initial groundwork for future investigations related to children's geographic education, environmental relations, psychology and the development of spatial cognition, and cartographic literacy. By using descriptive statistics and visual content analysis, this study aims to explore what children materially create when asked to draw a map and qualitatively understand what is being illustrated from a cartographic standpoint. In efforts to contribute to the ultimate questioning of what makes a map a map, this study provides a strong empirical case for the what and how of children's map-making processes concentrating on traditional cartographic conventions and elements. Furthermore, the 332 maps we report on here are just a sample of the over 3,000 maps collected over the span of about two years beginning in July 2017 until late June 2019, where just under 100 different groups of children participated in the mapping activity. These maps are incredibly diverse in both content and design, providing a unique window in the world view of the children and the creative means they use to express themselves cartographically. Studies such as Blaha (2011), Nieścioruk (2016), Goria and Papadopoulou (2017), and Silva (2019a, 2019b) have also analysed (relatively small) collections of hand-drawn maps, but the literature lacks studies that have such extensive and diverse data sets of children's hand-drawn maps as ours.

Specifically, future work will involve 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, we will also conduct further qualitative and statistical analyses as well as group the maps (and subsequently the map's content, design, behavioral patterns, and cognitive differences) according to the individual ages of the children who drew them to further refine and strengthen the understanding of what a map is according to children. Future work will involve gathering information for each child's education type, such as public school, private school, or home-school. In more extensive future work, it would also be fruitful to consider conducting similar studies using other modalities, such as digital mapping, to engage the children in different means of expressing themselves cartographically and presenting their embodied experience.

Perhaps the most interesting question we intend to explore—one that is rarely addressed in the literature—concerns the use of text. Here, we see multiple avenues of research. First, as it relates to children and the environment, we focus on the terms children used to call the body of water they toured (as it often ranged from terms like *pond* to *ocean*). Other elements such as presence of place names, social elements, or emotional expressions would also be fruitful for investigation. Additionally, an analysis of the written descriptions the children included on the back of these maps will provide insight into all the previously mentioned future considerations through a textual analysis using corpus linguistics (Moretti 2000; Knowles and others 2021). Paired with the visual content analysis of how and what children map, a textual analysis would enable an investigation into how children describe the map in words.

Finally, as it relates to the map itself, future investigations will 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 colours used, primary map content or subject matter, the positional accuracy of the map (what parts of the Meadows Center's grounds are stretched, shrunk, highlighted, etc.?), the representation of chronology, and the level of detail or range of sophistication from map to map.

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APPENDICES

Appendix 1: 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 Conversation 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

Appendix 2: 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 [name of research and education center] at X University in [city], [state]. The estimated number of participants is 300. The investigators formulated this study to be 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 [center's name] tour coordinators to ensure that appropriate information is collected from, and provided to, teachers prior to their arrival at the Center. Tour coordinators are [center's name] 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 the following the data collection protocol.

Tour Coordinator Data Collection Protocol

1. When teachers contact the 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 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 selecting in existing 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 research data collection IRB requirements.

Interpretive Guide Training. In the weeks prior to field trips where data are collected, investigators will train Center's interpretive guides, estimated to occur in April 2017. Interpretive guides are Center employees who deliver the educational modules during field trips and are typically X 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 the following 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 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.

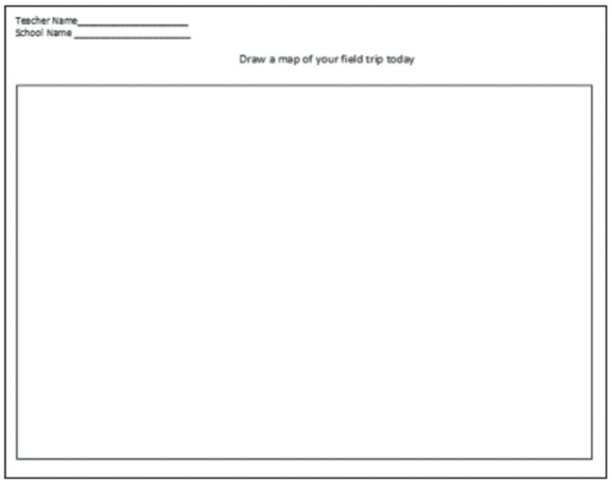
2. During 1a and 1b above, interpretive guides will fill out Mapping Module Questionnaire for Interpretive Guides questions 1-8. (See appendix 2)

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.

Appendix 3: Data Collection Sheet

Front 8.5 x 11



Back 8.5 x 11