Research In Geographic Education

Volume 1 1999 Number 2

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Children's Comprehension Of Spatial Location In Different Spaces

Scott Bell

Research in geography education must be inspired by the elements and standards outlined in Geography for Life, National Geography Standards. The first essential element, "The world in spatial terms" outlines the analysis and internal and external representation of geographic and spatial information as a primary goal of geographic educators. Before this is possible it is important to understand how geographic and spatial knowledge is acquired in the variety of spaces in which children learn and in which geographic information is presented. This experiment examines the geographic understanding of space by 3rd grade students in two distinctly different geographic spaces, as expressed through their recall of spatial location. A desktop space is used to simulate the space at which the majority of school learning occurs while an outdoor environment (laid out on the school playground) is used to simulate the more extensive space of everyday geographic interactions. Results of this study will improve our understanding of how size and scale affect geographic and spatial knowledge acquisition and will inform geographic educators who are interested in developing curriculum involving different types of spaces.

***Keywords**: geography education, spatial cognition, scale.*

INTRODUCTION

For the benefit of the geography teacher *Geography for Life, National Geography Standards*, outlines the essential elements of the geographically informed person. It does so through 18 standards that when met will lead to a comprehensive understanding of these elements (Geography Education Standards Project [U.S.], American Geographical Society of New York, Association of American Geographers, National Council for Geographic Education, & National Geographic Society [U.S.], 1994). The first element, The World in Spatial Terms, includes the representation of space, both externally (maps, Geographic Information System, descriptions, diagrams, etc.) and internally (mental models), and the analysis of the spatial organization of the Earth's surface (Geography Education Standards

Project (U.S.), American Geographical Society of New York, Association of American Geographers, National Council for Geographic Education, & National Geographic Society (U.S.), 1994). From this we can safely conclude that mental models of space are an essential element in the discovery of geography. The goal of this paper is to present research that helps us better understand how children process spatial information at different scales. Specifically, it examines whether spatial and geographic information in small and large spaces is encoded, stored, and recalled differently. The outcome of this research is important for a number of reasons. The majority of external spatial representations are presented (and most useful) in small desktop size spaces (either paper maps or diagrams, or screen displayed GIS maps), while the spaces they represent exist at a much larger size. Ignoring for the moment the relationships inherent between a representation of a space and the space itself, if spatial knowledge acquired in large and small spaces is different, then the way a child learns about geography in those two spaces may be affected. Additionally, many geographic processes and concepts that are taught in the classroom (with or without the use of maps and models) occur in dramatically larger spaces on the Earth's surface. Therefore, it is essential that we understand the differences between mental models produced for geographic information in different size spaces.

Are human behavior and knowledge acquisition affected by spatial scale? As suggested by Lockman and Pick (1984), this is an important question for revealing how spatial information is processed. Answering this question will help reveal the relationship between scale, spatial behavior and development, as well as help us better understand the development of spatial skills and abilities. All of these elements are essential to developing geographic curriculum. The pervasiveness of scale in geography and other spatial sciences demonstrates the important role it plays in human spatial behavior and that its role must be understood to evaluate effectively our general knowledge of spatial behavior.

Space can be subdivided and categorized in many different ways. That we must develop skills for dealing with varied spaces implies that we have a wide variety of tools and abilities for dealing with spatial information and for making spatial decisions. Evidence suggests that spatial behavior in different scale (size) environments is driven by different cognitive processes of encoding, internal manipulation, and decoding (Lockman & Pick, 1984). If this is the case, it is important that geographers develop a better understanding of how spatial knowledge is acquired in different size spaces.

The developmental importance of these issues should not be ignored. A clearer understanding of how children process spatial information can provide critical information relating to how well they understand spatial concepts and what they may or may not understand about different spaces at different ages. The majority of developmental spatial research has focused on what is generally called small-scale space, or the space of manipulation. Furthermore, when "large" spaces are used, they are generally nothing more than a functionally small space (a single room) subdivided such that portions of the environment are occluded from view (Weatherford, 1981). Although these spaces require different modes of integration in order to develop a comprehensive mental model of the space, they are not different in size (Ittelson, 1973; Montello, 1993). Integrating spatial knowledge through different modes of interaction (single perspective vs. requiring navigation) has been shown to affect the accuracy and flexibility of the knowledge, but is not the only characteristic of a space that determines how that space is understood (Presson, DeLange, & Hazelrigg, 1989; Richardson, Montello, & Hegarty, 1998; Thorndyke & Hayes-Roth, 1982). This research will examine how changing the size of the environment affects the accuracy and nature of spatial and geographic knowledge.

It is important for many reasons to understand how different size spaces are internally represented. Geography, cognitive science, and education all stand to benefit from an improved understanding of the impact of size and scale on spatial cognition. The purpose of this research is to examine how location recall of objects is affected by changes in the size of the space in which the locations are presented. This is examined by having children encode and recall spatial locations in two different size spaces; one small desktop space and one large environmental space. The patterns of their recall error will help uncover how accurately children represent these two different size spaces. If size affects how space is understood and internally represented, then the manner in which the spatial information is coded and recalled should also be different.

Background

Children and adults interact with their surrounding environment in many ways. Many of our day-to-day activities require complex skills and knowledge, including spatial knowledge acquisition and decision-making. Not only do we participate in activities in formal settings (school and work), we also engage in many informal activities that require similar skills and abilities. In particular, children are faced with many different opportunities and environments that have received very little attention in quantitative developmental research. It is the goal of this research to explore the nature of some of these environments and how children acquire spatial knowledge at different scales.

Classroom activities occur in constrained built spaces that include authority relationships, not only between the teacher and student, but also with respect to the space and the student. The child has little control over the space and its character. Even within the classroom there are diverse spatial experiences available to children. Whether working individually or working in an open space with others, a child's experience and the spatial decisions that are made are shaped by the space in which the activity takes place. Educational activities pursued in the classroom space and during outdoor free play exist on opposite ends of a continuum along which children's spatial experiences can be categorized. In between exist numerous activities and experiences that make up a child's daily lives and contribute to his or her social, intellectual, and psychological development.

Children encounter spatial information in a variety of situations. Individual situations can be dramatically different although on the surface they may seem similar. Perhaps the most eagerly anticipated time for children is when school is out of session and they are afforded time for free play. Hart (1979) spent many months with a community of children observing them in this situation and learned a great deal about how children interact with one another and with their environment during their free play time. This study revealed that children experience space and the environment in a variety of situations, many of them beyond the supervision of adults and in much larger scale spaces than those experienced during their time at school or playing indoors.

Scale

Scale can be defined in numerous ways and is an integral component in the study of any spatial system. Further, scale plays an important role in human interactions in and with space. Along with the multiple definitions of scale there have been numerous attempts to categorize space with respect to various indices of scale (Ittelson, 1973; Lockman & Pick, 1984; Montello, 1993). Changes in scale impact our interactions with space; not only can our direct relationship with the space be changed, but the degree to which we can perceive the entire space from a single vantage point can be altered (Larsen & Abravanel, 1972; Lockman & Pick, 1984; Roskos-Ewoldsen, McNamara, Shelton, & Carr, 1998; Weatherford, 1982).

The standard use of scale by geographers relates to the production of representations of space. Maps, charts, GIS, models, and diagrams all rely on scale transformations in order to accurately represent spaces that are not normally accessible from a single perspective or without special equipment. By setting the scale of a representation, the spatial relationships between objects can be transformed such that their accuracy is not compromised but the viewing of them is facilitated. Cartographic scale is traditionally defined as the ratio between the referent and its representation. Therefore, a large scale cartographic map represents a small area (as in a 1:1000 scale map of the University of California, Santa Barbara campus), while a small scale map can represent a much larger space (as is the case with the 1:500,000 scale geologic map of Colorado). On the other hand, many people refer to scale as the size of a space in which a problem is faced. Thus a large-scale space would have a relatively larger extent than a small-scale space. Montello (1993) argues that it is the relationship between a person (and the possible actions that the person can take) and the size of a space that is most relevant to how humans act and solve problems in those spaces. He describes a classification of space that includes six categories, including miniscule, figural (further subdivided into pictorial and object), vista, environmental, geographical, and gigantic. Each of these spaces is qualitatively distinct from the others in the way it is perceived and subsequently represented internally.

Lockman and Pick (1984) have previously discussed research and theory pertaining to the importance of size in spatial cognition, behavior, and development. They argued that not only are problems faced in spaces of different size, but that children and adults react directly and indirectly to changes in size (Lockman & Pick, 1984). Direct responses to a change in size provide evidence for quantitative differences in perception and cognition of size information, while indirect behavioral responses in different size spaces is evidence for qualitative differences resulting from changes in spatial extent, or size (Lockman & Pick, 1984).

Geographers have traditionally been interested in spaces varying widely in their extent and the functional nature of the activities that take place in them. Garling and Golledge (1987) characterized small, medium, and large-scale spaces. This classification drops the explicit distinction of method of integration (single perspective vs. requiring navigation), although it does imply a need for extended and necessarily piecemeal knowledge integration, particularly with respect to large-scale spaces (Garling & Golledge, 1987). In Mandler's (1983) and Garling and Golledge's (1987) medium-scale spaces, the spatial relations can be viewed from a single perspective, although Mandler (1983) does explicitly indicate that complete viewing is only possible via locomotion through the space.

There are a number of physical and information processing differences between different size spaces. The manner in which knowledge is acquired and integrated is perhaps the most important to geographers and cognitive scientists. The type of direct interaction afforded by a space will vary with the size of the space (Ittelson, 1973). The actual distances between objects in a referent and represented space will be different if only a scale transformation is made between the two spaces, as is the case in this research. Perhaps most obviously, the extent (or size) of the spaces and the viewing perspective afforded by them will be different in spaces of different size. This is the most relevant difference with respect to this research, as all physical relationships between the two experimental spaces are the same, given the scale transformation. For the research presented here, two experimental spaces were selected; one large and potentially navigable, and one small, offering interaction only from beyond the space's boundaries. The only difference is the potential interaction one could have with each space. The large space (playground) affords movement within and through the space, while the smaller space (desktop) only allows one the ability to reach into the space from beyond its physical extent.

Large environments offer the viewer many different perspectives from which to learn about the occurrences present in that space and the relationships among them (Ittelson, 1973). These environments can be viewed from outside or from within, they can be explored actively as in goal-directed navigation or they can be viewed from a stationary perspective. A large space offering this rich array of opportunities for acquiring and integrating spatial knowledge can influence the internal representation that will be developed as a result of interacting with and acting in that space, even if the interaction is static and from a perspective outside the space. This might be considered the experience that an individual is afforded by that space. As an example, take the view of a city from above; perhaps from a plane as you are about to land at the airport. The many possibilities that the real environment holds for you affect the nature of your integration of that information. This is quite different than the experience of viewing your desk cluttered with books, articles, your computer, etc. The latter space will not be explored at any time with the same navigational goals as will the city, although items on the desk might be rearranged in order to find something that is hidden beneath them. If further exploration of a desktop and environmental space is required, two different procedures are followed. In the environmental space, individuals would enter the space and actively explore using locomotion and navigation to maneuver through the space, changing their perspective with respect to the more permanent objects. Smaller desktop spaces can only be viewed from the outside, predetermining the nature of the interaction one will have with that space. In the desktop space, objects are rearranged in order to change the relationships between them, while the perspective from which the space is viewed remains unchanged.

Spatial Cognition

Theoretical and empirical background for the study of children's acquisition of spatial knowledge in different scale spaces comes from a variety of sources. The following section outlines the general nature of child development, as well as presents specific background for the study of children's spatial cognition in different size spaces.

Where possible, I refer to research that deals with either desktop spaces or environmental spaces, or on rare occasions, both.

Piaget and his colleagues (1956, 1960) have done the most extensive work on children's spatial development. Although generally limited to small-scale and representational spaces, Piaget contributed significantly to our understanding of general development in all spaces (Piaget, 1954; Piaget, 1960; Piaget & Inhelder, 1956). Piaget's main belief concerning location coding in children is that it develops from a purely egocentric to an allocentric topological skill. He did not believe that accurate coding of spatial location was possible until a child was at least nine or ten years old and had developed the ability to code metric information. Also of interest to this research is Piaget's work on perspective taking, as measured by the three mountain task, in which children are asked to look at a desktop model of three mountains (occluding each other from various perspectives) and tell an experimenter what someone would see from a perspective other than their own. Researchers have recently argued that Piaget's use of representations of the experimental environment confounded the results, and that perspective taking ability might be present at a much younger age than previous thought (Newcombe & Huttenlocher, 1992). Although Piaget has been criticized on topics central to this research, his contributions to understanding the order of skill development in children cannot be overlooked and has provided a guideline for the bulk of developmental research conducted over the last 40 years.

Contemporary work on children's spatial cognition, as it relates directly to the proposed study, falls into one of two categories: location recall, or the use of different representations and models. The latter will be discussed in the following section. Location recall by children, infants, and toddlers has focused on a number of cognitive and perceptual topics. Newcombe, Huttenlocher and their associates (1998, 1994) have shown surprisingly accurate recall of spatial location of single objects by children as young as sixteen months. In these cases, a single play object is hidden in a small, rectangular sandbox and the child is encouraged to retrieve it (Huttenlocher, Hedges, & Duncan, 1991; Huttenlocher, Newcombe, & Sandberg, 1994; Newcombe, Huttenlocher, Drummey, & Wiley, 1998). Additional research suggests that location within a featureless area will often be placed towards the prototypical center of the space (Huttenlocher, Hedges, & Duncan, 1991). With older children, Acredolo (1977) was able to show that five-year old children could find a previously learned location without the aid of landmarks in environmental space, but that three- and four-year old children were unable to do so. Additionally, the four-year old children improved their performance when instructions were given about the perspective from which they had learned the space, showing a clear development in the ability to locate objects in space with and without landmarks present (Acredolo, 1977). In 1982, Herman and his colleagues examined kindergarten and third grade children's ability to recall spatial locations in a large-scale space (room size space). He compared different viewing perspectives (walking through the space and viewing the space from outside) as well as different layouts (model town vs. an array of toys). He found that while there was no effect of viewing perspective, there was a significant difference between the two layouts. This suggests that for a room sized space (in this case labeled a large-scale space), viewing perspective is not the most important attribute contributing to knowledge acquisition (Herman, Roth, Miranda, & Getz, 1982). Additional research by Herman has shown that the ability to make judgements in unbounded space develops after the ability to make judgements in bounded spaces (Herman & Siegel, 1978). This body of evidence suggests that children are capable of accurately recalling location at a very young age (although with varying non-systematic errors) and that certain environmental characteristics can contribute to improved performance (orientation, boundedness, type of layout, etc.).

Not only does location and perspective taking develop with respect to locating individual and multiple objects in space, but also with the ability to discern location in different fields surrounding the individual. There is evidence that younger children (four years and under) are able to solve perspective problems in the near/far fields but not the left/right fields, while 5-year-old children perform equally well in both fields (Newcombe & Huttenlocher, 1992). These are exactly the frames of reference that would be utilized during the coding of spatial locations in the two experimental spaces used in this study.

Representations and Models

Research in different scale spaces has included the use of representations of space by children: particularly the use of maps, models, and various types of photographs (Blades & Spencer, 1987; Blaut, 1991; Blaut, 1997a; Blaut, 1997b; DeLoache, 1989; DeLoache, 1990; Downs & Liben, 1988; Liben, 1997; Liben & Downs, 1992; Liben & Downs, 1993; Liben & Downs, 1997). DeLoache (1990) has shown that very young children are capable of finding a play object hidden in a referent space (large space) after viewing the object being hidden in a smaller model of the space. Interestingly, at even younger ages, when children are incapable of this task and they are told that the model in which the object is originally hidden is being placed in a machine that is making it larger, they are subsequently able to find the hidden object in the larger space (DeLoache, Miller, & Rosengren, 1997). Keep in mind that these are very young children (29-33 months), but that the evidence suggests that the use of symbolic representations of space is developed quite early in children and can be used to solve goal directed problems. Perhaps more related to geographic education and education in general is work conducted on the use of maps and aerial photography by Blaut (1991, 1997a, 1997b), Blaut and Stea (1971), and Liben and Downs (1993, 1997). Although they disagree as to the nature of mapping in terms of development, both groups have provided some excellent evidence for the early use of maps by children and the potential for incorporating their findings into a geographic curriculum. One of the most important aspects of this work relates to children's use of symbols, a critical element in any representation. It appears that children's ability to use symbols develops slowly and can be impeded by using symbols that themselves have meaning or are real objects (Deloache, Uttal, & Pierroutsakos, 1998; Uttal, et al., 1998).

The preceding relates directly to the choice of spatial scale for this study. It is clear that children develop the ability to recall object location in a variety of spatial situations at a very young age and that the development of this ability relates not only to the characteristics of the space (presence of landmarks, boundedness, perspective, mode of interaction, etc.), but also to the complexity of the arrangement of objects in the space. If the ability to recall location emerges before the end of the second year and proceeds throughout development, this field of research must be extended to consider the development of abilities in less controlled and larger spaces. In a variety of research settings, environmental learning, for both navigation and object recall type tasks, improves meaningfully between 4-6 years of age and 11-12 years of age (Cornell, Heth, & Broda, 1989; Heth, Cornell, & Alberts, 1997). Not only are older children able to select salient and meaningful landmarks (similar to those selected by adults), they are also able to perform complex goal directed activities that require those landmarks and the accurate recall of their locations and relationships with other objects in an environment (Allen, Kirasic, Siegel, & Herman, 1979; Cornell, Heth, & Broda, 1989).

The following experiment examines how 8- to 9-year old children code and recall spatial location in two different spaces; one small space using handheld manipulable objects, and one large and experiential space using shapes that can be carried but not manipulated easily. The experimental age group was selected because it falls in the middle of the age range indicated above as being critical in the development of large-scale navigational abilities. The two spaces have been designed to provide a comparison between one size space that has been commonly used in developmental spatial cognition research and children's daily educational activities (desktop size space) and another space that has received much less attention, but is integral to understanding how children comprehend geographic and spatial concepts (playground). For the purposes of this experiment, these two spaces, and the interactions that participants have with them, have been closely controlled. Only the size is different; viewing perspective, viewing angle, experimental objects, color, and placement in the environment, along with other critical variables, have been kept consistent for both spaces.

METHODS

Participants

Forty students from three third grade classes at La Patera School in the Goleta Union School District, Goleta, CA, participated as volunteers in the study. There were 21 female participants and 19 male participants. All participants were between the ages of eight and nine (average age: 8.4 yrs.), and were randomly assigned to either the large or small experimental space.

Materials

Children were exposed to one of two experimental environments, either a desktop size space or an environmental size space. The desktop space consisted of a student desk similar to desks and tables at which children work during their normal classroom activities. A 60 centimeter square was displayed on the desk's green surface using yellow tape and acted as the experimental space for the study. The large space consisted of a 30 meter square, delineated by high contrast yellow rope, on the school's grassy (green) playground. The scale relationship between the two spaces was 50:1. A set of seven geometric test objects (sphere, long triangle prism, pyramid, box, rectangle prism, tall triangle prism) were used and were always present near each space (along the outside of the bounding box for each experimental space when not being used during testing). The objects used in each space also had the same size/scale relationship as the spaces, 50:1. The environmental or large space objects were between 0.7 meters and 1.3 meters on their longest axis, while the objects for the desktop space were approximately one to two centimeters along their longest axis. All experimental objects were painted blue for consistency, and five of the seven objects were used in each of five trials. Five arbitrary locations were chosen for the objects in each testing trial and were based on ensuring that no perceivable pattern was apparent and that no single object occluded any other object(s) in the space. The same arbitrary locations and objects were used for all participants, and in both spaces. For trials in the small space, children were asked to place their chins at the end of a ruler extending 15 centimeters from the edge of the experimental space (the tabletop was lowered or raised to reduce discomfort from a potentially awkward sitting position). This helped ensure that the vertical perspective was representative of that offered in the large space when standing at the viewing location, approximately 45 meters from the edge of the experimental space. All children (large space or small space) viewed their experimental spaces from the same perspectives in the school playground. This resulted in a similar background for both spaces and placed both spaces with the same surrounding frame of reference. Each day of trials was devoted to one space or the other so children in the small space group could not simultaneously view the large space, or vice versa. Every care was taken to ensure that the differences between the two experimental spaces were minimized to their relative size (scale difference), in order to allow for conclusions related to the different cognitive processes operating in large and small spaces.

Procedures

The experiment consisted of two phases: a learning phase and a testing phase. During the first phase of the experiment, children observed the locations of five geometric shapes in one of the two experimental spaces. In the second phase, they were asked to reconstruct the array of objects by returning each object to the experimental space in the position they remember it being. Between the two phases, research assistants removed the shapes, and placed them with the two distracter shapes at the side of the experimental space.

Children were told by the researcher that they were playing a memory game called "Where are the shapes?" and that they would be playing the game with the researcher while two of the researcher's friends would be helping them. The experiment was conducted on the school's playground and both spaces were laid out in the same orientation with respect to the surrounding environment. Each participant was asked to remember everything he or she could in the square (either on the desk or in the playground). Each participant was told that they had to remember the shapes in the square and where the shapes were in order to play the game. They were given 20 to 30 seconds to view the array of objects in the space. After viewing the objects, the participant was asked to turn away and the objects were removed from the experimental space. After the objects had been removed the participant turned to face the space again. Each participant was first asked to show the researcher where they remember one of the experimental objects (predetermined by the experimenter) being in the space. This represented their recall of landmark-free (absolute) location with no other reference landmarks available within the space. After placing that object in the space, the participant was then instructed to replace the remaining objects in the experimental space. These locations represented their relative or survey level recall of location. After the first two trials, the instruction to replace the remaining objects was no longer needed, as all participants knew what they were to do during the activity. The resultant X, Y coordinates of each object placed in the space were recorded between trials so that Euclidean distance errors could be calculated and location accuracy assessed.

Design

All comparisons in the location memory task were between subjects. This facilitated the identification of a clearer difference between performance in the two spaces, as well as ensured that participants considered neither space a representation of the other space. This experiment is not concerned with the concept of representations as such, although performance in the smaller space will have implications for children's use of representations, as that space is similar in extent to the space of many spatial representations (maps and models).

Anticipated Results

The dominant trend in the developmental literature suggests that children develop an understanding of proximal spaces prior to the development of abilities in larger, more extended spaces (Piaget and Inhelder, 1956). Unfortunately, few studies have attempted to control for all but the size of the space in which a task is completed in order to draw direct comparisons. It must be remembered that the bulk of a child's free time is spent moving through large complex spaces. Sometimes these spaces are open, like their school playground, and sometimes they are bounded, as in their school classroom or home environment. In both types of spaces, movement is afforded and encouraged. This would lead one to speculate that it is distinctly possible that abilities, particularly spatial abilities, might progress and develop more rapidly in these types of spaces, once freedom is allowed. While it is possible that abilities in small proximal spaces emerge earlier than abilities in larger spaces, this is not the only potential model. By a certain age, children explore spaces which they must traverse in order to appreciate. As this freedom increases so might their spatial understanding of relationships in these spaces. With increased experience, I believe children's spatial abilities that operate in large spaces develop more rapidly than those used in small spaces.

I anticipated differences between the two spaces for the third grade participants. As indicated above, there are two potential outcomes and theories of development that might support each. Early school years are essential for the development of spatial abilities associated with acquiring spatial knowledge in both large and small spaces. If recall is better in the larger space, it might be concluded that environmental spaces are very important for the development of spatial and geographic understanding. Although these results may be contrary to Piagetan theory, there is very little empirical evidence comparing large and small spaces that would indicate spatial abilities in large spaces lag behind abilities in small spaces.

RESULTS

Data collected in both spaces were translated to the scale of the small space to allow a quantitative comparison. Error, reported in centimeters, was calculated based on the Euclidean distance between the correct location of each experimental shape and the location chosen by the participant. Two measures of error were computed for each experimental trial. The error in placing the first object was measured to indicate the participant's recall of absolute or landmark free recall. The average error for all five shapes in each trial (including the first object) was measured to indicate relative or survey level location recall. The first shape (used in calculating absolute location recall) was included in the relative measure because participants were allowed to move any of the shapes to new locations as they placed additional shapes in the space. Therefore, the location of the first shapes was elastic after additional shapes were brought into the space. The initial location and final location for the first shape were recorded if it was moved. Absolute location recall (recall of a single object with no other referent objects in the space) and relative, or survey location recall (recall of object location with other experimental objects in the space), were both examined as aspects of children's location recall abilities.

A repeated measures Analysis of Variance (ANOVA) was conducted on both relative and absolute data. This analytical technique

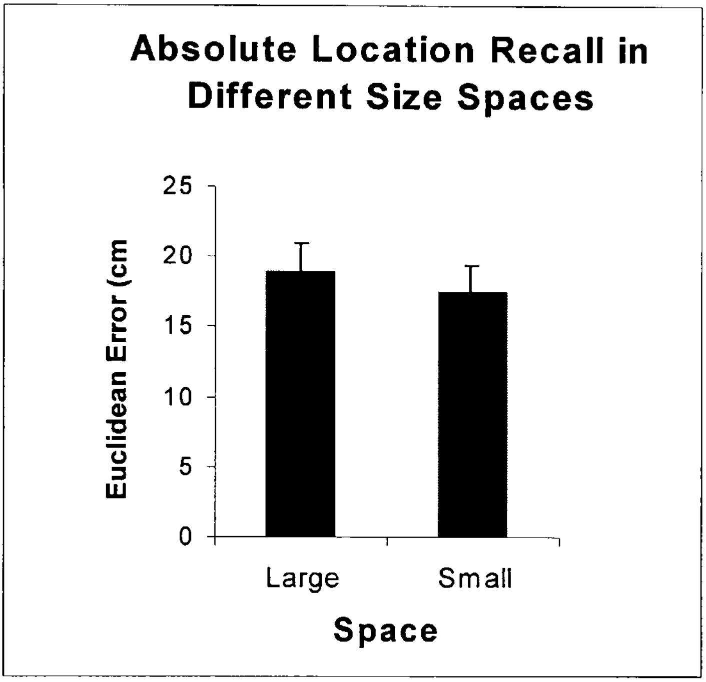

Figure 1. Absolute location recall in different size spaces. Recall is similar for large and small spaces, but overall recall is poor for both spaces in comparison to relative location recall.

made it possible to compare between trials (within subject, within space) and between individuals (between space). It was anticipated that there would be little difference between the individual trials, as all that changed was the location of the 5 experimental objects. This was confirmed; the model indicated that there was negligible difference between the 5 trials for both absolute and relative distance error (absolute: $F\ (1, 38) = 1.48$, ns, relative: $F\ (1, 38) = 1.063$, ns)

There was no significant difference between the two spaces when children were recalling absolute spatial location, although error was greater in the larger space than the smaller space ($F\ (1, 38) = .846$, ns). Average error when recalling the location of the first shape for the large space was 19 centimeters, while error in the small space was 17.5 centimeters (fig. 1). This indicates a certain amount of difficulty determining spatial location in the absence of nearby landmarks or spatial relations in both large and small spaces. This prompted the questions, "How accurately do children recall location

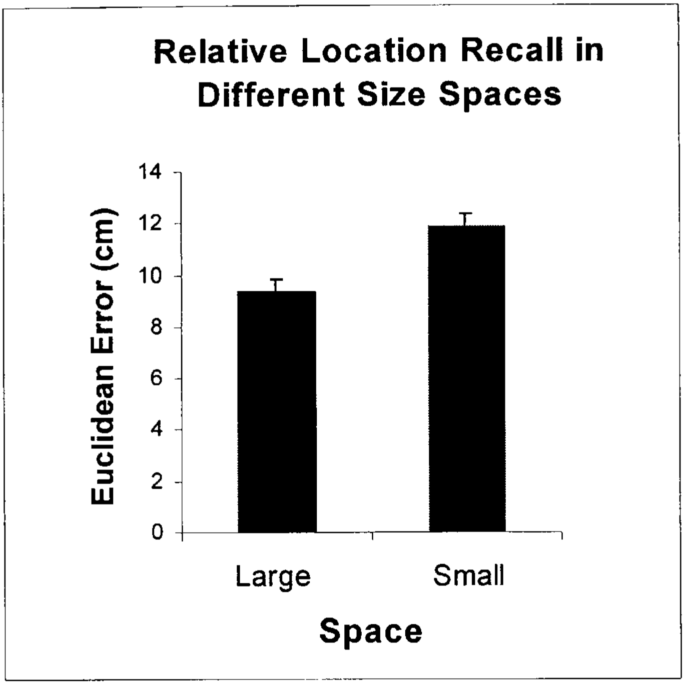

Figure 2. Relative location recall in different spaces. Recall is significantly better in the larger space as well as significantly better for both spaces than absolute location recall.

when they must replace multiple objects in each space? Would the error increase or decrease?"

The accuracy of location recall when other objects or landmarks were present (relative location recall) in the space increased for both spaces. Error for the large space averaged 9.2 centimeters, an improvement of almost 10 centimeters, while error in the small space averaged 11.8 centimeters, an improvement of 5.7 centimeters (fig. 2). This difference was statistically significant in the repeated measures model described above ($F(1, 38) = 7.79, p < .01$). Although there was no difference between the two spaces in absolute location recall, relative location recall was dramatically better in the larger space than in the smaller space. The improvement for both spaces when the children were free to choose and place shapes in the experimental spaces underlines the reliance on relative frames of reference for recalling location at this age. Even more interesting is the significantly more accurate relative location recall in the larger space, as well as a much more dramatic increase in accuracy from absolute to relative location recall in this space. These results would contradict what one might expect if it is assumed that children are more adept and acquire skills in small proximal spaces prior to skills in larger, navigable spaces. These results suggest that the relationship between spatial extent and spatial/geographic abilities in those spaces is more complex than might be concluded from earlier research and theory. Although the results reported here do not indicate that abilities in large spaces emerge prior to abilities in small spaces, they do indicate that abilities in large spaces might be more advanced at one stage in development and that assumptions about spatial size and abilities might need to be re-examined.

CONCLUSION

Many scientists have written about issues dealing with cognition at different scales (Ittelson, 1973; Lockman & Pick, 1984; Montello, 1993; Tversky, Morrison, Franklin, & Bryant, 1999). In addition there has been a variety of research conducted on how children comprehend and make spatial judgements in different spaces (Acredolo, 1977; Herman, Kolker, & Shaw, 1982; Herman, Roth, Miranda, & Getz, 1982; Huttenlocher, Hedges, & Duncan, 1991; Huttenlocher, Newcombe, & Sandberg, 1994; Newcombe, Huttenlocher, Drummey, & Wiley, 1998). Unfortunately, other than Piaget, there has been very little work done that has addressed how children process spatial information and knowledge in different size spaces (Piaget & Inhelder, 1956). Furthermore, work on this issue with mature participants has also been clearly lacking.

Children experience life in many different spaces. They play both inside and outside, in controlled and uncontrolled settings. The same can be said for how they learn and are instructed. Understanding subtle differences in the way children acquire spatial knowledge in different spaces can help us understand much larger issues related to development and education. That children as young as eight years of age can recall spatial location in any size space at the level of accuracy represented by these data indicate that they have a highly accurate basis for making more complex spatial judgements.

The results reported here are only an initial step toward a better understanding of how spatial information in large and small spaces is coded, processed, and recalled. Although there may be few direct applications of these results, they should provide a starting point for further investigation into how location and other spatial concepts are cognized by children. These results also indicate a preference for specific frames of reference when recalling location. The improved recall of spatial location when other objects are present in the experimental space may indicate that children rely on proximal landmarks and, therefore, relative frames of reference for accurately recalling spatial location. Furthermore, it may suggest an inability at this age to use external frames of reference, represented by the bounding box as well as distant landmarks beyond the boundary of both spaces (trees, houses, buildings, etc.). A small amount of spatial complexity in the near environment appears to support a more accurate recall of spatial location, in both large and small spaces, but moreso in large spaces. Recalling a single object in a featureless environment appears to be more difficult which might lead one to believe that this type of task relies on a different type of location coding than recalling the locations of objects within a more complex array of locations.

The significantly more accurate relative location recall in the larger space is additional evidence for the importance of these types of spaces for children. Exploring and experiencing outdoor spaces is an integral component in a child's development (Hart, 1976). Incorporating a variety of spaces into a child's education may allow a teacher to take advantage of optimal learning environments for certain skills, particularly those with a spatial basis. Children may be more at ease learning spatial concepts in spaces in which they are more confident. If accurately solving fundamental spatial tasks is a precursor to comprehending more complex spatial and geographic concepts, the results of this research suggests that activities conducted in larger, experiential spaces may help children develop geographic skills more efficiently and with greater confidence.

Understanding how children code and recall fundamental spatial information is a key piece of knowledge towards a better understanding of how they develop a geographic sense of the world.

Furthermore, it is an important step towards developing curriculum that takes advantage of a child's cognitive strengths rather than constraining them to traditional classroom instruction. Many of the teachers with whom I have discussed this are quite aware of the positive effect of instruction outside the classroom, although in most cases they are on their own when it comes to the development of activities or curriculum that center on outdoor, large environments. That children can think as accurately as they can about spatial concepts and, in some cases, more accurately about large experiential spaces than smaller desktop spaces opens many doors for teacher and researchers alike.

This research was an initial attempt to bring many issues together and offer a "call to arms," so to speak, for developmental scientists, cognitive scientists, and educators. It is hoped that the importance of the issues presented in this paper along with the empirical results of an initial experiment will increase the attention that learning in different size spaces receives by both researchers and educators.

ACKNOWLEDGEMENTS

I would like to thank all of the teachers at La Patera School in Goleta, CA for their cooperation during data collection and their input throughout the project's duration. Thanks to Toni Schinnerer, Marcia Warrecker, Hillary Peattie, Linda de Bievre, Sue West, and Sean Greening. This research was partially funded by the Geographic Education National Implementation Program and Research Unit on Spatial Cognition and Choice.

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Mapping Success: Reversing The Matthew Effect

Sr. Madeleine Gregg fcJ.

The effects of two models of teaching on map reading and interpreting of seventh graders were compared. Data were obtained from pre- and post-tests and from audio-taped transcriptions of student interviews with 4 high- and 4 low-knowledge students. The test scores were analyzed to determine if the different models of teaching were associated with differences in what the children learned. Analysis of the interview data provided more fine-grained understanding of exactly what was learned and how students were able to reason with their new knowledge.

The results showed: 1) All students learned, no matter how they were taught; 2) Map-makers learned more than map-readers; 3) The map-making lessons especially benefited the low-knowledge students' learning about symbols on maps. 4) Both groups of students learned more about symbols and latitude and longitude than about scale. 5) The findings from the interview data matched the results from the test data.

Keywords: *Matthew Effect, teaching models, map reading and interpretation*

In today's typical elementary school classrooms, teachers face a vast range of student needs, both academic and social. The great diversity of student learning styles, developmental differences, and cognitive abilities that characterize classrooms has resulted in the creation of two groups of children within the schools: one that is succeeding in school and one that is failing. Some children's life experiences and family expectations map nicely onto typical school culture and thus set them up for success in school. For other children, life and family expectations do not map onto the culture of the school; they struggle and often fail. It is a truism that students who are already knowledgeable about topics more easily learn new information about those topics (Chiesi, Spilich, & Voss, 1978; Pearson, Hansen, & Gordon, 1979). Students who have little prior knowledge about topics often fail to learn as much new information as students who are studying familiar topics. Thus, in knowledge as well as in finance, the rich often get richer, and the poor get poorer (Goodlad, 1984).

This situation has long been called "the Matthew Effect" (Merton, 1968; Stanovich, 1986; Walberg & Tsai, 1983). The allusion is Biblical: in the Gospel of St. Matthew, in the parable of the talents, the person who hid his money, fearing the owner, had even the small amount given to him taken away and given to the person who had received the most initially. The Biblical text says, "To him who has much, more will be given, but to the one who has little, even the little he has will be taken away" (Matthew 25:29). Children who are set up for school success are "the rich," and as they move through school, they get richer. Children not set up for success are "the poor" and their experiences in school may ultimately make them lose what they have, such as their self-esteem, their curiosity, and their joy in life.

Figuring out how to teach in ways that engage the interest and attention of all students while simultaneously providing the "have nots" with the requisite background knowledge for the content they must learn is a perennial concern of almost all teachers. Many teachers are interested in "reversing the Matthew Effect" – that is, in designing instruction that allows all children to succeed in their classrooms. At present, the activity-inquiry approach, "in which the events, people, and/or materials themselves provide information and feedback" (Larkin, Colvert, Ellis, Iran-Nejad, Casareno, Gregg, Rountree, & Schlichter, 1995, p. 73) to students, has been proposed as a powerful way of providing students with the knowledge and skills they need for success. The activity-inquiry model, which has enjoyed brief periods of attention since the time of Dewey, is currently experiencing something of a renaissance in public elementary schools in the United States (Leinhardt, 1993). In a classroom characterized by the activity-inquiry model, instruction is student-centered. During lesson time, students are engaged in a variety of processes and with a variety of materials. Noise levels may be high. The students consider themselves to be part of a community of learners who are all interacting and sharing their expertise (Brown, Ash, Rutherford, Nakagowa, Gordon, & Campione, 1993).

An activity-inquiry geography learning task might be to make a thematic map of a country, showing, for example, mineral resource developments that are contributing to the economic base of the country. In collaborating on such a task, the "haves" and the "have nots" work together, constructing meaning, negotiating understandings of the tasks, and producing products that serve as evidence of their growth in knowledge.

The activity-inquiry model is set in contrast to a philosophical approach to teaching, the didactic-analytic model, which is still the dominant model for instruction in many schools (Goodlad, 1984). Using this approach, teachers design instruction based on an analysis of what an expert in a subject domain knows and can do. Acquisition of the knowledge and skill base necessary for expert performance in the domain is partitioned over the course of the education of the students so that they are not overwhelmed by the entire task at one time (Glaser & Resnick, 1972). The resulting curriculum is a set of optimal instructional practices that in its most basic form is a scope and sequence chart. Instruction based on the didactic-analytic model is teacher-directed. Lesson time is characterized by teacher talk, either explaining or lecturing, or by student practice of some component of the subject matter.

A didactic-analytic geography learning task might be to practice locating cities on a map, given the latitude and longitude coordinates. This approach to teaching presumes that students are able to acquire requisite skills and knowledge from whole-group presentations. When some of the students are not able to acquire them, the Matthew Effect comes into play: those who had been prepared for whole group learning, learn the new material and get richer. Those who had lacked the prerequisite skills and knowledge become poorer, and the gap between the two groups widens.

This paper reports some encouraging empirical findings that support the position that instruction designed to reverse the Matthew Effect can lead to considerable success for all students. These findings are part of a larger study that examined map learning and transfer.

METHODOLOGY

Setting of the Study

This study was conducted in two seventh-grade social studies classrooms in a large urban school district in Western Pennsylvania. Although this school was a parochial school, the student demographic makeup reflected a low socio-economic background, with sixty percent of students in the school receiving at least partial tuition subsidy. Of the minority students in the school, that represented 22% of the total population, 55% were African-American, 27% were Asian, and 18% were Hispanic children, with most of the Asian and Hispanic children coming from homes where English was not spoken.

Subjects

Forty-two seventh-grade students (average age, 12.4; ranging from 11.7 to 13.4 years) served as subjects in the study. They had been assigned to two heterogeneous classes on the basis of their past performance in school in such a way as to ensure that the two classes would have a mix of students with about the same balance of achievement and personality. There was no statistically significant difference in mean achievement test results between the two classes; thus, they were considered to be samples of the same population.

Teachers

The seventh-grade social studies teacher, Mr. Ray (pseudonym) served as the cooperating teacher in this study. At the time of the study, he had been teaching computer and social studies classes to students in grades 6-8 for 15 years and was considered by his principal to be an excellent teacher. His social studies classes met four times per week for 50 minute periods.

Map Instruction

The study of Canada was part of the seventh-grade, year-long geography curriculum. For the purposes of this research, both classes of students received 11 days of map instruction focusing on Canada; this unit was not part of the usual curriculum. At the end of the instructional unit, all students handed in a map of Canada. For one group, this was a fill-in map; for the others, this was the map they had created during their work sessions. Students in both groups who needed additional time to complete their maps finished their work at home.

Instructional days consisted of two parts: the teacher's presentation of an important component of maps, and a work session. The map component portion focused on three map topics: map symbols, longitude and latitude, and scale (Gregg & Leinhardt, 1994). The goal of the presentations was to provide a coherent and rich instructional explanation of each component. The presentations were didactic in nature. The topic for the day was introduced, the student's prior knowledge or previous work on the topic was reviewed, and then the teacher gave a short lecture or led a short discussion about the topic. Following the initial presentations, the two groups participated in two different work session contexts.

Map Readers. In one classroom, the approach was didactic-analytic: students completed exercises based on a variety of commercially available maps of Canada. These exercises practiced using the map component just presented. Some asked students to solve problems (e.g., to discern the structure of the lines of longitude and latitude or to identify a city from its coordinates) or navigate (e.g., to plot the quickest route between two Canadian cities). Others challenged students to create a product that used information from the maps (to create a sight-seeing itinerary for a three-day trip to one of the eight Canadian cities which have National Hockey League teams).

The Map Readers' practice thus incorporated many of the elements of the didactic-analytic model of teaching (Glaser & Resnick, 1972; Rosenshine & Stevens, 1986). They read and interpreted each map component immediately after it was taught. In general, their practice was discrete rather than integrated: their tasks did not require them to work with more than one map component at a time. They worked with commercially available maps designed to be accurate, rapidly understood and easy to use.

Map Makers. In the other classroom, the approach was based on the activity-inquiry model. These students used their time to work on creating their own maps of Canada from base maps of Canada available in the Goode's World Atlas, 18th Edition (1990). After drawing the basic outline of Canada, the students chose additional information that they wanted their maps to communicate (mineral resources, major cities, languages, climates, etc.) and designed the symbol system they used to portray it.

During these map-making sessions, information about the map components that had been presented earlier in the lesson was available to the students as they needed it. However, the integration and use of that knowledge was not directed by the teacher. Because students were free to select different parts of the task to work on each day, there was a great deal of variety in the map-making group in terms of what particular students were doing at any given moment. Thus, their practice of the map components was not as closely related to the map component presentation as was the Map Readers'.

To summarize the differences in the work sessions of the two classes: the Map Readers' practice activities were modular; the Map Makers' activities were cumulative and integrative. The Map Readers' use of information about symbols, latitude and longitude, and scale was discrete; the Map Makers had to integrate this information. The Map Readers' attention was focused on relatively straightforward tasks involving reading and interpreting expertly produced maps; the Map Makers were focused on the unstructured task of creating their own maps.

Data Collection

There were three sources of data for this study. One data set was quantitative, consisting of the students' pre-and post-test scores on a map skills test.[1] (There were actually two tests: one for Canada and one for China, but the issue of transfer is reported in a separate paper.) The two test forms were counterbalanced as pre- and post-tests.

The second data set was qualitative, consisting of verbal responses given by eight students during individual interviews conducted before and after the map unit. After the pre-tests were scored and before the instructional unit began, four high-scoring and four low-scoring students from each of the two classes were selected for in-depth interviews (16 students altogether). The pre-intervention interviewing of 16 students was undertaken to ensure that there would be at least eight students (two high-scoring and two low-scoring students from each of the two classes) for post-intervention interviewing who had not missed any of the instructional unit.

Nine interview questions were created for the interviews. Seven questions contributed information about students' knowledge of symbols on maps. Three questions asked students about specific symbols on maps, and the other four required students to understand the use of symbols in order to answer questions about longitude and latitude and scale. Three interview questions asked students to discuss or use latitude and longitude and three questions focused on defining and using scale.

The third data set consisted of the lessons themselves. Each day, the lessons were video-taped and all lesson materials were collected. Photocopies were made of students' completed worksheets. Photographs were taken of the completed maps.

Data Analysis

The analysis of the data was designed to reveal: 1) the nature of student knowledge about symbols, latitude and longitude, and scale before the instructional unit; and 2) how that knowledge changed as a result of the instruction. The quantitative analysis of the test score data used an ANOVA with one between factor (instructional groups: Map Makers and Map Readers) and two repeated measures (time: Pre- and Post-test and components – symbols, latitude and longitude, and scale). This analysis provided evidence about whether students learned anything during the map unit and about whether one of the treatments was more effective in facilitating student learning.

Content protocol analysis, which reveals the nature of the information to which people are attending during the performance of a task, was used for the qualitative analysis (Ericsson & Simon, 1984). The qualitative unit of analysis was the idea unit, modeled loosely after the narrative analysis procedure used by Beck and her colleagues (Beck, McKeown, Omanson, & Pople, 1984). An idea unit is the smallest semantic entity that carries meaning about a concept. Idea unit analysis first segments sentences or utterances into clauses. However, since each clause may contain several distinct concepts or relationships among concepts, the clauses are further broken down. Thus, each word or phrase from a student answer that carried meaning about the target map content was coded as an idea unit.

The interview data from the eight students were analyzed by comparing the students' pre- and post-instruction idea units about symbols, latitude and longitude, and scale. Both the number of units and their quality provided information about the nature of the students' map knowledge. Changes in the number of idea units and their quality were examined for the whole set of eight students, for the map reading and map-making students, and for the high- and low-knowledge students.

The lesson data were analyzed to understand the nature of student engagement during the practice sessions. The content presentations were based on a script and, while slight variations occurred as a result of student responses, further analysis was not warranted.

RESULTS

Test Score Results

The ANOVA with the data from the Canada tests showed a main effect for time [$F(1,40) = 33.6$, $p < 0.00$], meaning that collapsing across groups, the post-test scores were found to be higher than the pre-test scores and that this difference was statistically significant. Thus, the students learned about reading and interpreting maps, regardless of the type of instruction they received. There was also a main effect for type of instruction [$F(1,40) = 4.72$, $p = 0.04$]. The gain scores of the Map Makers were higher than those of the Map Readers, which suggests that the map making students learned more than the map reading students.

Interview Results

Symbols. Figure 1 shows the difference between the eight students' pre- and post-interview knowledge about symbols expressed in terms of the number of idea units found in the pre- and post-interview protocols.

The first set of bars shows that the students who were interviewed benefited from the map instruction in terms of their ability to talk about symbols on maps. This evidence confirms the findings from the test score data that all of the students learned a considerable amount about symbols during instruction. The second and third sets of bars show that the Map Makers learned more about symbols than did the Map Readers. The next four sets of bars compare the high- and low-knowledge students. The more knowledgeable students in both groups clearly gained in their ability to talk about symbols on maps. The less knowledgeable Map Makers made greater gains in idea units about symbols than anyone else, while the less knowledgeable Map Readers gained the smallest amount of knowledge.

The content analysis showed student growth in recognizing and defining symbols, in understanding the realities the symbols express on maps, and in understanding how symbols function on maps. The pre-interview data showed that students already knew both the basic forms that symbols take (i.e., line, point, area, color, size of letters) and that symbols are representations of different degrees of abstraction (i.e., picture, icon, abstract sign). The post-interview data showed

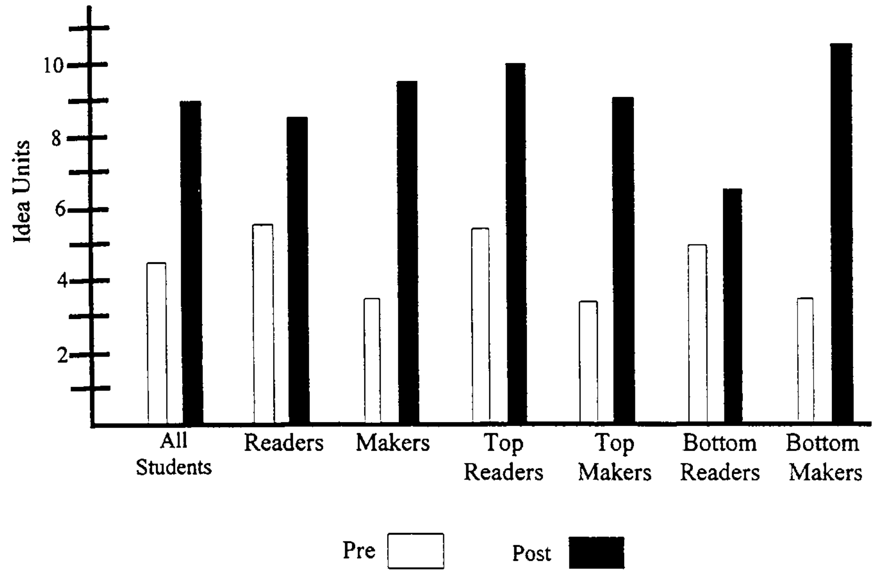

Figure 1. Pre- and post-interview knowledge about symbols in Idea Units (n=8).

that students had grown in their ability to use more sophisticated and precise vocabulary in their discussion of the forms and degree of abstraction. They also grew in their knowledge of the kinds of information that symbols carry, specifically that symbols show the existence and location of places, convey numerical information like elevation or size, or show patterns of relationships among things on maps. Finally, students grew in their knowledge about how symbols function on maps (e.g., taking up less space than words, making it easier to read and write on a map, and making it easier to find places).

Latitude and longitude. Figure 2 shows the difference between students' pre- and post-interview knowledge about latitude and longitude. The first set of bars shows that the students who were interviewed greatly improved their ability to discuss and use latitude and longitude on maps; in fact, the number of idea units expressed in the interviews nearly quadrupled. These results again agree with the test score data. The Map Readers showed greater growth in their knowledge of latitude and longitude than the Map Makers. The remaining four sets of bars show how the gains in knowledge differed according to

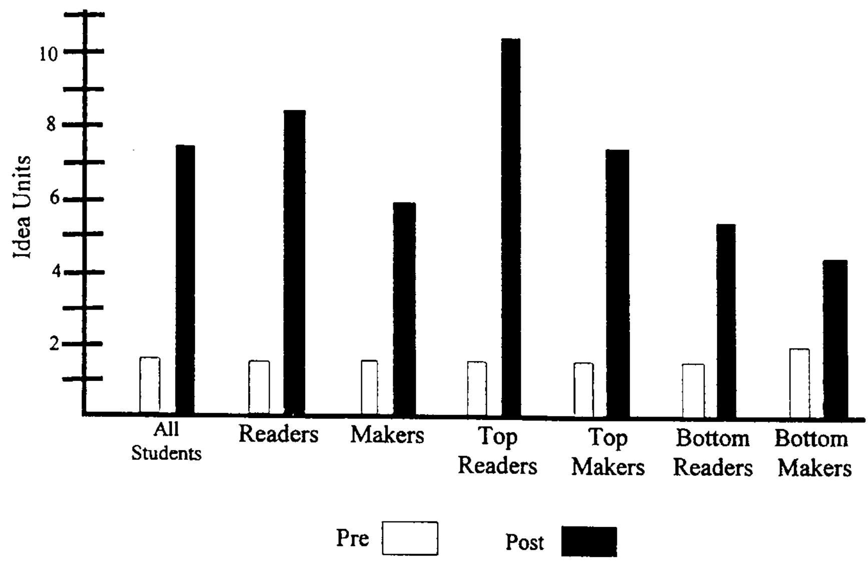

Figure 2. Pre- and post-interview knowledge about latitude and longitude in Idea Units (n=8).

both the method of instruction the students received and how much map information the students had prior to the map skills unit. The expected pattern of the Matthew Effect is clear in these data.

The content analysis of the pre-instruction interviews showed that all but one of the group of eight students had had some notions about latitude and longitude before the instructional intervention. However, at that point, none of the students could define or describe latitude or longitude and most had very little knowledge about the structure of the lines, even though seven of eight students knew that the purpose of the lines was to facilitate locating places on maps. As a group, the students showed substantially more knowledge in all of these aspects of latitude and longitude in their post-interviews. Students in both groups also learned to use latitude and longitude accurately on the maps, even to interpolate latitude from the map. However, on questions related to the structure of latitude and longitude lines, Map Readers outperformed Map Makers.

Scale. Figure 3 shows the difference between students' pre- and post-interview knowledge about scale. Analysis of the idea units

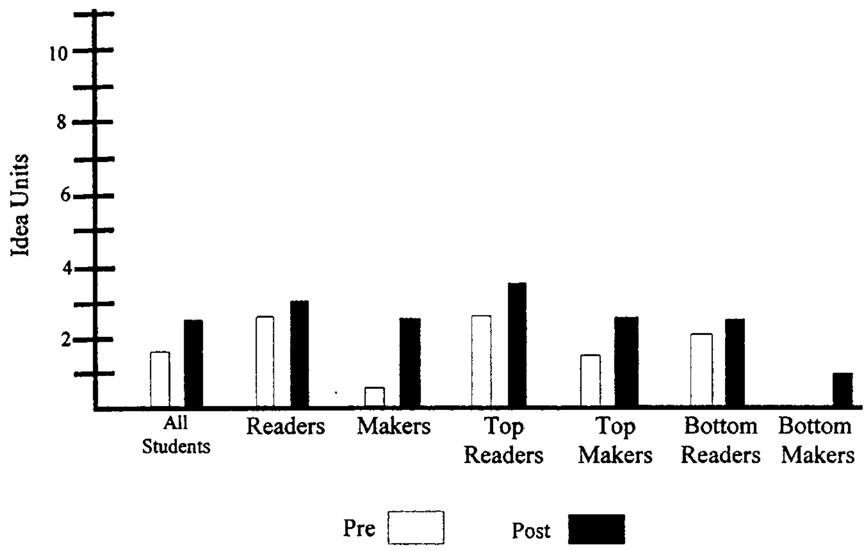

Figure 3. Pre- and post-interview knowledge about scale in Idea Units (n=8).

found in the three interview questions designed to probe students' understanding of scale on maps confirmed the finding from the test scores that the students did not learn much about scale during the course of the map unit.

Although there were positive gains from pre- to post-interview, the gains were much smaller than were seen in the cases of symbols and latitude and longitude. The results show that Map Makers learned (marginally) more than Map Readers, more able students learned more than less able students, and less able readers learned least of all. The content analysis showed no difference between Map Readers and Map Makers in terms of their reading of map scale or their reasoning about size and scale.

DISCUSSION

The quantitative analysis showed that Americans' well-publicized ignorance of geography is probably due to insufficient instruction rather than to some inherent difficulty with the subject matter itself.

Considerable student learning was produced in a two-week unit. Clearly, when students are given opportunities to learn about map reading and interpretation, they benefit greatly, whether the subject is approached from a didactic or an activity-inquiry perspective. However, the test data also showed that students who were taught using the activity-inquiry approach learned more. This is consistent with the activity-inquiry model's claim that tasks, which require the active integration of ideas in an authentic, generative way result in more leaning than practice using information in isolated, well-structured tasks.

The analysis of knowledge about symbols from the interview data also supports the conclusion that the Map Makers learned more. It would thus appear that generating symbols does more to increase learning than reading them. Furthermore, in contrast with the Map Makers' symbol data, the Map Readers showed the expected Matthew Effect: students who began the unit scoring high on the pre-test showed the highest gains in idea units; students whose initial knowledge state had resulted in low pre-test scores showed the least. Making maps strongly benefited the students who had the least amount of prior knowledge of the subject matter, without adversely affecting the learning of the students who had begun the unit with high amounts of prior knowledge. This finding seems to be compelling evidence that the activity-inquiry model of teaching can reverse the Matthew Effect.

Several factors possibly contributed to the success of the students who had to make maps. Because they had much less teacher guidance during their practice sessions, the students had control of their attention while on task. They could spend as much, or as little, time as they needed in order to comprehend fully some part of the task. In addition, making the map constantly required them to draw on all of their available knowledge about maps. Such integration may have functioned both to increase rehearsal of specific aspects of map skills and to make those elements more meaningful. Integrated rehearsal did not happen for the Map Readers who practiced map skills one at a time. A third possibility is that since the Map Makers used their knowledge about symbols, latitude and longitude, and scale in context, the constraints on the use of the knowledge were more thoroughly learned by them. Thus, their knowledge was more comprehensive. Finally, using knowledge in context allows for redundancy of encoding: future access to the knowledge could be by way of episodic memory (association with the context) as well as by semantic memory (association with the feature), which may result in better use of the knowledge.

It is important to realize that the map-making conducted in this research was intended to approximate the activity-inquiry model of teaching. In more purely activity-inquiry classrooms, students typically have more control of what they learn; they select the area of the world to map; they are given lectures about map components only when they ask for them; and while exploring different problems in map design, most students invent many of their own solutions. Although the students in this study had no choice about the country they had to map, it was an authentic task that invited student engagement and it required the integration of many pieces of knowledge. It was a somewhat ill-structured task that provided the students with multiple opportunities for problem solving. In addition, it was generative in many of its particulars, that is, the students not only had to figure out what they should do next at any particular moment, but they also had to figure out how to do it.

However, the clear-cut conclusion that the activity-inquiry model of teaching can reverse the Matthew Effect is complicated by the fact that the Map Readers ended the unit with more knowledge about latitude and longitude than the Map Makers. The analysis of the lesson data indicates that the nature of the activity determines the extent to which students have the opportunity to learn the desired content, not the instructional model through which the information is presented to them. The difference in the way the two groups learned may be accounted for by the fact that they focused their attention during their practice sessions on different aspects of the content. In one Map Reader work session, the students' attention was directed towards the "problem" of how latitude and longitude lines are structured. Their worksheet questions could be answered only by looking at a globe and tracing lines of latitude and longitude with their fingers, laying pieces of dental floss along the lines, or visually comparing two lines for attributes or the spatial relationship between them. In other words, by its very nature, the task required both student engagement and sense-making. Many educators oppose worksheets because they do not offer students a "hands-on" opportunity to learn.

However, because the students had to think about the structure of the lines in order to complete the worksheet, the Map Readers' attention was engaged with the critical aspects of the lesson and their post-tests revealed correspondingly large gains in knowledge.

The Map Makers' attention was directed to the "problem" of drawing lines on their maps. They did not have to think about the structure of the lines because they had been given a template to determine the angles for the lines of longitude, and pre-determined measurements for the lengths of string needed to form the arcs for their lines of latitude. Intent on creating lines on their papers, they did not focus much, if at all, on the structure of the lines. Students were thus caught up in the action system of the activity without having to engage with the content in ways that facilitate learning it. In particular, since the students did not experience the problem for which a piece of knowledge was the solution, they simply used the knowledge without ever actually understanding or learning it. If the Map Makers had had to solve the problem of how to construct a grid for a curved sphere, or of how to transfer such a grid from three to two dimensions, they might have learned more about the structure of the lines. But for them, the motivation or question for which latitude and longitude are the answer was missing (Cognition and Technology Group at Vanderbilt, 1990). Consequently, their post-tests revealed little gain in knowledge of latitude and longitude.

Neither group learned much about scale from this map unit. It may be that the students already knew the information about scale presented in the unit. However, a close examination of the lesson data provides an alternative explanation: both groups were able to avoid actually making sense of scale issues. The Map Readers' practice sessions emphasized correctly finding and copying expressions of scale from maps and using them to measure lines. These students appear to have a rote process for answering questions about scale that did not involve reasoning about the information they obtained and none of the practice activities required the Map Readers to make sense of their answers. The Map Makers were able to avoid engaging in sense-making with scale by using the position of points relative to the edges of the page and to the lines of latitude and longitude.

These results show that when instructional activities force students to attend to critical features of content, they cause students to learn what is truly generative about the content. Generativity may be measured by how well some aspect of a topic serves as an anchor or organizer for more knowledge about the topic. The core concepts of topics are generative in this way. Alternatively, generativity may be revealed in the utility of some knowledge in reasoning and building a case. Powerful examples can be generative in this way. For symbols, what was truly generative for the students were the critical features of the shapes, sizes, and positions of map symbols. For latitude and longitude, the critical features related to how the lines are structured, far more generative than knowledge about how to read the lines or draw them. For scale, the critical feature is the correspondence between map spaces and the surface of the earth, which enables proportional reasoning about distances or "translating" information about distance in meaningful ways.

Thus, instructional activities need to be structured so that students cannot help but make sense of the information with which they are working. Otherwise, instead of inventing tools and connections and solutions to problems, all of which generate knowledge, students will invent ways to avoid the aspects of tasks that force them to make sense of the knowledge.

CONCLUSIONS

In this study, two models of teaching were used to give instruction in map reading and map interpretation. Lessons based on the didactic-analytic model consisted of a short map component presentation followed by time to work through activities designed to practice that component in isolation. Lessons based on the activity-inquiry model consisted of the same initial presentation of a map component followed by time to continue creating a map.

Three important findings emerged from the data. One is that both the traditional didactic and the activity-inquiry lessons offered opportunities for students to learn. A second is that for one subset of students, those who came to the unit with little or no prior knowledge, how the learning activities were structured was very important. Students who came to these lessons already possessing a number of concepts about symbols, latitude and longitude, and scale learned a great deal, no matter how the material was taught and practiced. But when the students actually had to engage deeply with the target material, as in the map-making task, the students who had lacked prior knowledge learned even more than the students who had initially known more. Because these results were based on very few subjects, further research is needed to confirm the finding.

A third finding is that learning activities must be structured in such a way as to have the students, not the teacher, solve the problems that arise while doing the activity. It is the problem-solving activity that promotes learning, by showing the student what is problematic, and then by requiring him/her to engage with the content in a way that can solve the problem. In the case of making maps, the student who has struggled to solve a map making problem will better understand what is involved in solving the problem, even if the solution is not the most parsimonious or elegant. Indeed, such students may be more able to appreciate the standard solutions adopted by professional map makers as a result of their struggles.

An implication of this study is that pre-service preparation programs must teach future teachers how to design learning activities that will be generative. They need to understand the theoretical and conceptual bases underlying the structuring of generative tasks, the aspects of a subject matter that are most generative for students, and the social skills that students need to be successful during such activity-inquiry activities.

Given the positive affect that generative tasks had on reversing the Matthew Effect, good teachers will want to ensure that the learning tasks they set before their students force them to focus on the critical aspects of the content. In this way, they may succeed in narrowing the gap between "the rich" and "the poor" in our classrooms.

NOTES

[1] Copies of the tests and a description of how they were tested to determine if they were parallel forms may be obtained by writing the author.

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The Eurocentric Nature of Mental Maps of the World

Tom Saarinen

Sketch maps of the world, a form of mental map, indicate that our images of the world tend to be Eurocentric. These sketch maps are generally centered in Europe (Saarinen 1988), and the size of Europe is greatly exaggerated (Saarinen et al. 1996). Furthermore, Europe is known in greater detail than any other continent. These conclusions are based on the Parochial Views of the World project, a worldwide study of mental maps of the world. The project was supported by the International Geographical Union and funded by the National Geographic Society.

Keywords: *mental maps, Eurocentric view*

THE PAROCHIAL VIEWS OF THE WORLD STUDY

The Parochial Views of the World study was conceived as peace research near the end of the Cold War. One defense against the dangers of an unstable international system would be a reasonably accurate shared image of the world. No documentation existed concerning whether there was a shared image of the world or a series of parochial views held by people from different countries. The study aimed to remedy these deficiencies by providing a systematic set of world images by having individuals from a carefully selected sample of countries sketch a simple map of the world. When current world images are understood education can be designed to remedy any weaknesses revealed.

University geography departments on all inhabited continents were visited and students in first year geography classes were asked to sketch a map of the world. This population was selected to represent people who have completed the basic educational process in their country and are interested enough in geography to enroll in a geography course. It was assumed that their general level of competence in map-drawing would enable them to produce sketch maps of the world representative of the general level of geographic knowledge of the educated population of their country. A major advantage of the sketch map method is that, once the short and simple instructions are translated, it is easy to administer and it provides directly comparable products from countries of widely differing languages and cultures. Standardization of procedures to enhance comparability of results were accomplished by having the exercise administered directly by the principal investigator and his research assistant.

The exact wording of the instructions were:

> "Draw a sketch map of the world on this sheet of paper (8 1/2 x 11 inches or the closest local equivalent). Label all the countries and any other features you think are of interest or importance. Do not worry if your map is not perfect. Just do the best you can. I am sure you will find this an interesting experience once you get started. Take about 20 to 30 minutes to complete the task."

For the group sampled, drawing a sketch map of the world was an interesting challenge and only a handful of the 2488 participants turned in a blank sheet. The sample was extended by having cooperators follow a standardized set of instructions and mail the sketch maps they collected to the author. This final total consisted of 3568 sketch maps from 75 sites in 52 countries (Table 1).

In drawing a map of the world on a blank sheet of paper, the sketcher is trying to reproduce a world political map from memory, since the instructions explicitly asked for the names of all the countries. These instructions should enhance the general tendency observed on previous global sketch maps to use nations as building blocks (Saarinen, 1973). The task, though interesting, is difficult. The map sketcher likely relies on memories of the type of world map that most readily comes to mind. The map most readily recalled would probably be the one most commonly seen and used in the map sketcher's society. How the sketch maps were centered in this broad international sample reveals something about how the world political map is presented in different parts of the world and gives insight as to how one's society is viewed in relation to the rest of the world.

On the back of the maps the sketchers provided basic information on their age, sex, education, world travel, and languages spoken. In addition, after the exercise, a subsample of map sketchers were asked a series of questions about their maps, such as: where they began, the sequence of continents sketched, which portions were easiest, and

Continent	No. of countries	No. of sites	N	%
Africa	11	13	656	18.4
Asia	16	24	950	26.6
Europe	13	13	706	19.8
North America	5	14	726	20.3
Oceania	3	5	305	8.5
South America	4	6	225	6.3
World Total	52	75	3568	100

Table 1. Number of sketch maps of the world collected by continent (November 1985-March 1987)

most difficult to draw and why, as well as specific questions related to why areas were left blank or done in great detail.

LITERATURE REVIEW

The research is a derivative of the burgeoning interest in "cognitive maps," whose scope and approaches, were first sketched out by Downs and Stea (1973); though the earliest use of the term is credited to Tolman (1948) and early inspiration is traced to *The Image of the City* by Lynch (1960). The present project extends the sketch map technique to the global scale and was one of the first cognitive mapping studies to explore images of the world (Whittaker and Whittaker 1972, Saarinen 1973; Bosowski 1981, Overjodet 1984).

During the 1990s there has been a steady trickle of papers by geographic educators using sketch maps of the world as a research and teaching tool. Wise and Heckley-Kon (1990) wrote a paper about assessing geographic knowledge of students using sketch maps. Metz (1990) showed how the use of repeated sketch maps over the course of a year could lead to marked improvement in student knowledge. Stoltman (1990) found that the accuracy of world sketch maps drawn by teachers was most closely related to secondary school geographic education. Marran (1992) also advocated repeated use of sketch maps to help grade 12 students learn what they should know about the world. Rifas (1996) outlined a method for sketching an accurate world map. Chiodo (1993) tested preservice teachers' mental maps of the world and found them wanting. Chiodo (1995) developed lessons to improve the mental maps of 7th grade students.

The first paper utilizing the Parochial Views of the World data set was on the centering of mental maps of the world (Saarinen, 1988). A paper probing the use of world sketch maps as surrogates for geographic knowledge followed (Saarinen, MacCabe and Morehouse 1988). In it qualitative and quantitative scales were developed to classify map quality. and major sources of map knowledge were investigated.

The first paper, focusing on a single country, used a Finnish sample and it served as a how-to guide to aid cooperators in the task of combining statistical data and sample maps into a portrayal of their nation's image of the world as well as the world's image of their country (Saarinen and MacCabe, 1989). The desirability of involving a local geographer in the explanation of why certain countries were included became apparent early. They were sought for the regional papers that followed on India (Tewari et al., 1989), Australia (Walmsley et al., 1990), Rwanda (Lowry, 1990), Poland (Nunan, 1990), and South Africa (Saarinen et al., 1990). The quality of the sketch maps in South Africa, drawn by three samples of students, two white, from an English and an Afrikaans university, and one from a "colored" university, showed great disparities, due to educational differences under Apartheid.

Further national studies followed on Hong Kong (Wong et al., 1992), Saudi Arabia (Al-Maharwi et al., 1992), Israel (Burmil et al., 1993), Singapore (Kong et al., 1994) and Norway (Dale et al., 1996) in which gender differences were explored. Cumulatively, these studies of different areas, besides elucidating national images, were also used to test whether there was a shared world map at the time the maps were obtained.

Pinhiero (1991) demonstrated the reliability of the scoring system using many different scorers. Keidel (1991) wrote a paper on sketch maps as research tools reviewing the recent positive assessments of the sketch map technique.

As the reunification of Germany approached, Saarinen and

MacCabe (1990) wrote a paper on the world image of Germany. Although East and West Germany were separated for half of this century and for the entire life of the students doing our sketch maps, the area was more often referred to as Germany than either of the then official names. The same pattern applied in the use of Korea, instead of North and South Korea (Saarinen et al., 1991)

Papers incorporating a large number of similar samples followed. Gourley et al. (1991) found that only a faint image of the British Commonwealth remains in the 1305 sketch maps drawn by Commonwealth students. Kirsch et al. (1998) examined the world image of Eastern Europe and the Eastern European image of the world just prior to the end of the Cold War. Berkowitz analyzed the differences and similarities of the African and world images of Africa (Berkowitz et al., 1992). Dean et al. (1992) wrote an analysis of Chinese sketch maps, including those from Hong Kong. Choker and Saarinen analyzed West African nations, Nigeria and Togo (1992). Another paper compared the two map sets from Armidale, Australia and Dunedin, New Zealand, and included discussion of male-female differences in map drawing and map humor (Gourley et al. 1993). Southeast Asia is one of the least known areas on Earth. This was documented in detail and contrasted with the worldview of various Southeast Asian nations (Kong et al., 1992). Bailly et al. (1995) studied the Francophone nations' views of the world and how they were viewed by the world.

Blades (1990) demonstrated the reliability of the sketch map technique, at the intraurban scale, by having respondents sketch two maps of the same area separated by some time. At the world scale, groups of students from similar classes separated by five years (1986-1991) produced group images almost identical. The only exceptions were for new additions, due to current events, such as new nations, that were formerly parts of the USSR, or countries appearing more frequently because of the Gulf War i.e., Kuwait, Iraq, or Saudi Arabia (Keidel et al. 1992, Pinhiero 1992, Gams et al. 1993). The reliability of the sketch maps technique is further attested to by consistency of scores among separate samples from the same nation (Saarinen and MacCabe, 1995).

Several other works more topical than regional were: world patterns of geographic literacy (Saarinen and MacCabe, 1995), relative size of continents on world sketch maps (Saarinen et al., 1996), and determining whether sketch maps depend more on knowledge or drawing skills (Saarinen, 1998).

In his dissertation, Pinhiero (1996) used a multiple regression model to work out the main influences determining the distribution of countries known to a sample of Brazilian students. These influences were: a Brazilian version of the board game Risk, citations of nations in Brazilian newspapers, size and map position of nations, and soccer participating nations.

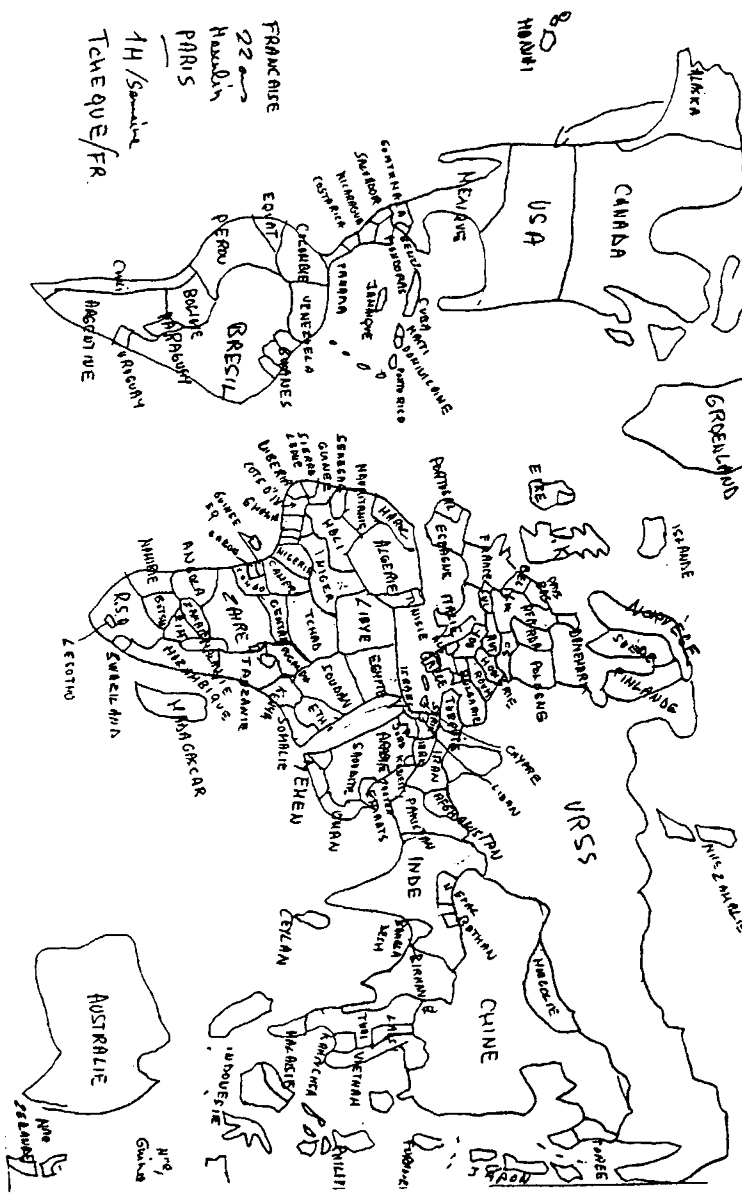
THE CENTERING OF THE MAPS

Examination of the sketch maps indicated obvious differences in the ways students centered them. The three most common types of centering are described as Eurocentric, Sinocentric, and Americentric. In addition, a variety of other maps were not centered in any of these three ways.

For the purposes of this study the Eurocentric category includes all maps with the Americas on the left, the Atlantic Ocean, Europe, and Africa central, and East Asia on the right. The Pacific Ocean is not featured and appears only on the edges. Europe is not necessarily dead center, nor is the continent always depicted accurately in size or shape. Map 1 shows a sample sketched by a student from Paris. It is the best map in the entire set. It is not just Europeans who draw this arrangement. It was produced in countries on all continents as is illustrated by Map 1 from France, Map 2 from Saudi Arabia, Map 3 from Cameroon, Map 4 from Canada, and Map 5 from Thailand. Map 6 from Australia shows, in a witty way, one potential problem for Australians who use a Eurocentric map.

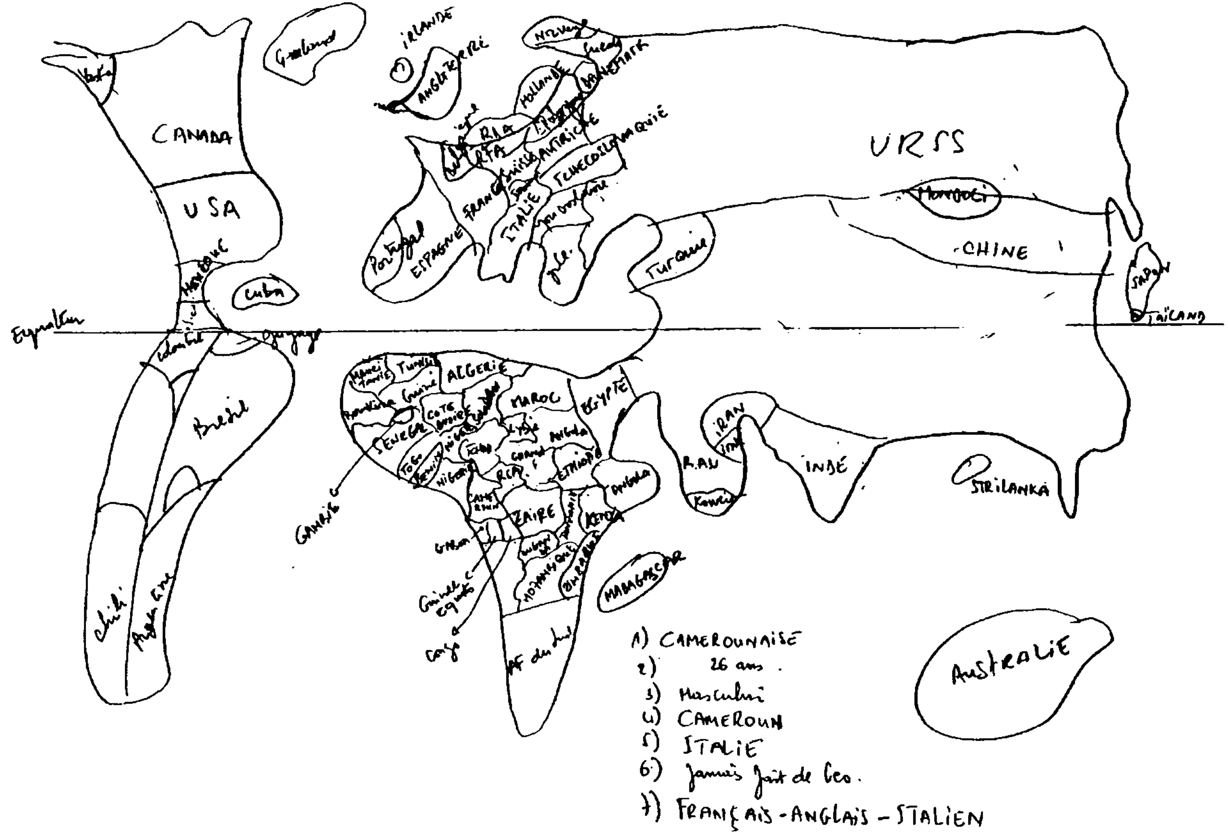
The predominance of Eurocentric maps, found on 79 percent of the sketch maps, shows that this is the standard world map, the one accepted by convention since the first International Meridian Conference of 1884. At that time, when Great Britain was the dominant power, it was decided that the prime meridian should pass through Greenwich, England. With this convention the meridians were labeled east and west of Greenwich and the Eurocentric map formed the conventional world image with west on the left, east on the right, and north on the top. Before the Greenwich Meridian was agreed upon many prime meridians had been used.

The Eurocentric map is an aesthetically pleasing arrangement of

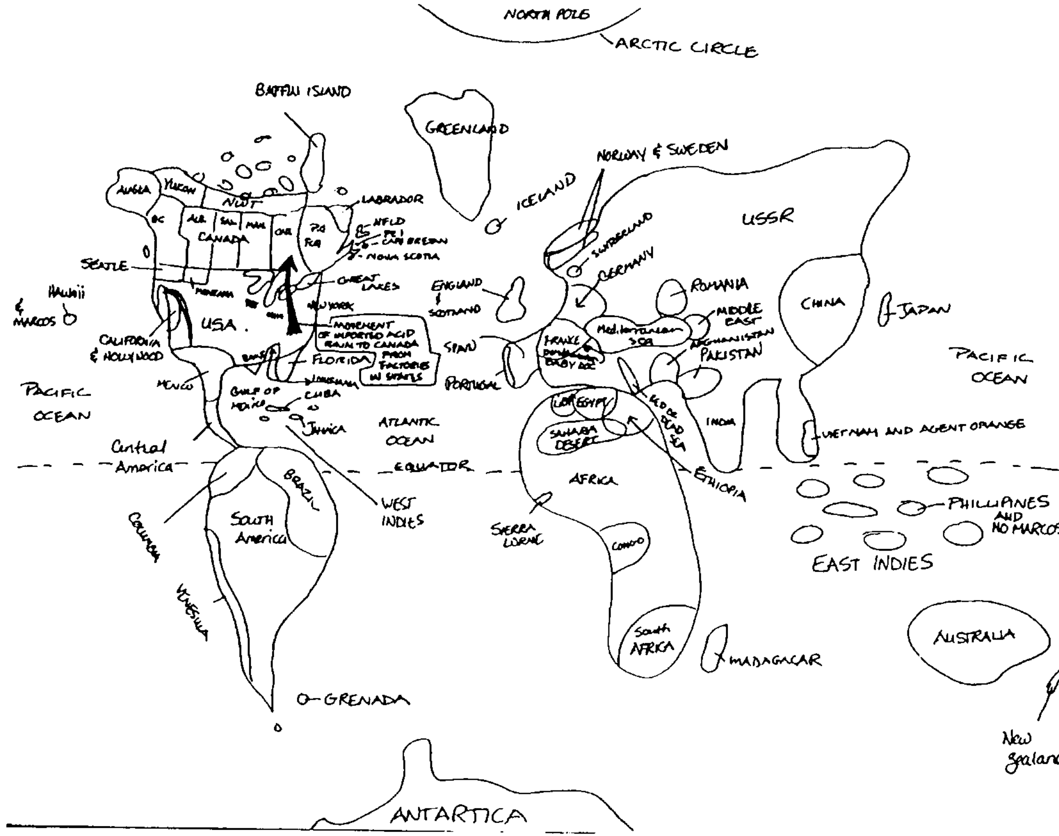


Map 1. World map drawn by a student in Paris, France.

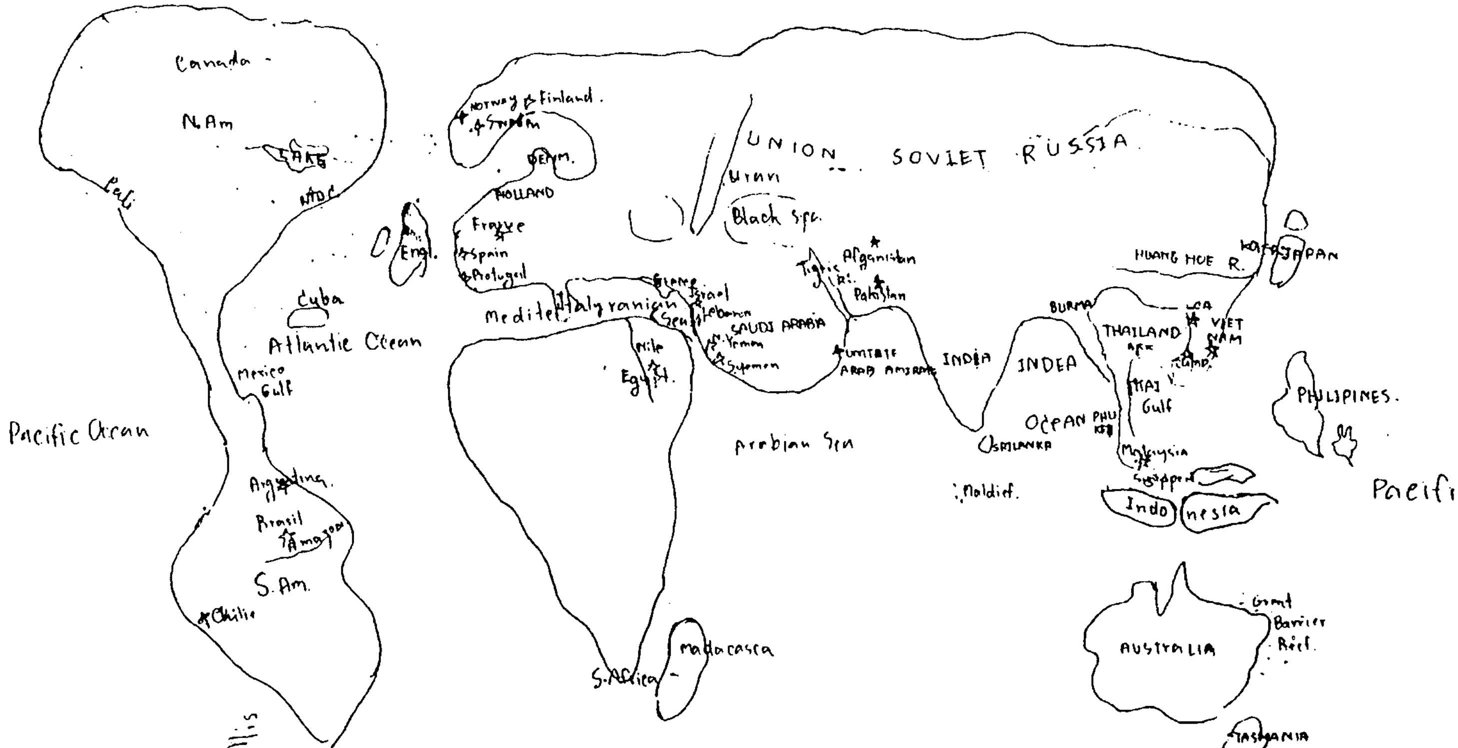
Map 2. World map drawn by a student in Saudi Arabia.



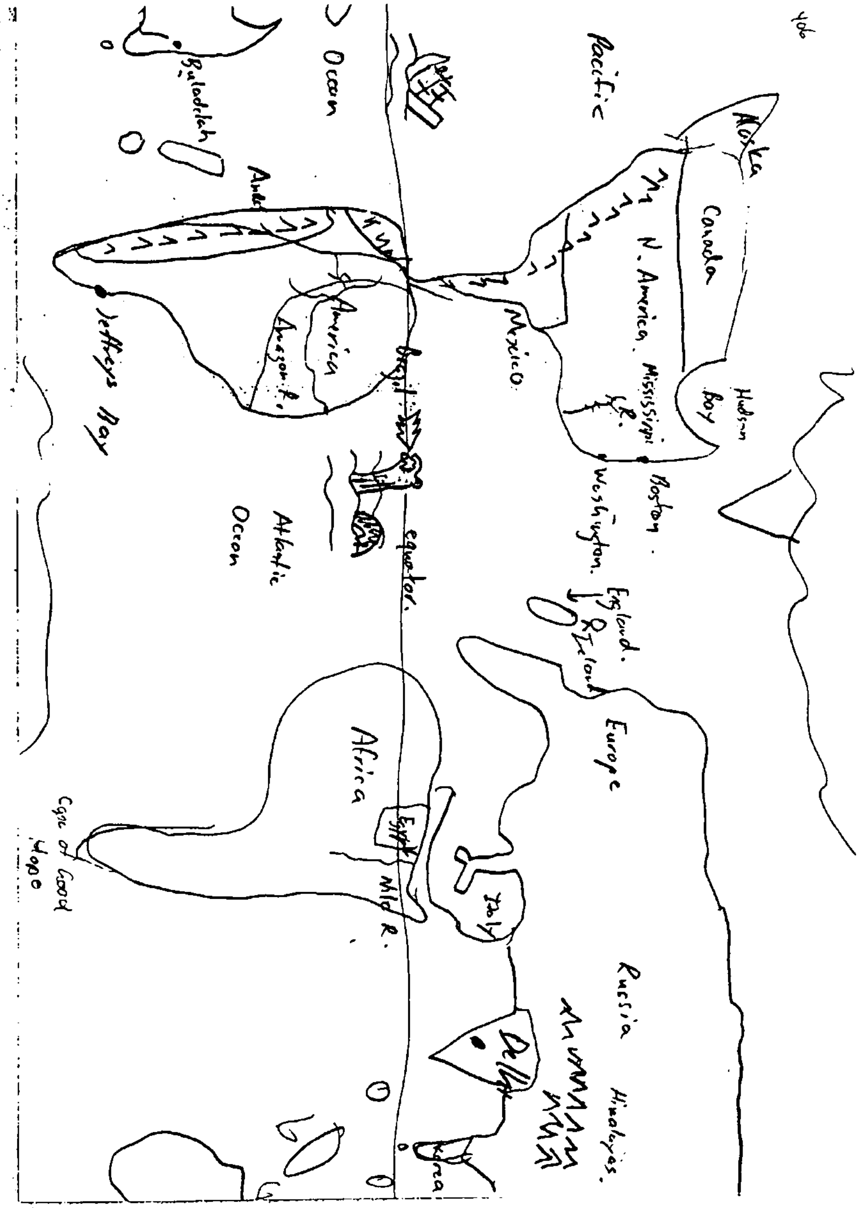
Map 3. World map drawn by a student from Cameroon.



Map 4. World map drawn by a student in Canada.



Map 5. World map drawn by a student in Thailand.



Map 6. World map drawn by a student in Australia.

the world's landmasses, which minimizes the space devoted to oceans. Like the Sinocentric map it represents all continents whole.

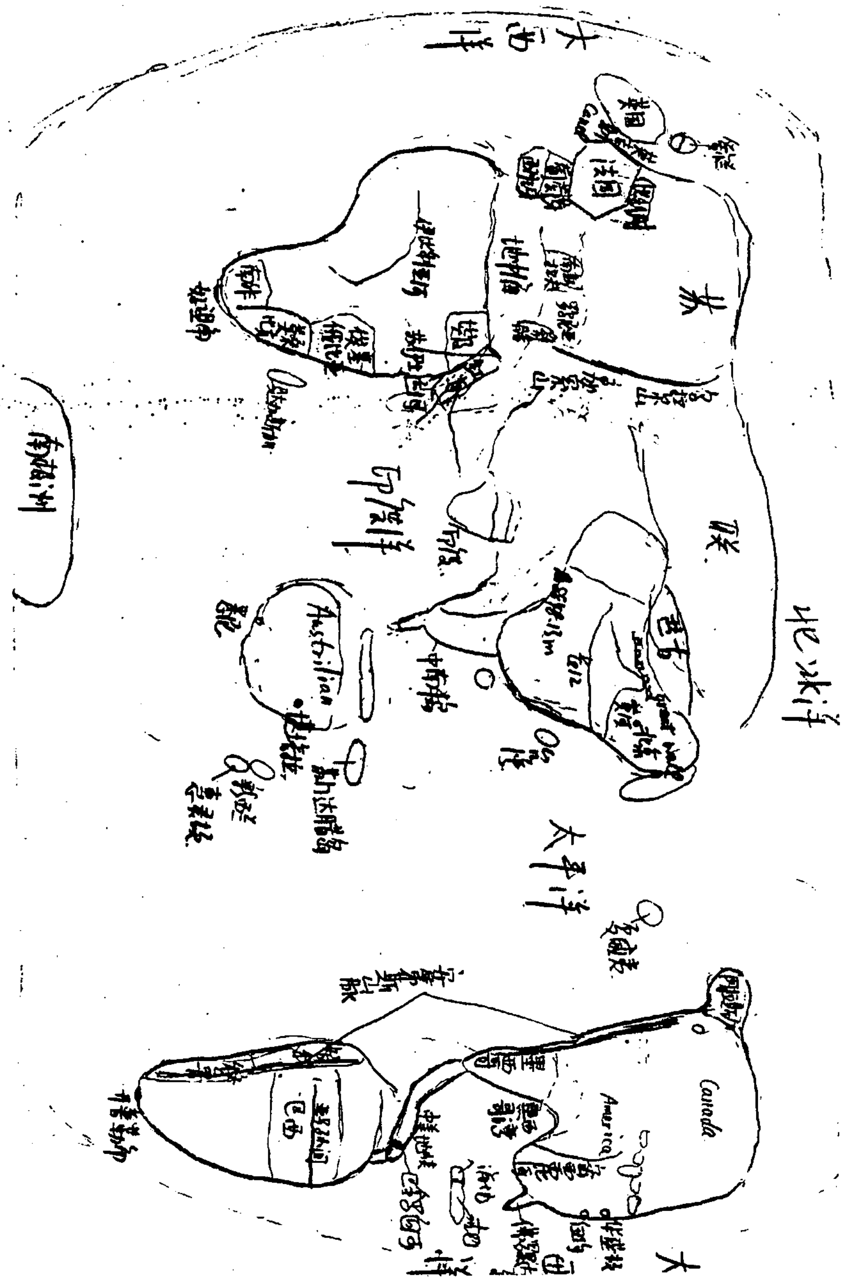
Sinocentric maps are arranged with Europe on the far left, East Asia and the Pacific Ocean central, and the Americas on the right. The Atlantic Ocean only appears on the edges of the map. This type of world map dates from the time of Matteo Ricci, a Jesuit priest, who arrived in China in 1583. He is credited with bringing Renaissance knowledge of cartography to China (Needham, 1959). Many scholarly Chinese were fascinated by the world map he displayed in his mission, but did not think it appropriate to place China on the map edge rather than the center where, it seemed to them, it belonged. Ricci responded with his famous world map of 1602 (Baddeley, 1917), which centered on China. This type of centering was second to the Eurocentric accounting for 11 percent of the sketch maps of the world.

Map 7 from China, and Map 8 from Japan are typical examples from countries where the Sinocentric map has a long tradition. Map 9 from New Zealand represents a nation which more recently started using such maps.

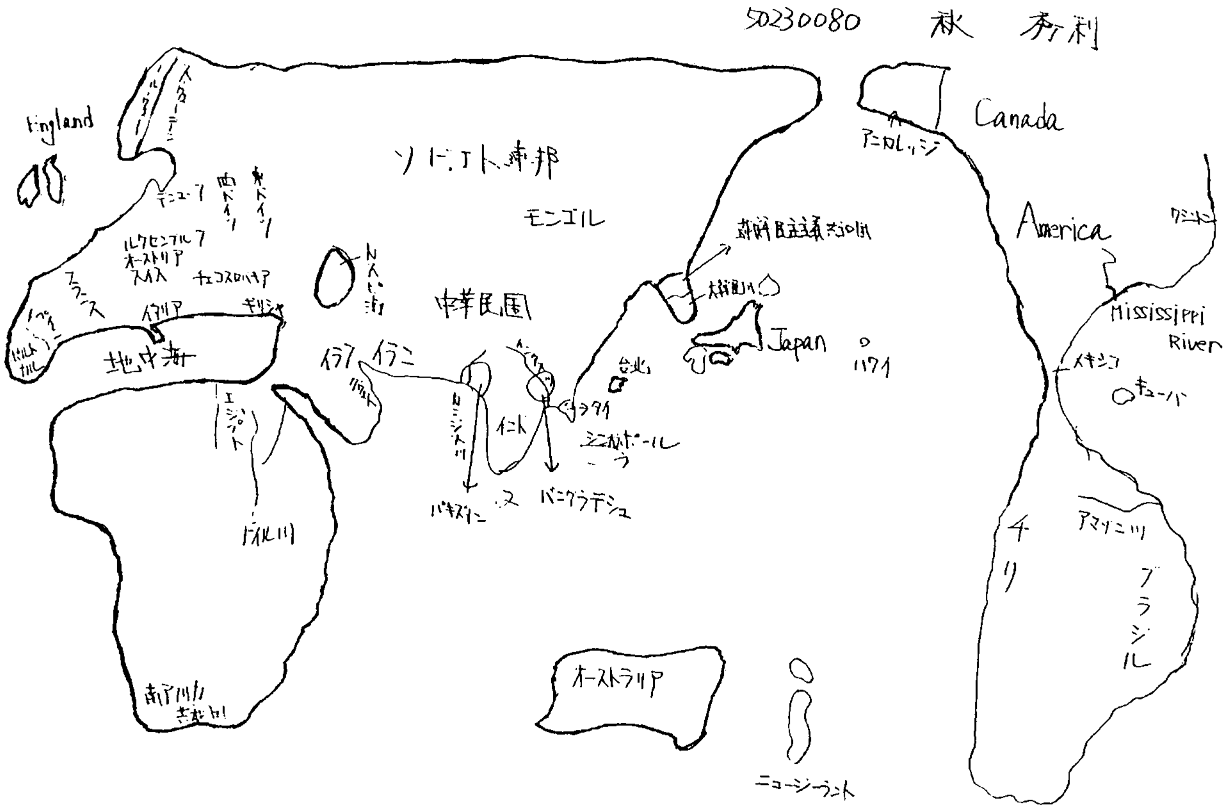
The Americentric maps of the world are those that place the Americas in the center. This has the advantage of featuring both the Atlantic and Pacific Oceans but the disadvantage of splitting the Eurasian continent so that the eastern portion of Asia appears on the left side of the map, and parts of Europe and Africa on the right. According to Alan Henrikson (1980), some of the earliest of the Americentric world maps were published in Boston in 1850 and New York in 1851. Map 10 from Chicago and Map 11 from Taiwan are typical. Map 12 by a student from Peru is interesting. It is clearly Americentric, which raises the question, whether a sample on the west coast of South America would yield more of this type of world sketch map. Of the total sample, 7 percent were Americentric.

The other category contained a variety of maps, which could not be classified in the first 3 categories. Some of these maps, such as Map 13 from the Philippines, were ethnocentric, including only the homeland. The other category also included two hemisphere maps, azimuthal equidistant polar maps, incomplete maps, and others. The other category was 4 percent of the total.

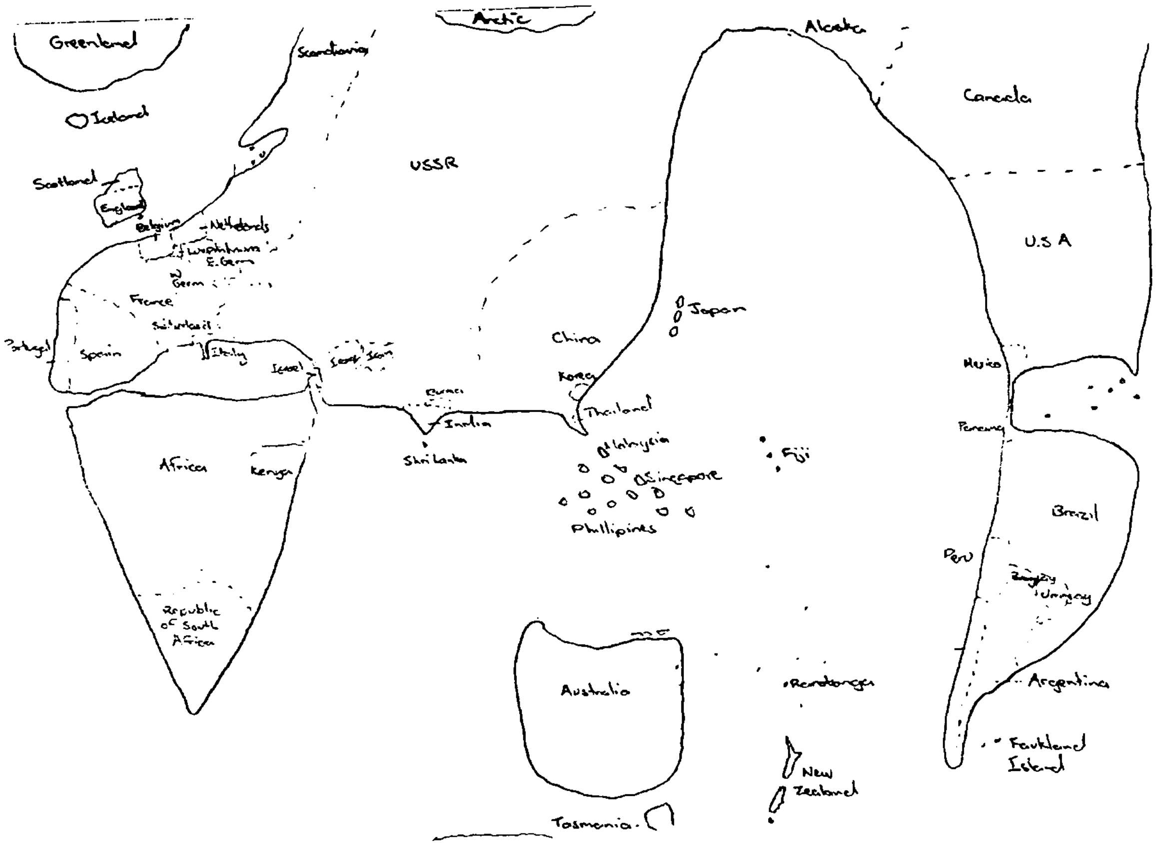
This paper does not focus on idiosyncratic differences, but rather on trying to discover whether there are general tendencies, which



Map 7. World map drawn by a student in China.

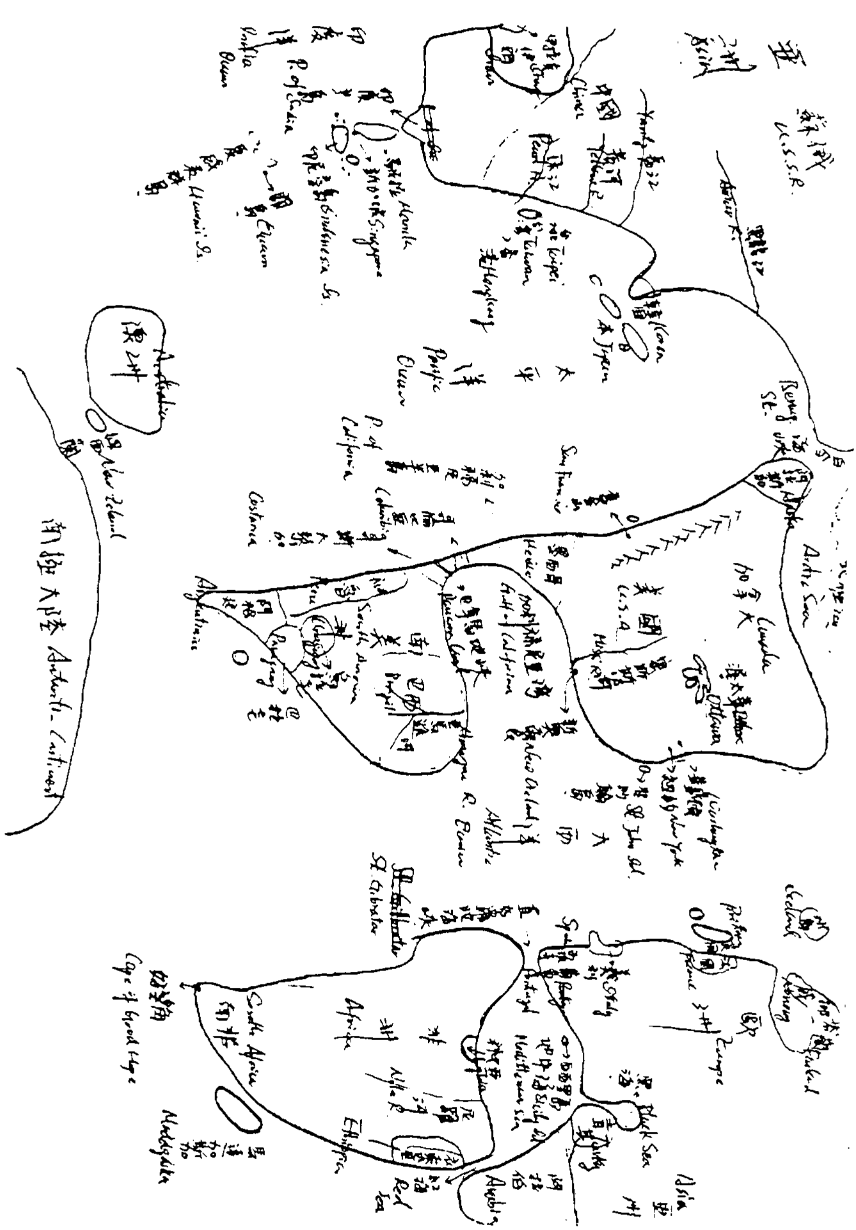


Map 8. World map drawn by a student in Japan.

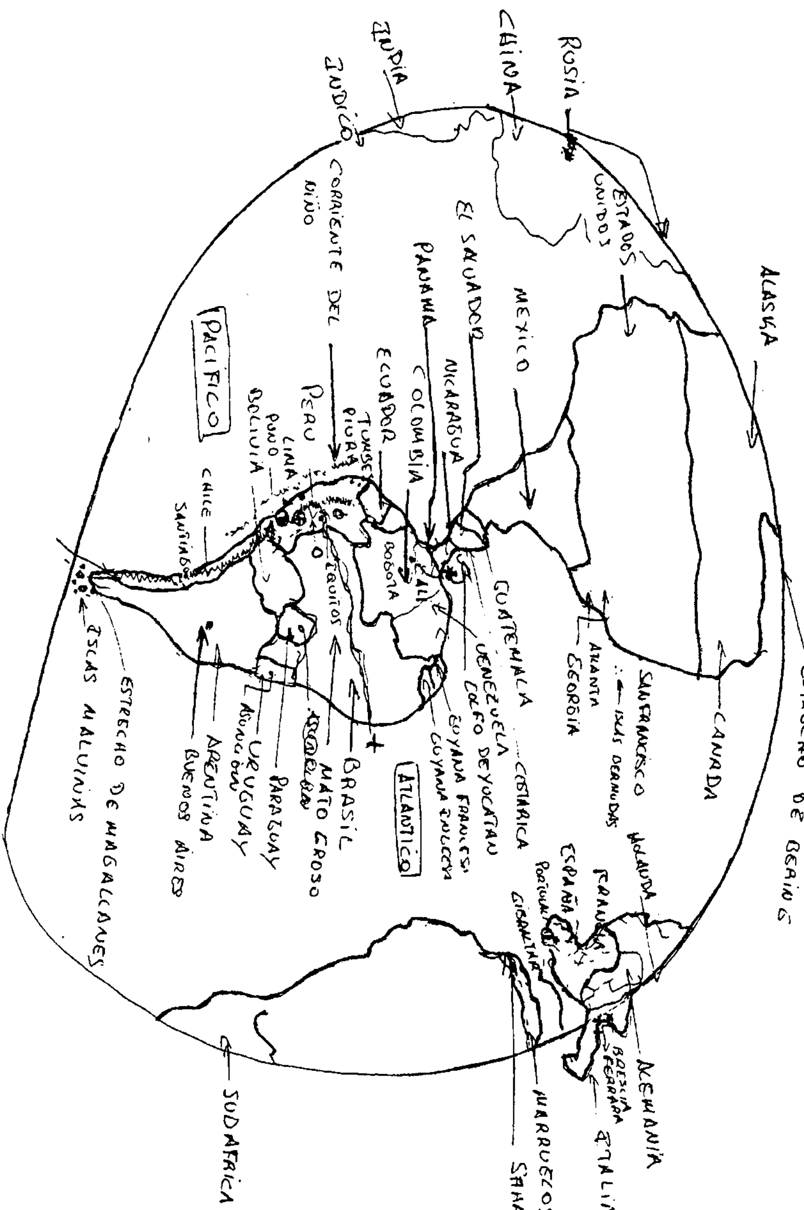


Map 9. World map drawn by a student in New Zealand.

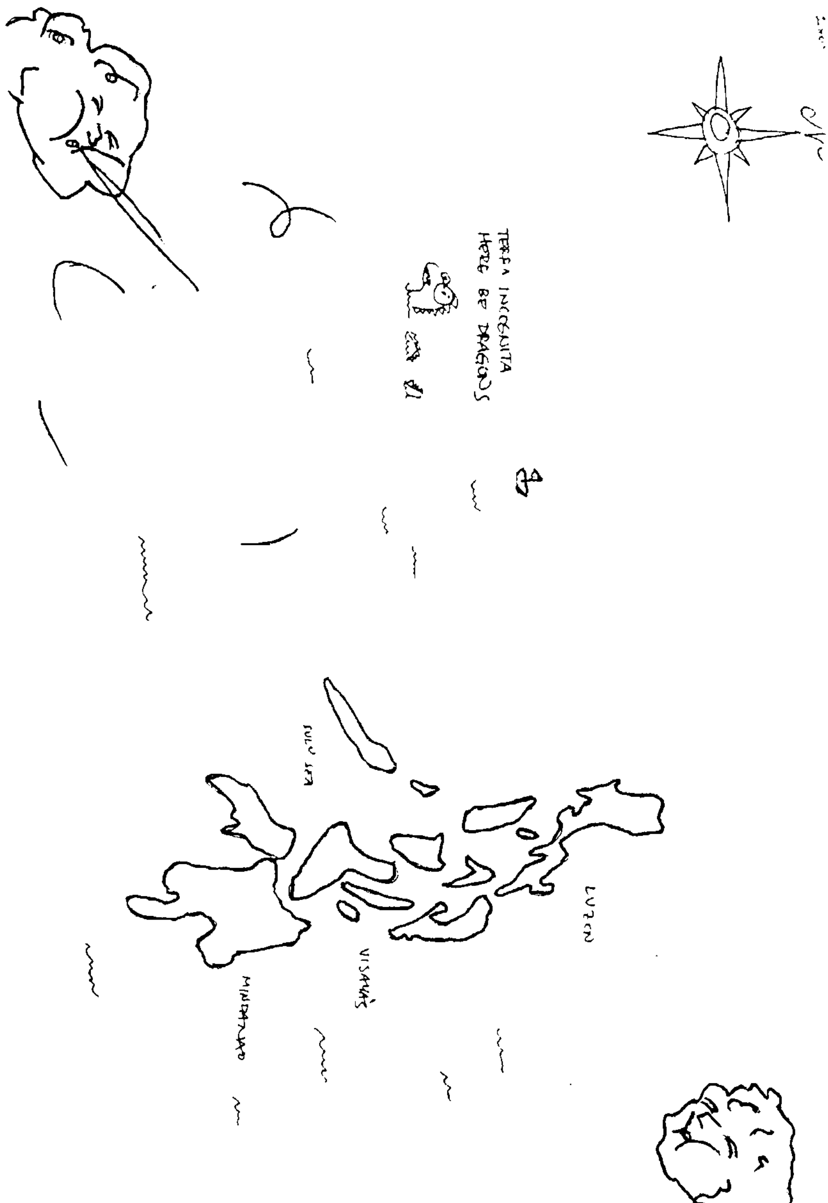
Map 10. World map drawn by a student in Chicago, USA.



Map 11. World map drawn by a student in Taiwan.



Map 12. World map drawn by a student from Peru.



Map 13. World map drawn by a student in the Philippines.

becomes apparent when all the maps from one place are grouped.

Figure 1 shows a generalized pattern for the entire world sample. Clearly the predominant factor explaining deviations from the norm of the conventional Eurocentric map of the world is longitude. Judging from the sketch maps collected, people in most countries are quite content to use the Eurocentric map and it serves reasonably well in indicating the location of each of the world's countries in relation to the rest of the world.

It is in the countries that appear on the edges of conventional Eurocentric maps of the world that dissatisfaction develops. Such feelings first occurred four centuries ago in China where dissatisfaction with the Eurocentric world map led to the development of the first Sinocentric version. It probably also became the standard image of the world in countries such as Korea and Japan, whose histories were closely entwined with China. Sinocentric maps are also seen as most appropriate for their own countries by students from Indonesia, Papua New Guinea, Australia, and New Zealand.

The Americentric map was most commonly drawn by students at the western extremities of North America. A Eurocentric map would place them on the periphery of the world, so they switch to an Americentric, or even a Sinocentric map, which better relates their location to the rest of the world.

THE RELATIVE SIZE OF CONTINENTS ON WORLD SKETCH MAPS

Sketch maps at a variety of scales consistently tend to exaggerate the size of the home area (Wood, 1971; Downs and Stea, 1973; Gould and White, 1974; ; Tuan, 1974; Saarinen, 1976). Greater detail and central placement of the home area often accompany such home area exaggeration, exemplified by the famous "New Yorker's view of the United States" (Wallingford, 1936). Exaggeration at the center and diminishment on the peripheries are related to the mapmaker's level of knowledge and the area's perceived importance. So the home area is drawn in great detail, while less space is devoted to the more distant and less-known areas beyond. These maps reflect a universal ethnocentrism that has resulted in numerous variations on the theme: sketch maps drawn other places in a similar style have been created for sale

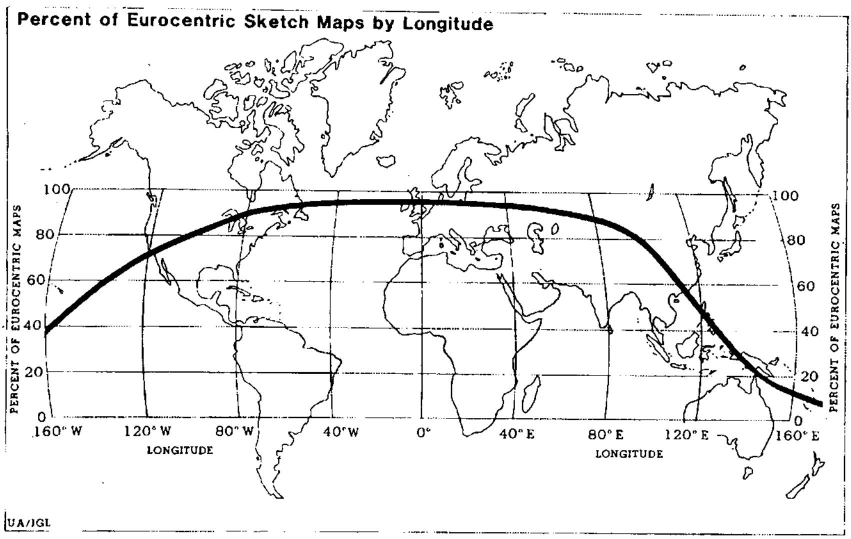


Figure 1. Percent of Eurocentric sketch maps by longitude.

as souvenirs in Texas, Paris, Boston, and elsewhere.

I address here the question of whether sketch maps of the world will reflect this same tendency to exaggerate the home area. It was hypothesized that the home country and immediately surroundings areas would be better known, perceived as important, and exaggerated in size - that there would be a home continent bias. Thus, the home continent would tend to appear larger in relation to the other continents than it actually is. I used home continent, rather than home country, because continents are consistently represented on world sketch maps, while individual countries vary enormously in the frequency of their inclusions.

To test my hypothesis, I selected a subsample of my larger world sample. This subsample was selected to reflect locations within each continent and dispersion latitudinally and longitudinally throughout the Earth. The sample sites and numbers are indicated in Table 2. From the larger sample at each site we selected the first 20 maps having clear outlines of the continents. Time constraints precluded a larger sample. The Rwanda sample consisted of only 18 maps, so the number for this site was less than the others.

Site	Number	Site	Number
Abidjan, Ivory Coast	20	Trondheim, Norway	20
Antananariv, Madagascar	20	Lisbon, Portugal	20
Rabat, Morocco	20	Istanbul, Turkey	20
Ruhengeri, Rwanda	18	Ottawa, Canada	20
Stellenbosch, South Africa	20	Fairbanks, United States	20
Hong Kong	20	Tucson, United States	20
Pune, India	20	Seattle, United States	20
Seoul, Korea	20	Nassau, Bahamas	20
Kuwait	20	Buenos Aires, Argentina	20
Silpakorn, Thailand	20	Belo Horzonto, Brazil	20
Armidale, Australia	20	Caracas, Venezuela	20
Total Number	438		

Table 2. Sample areas and numbers.

From the world sketch maps I selected seven major units for measurement; North and South America, Europe, Asia, Australia, Africa, and Greenland. While additional landmasses could have been added, these were chosen because of their massive size and overall consistency throughout the data set.

The unit area was encoded with the aid of an electronic planimeter that calculates area as an operator traces the perimeter of a continent using a stylus. The values are then transferred to a computer for manipulation and storage. A basic computer program was written to prompt for map number, source country and each of the measure units. As each map was entered, the program also totaled the combined areas.

While the sheet size was realtively constant throughout the data set, inconsistency in the overall projection size on a given sheet varied enough to warrant some form of standardization. I converted all real area measurements to percentages of the total of the seven measured units for each map to allow for comparision between maps. In this way, I established a common standard for relating measurements.

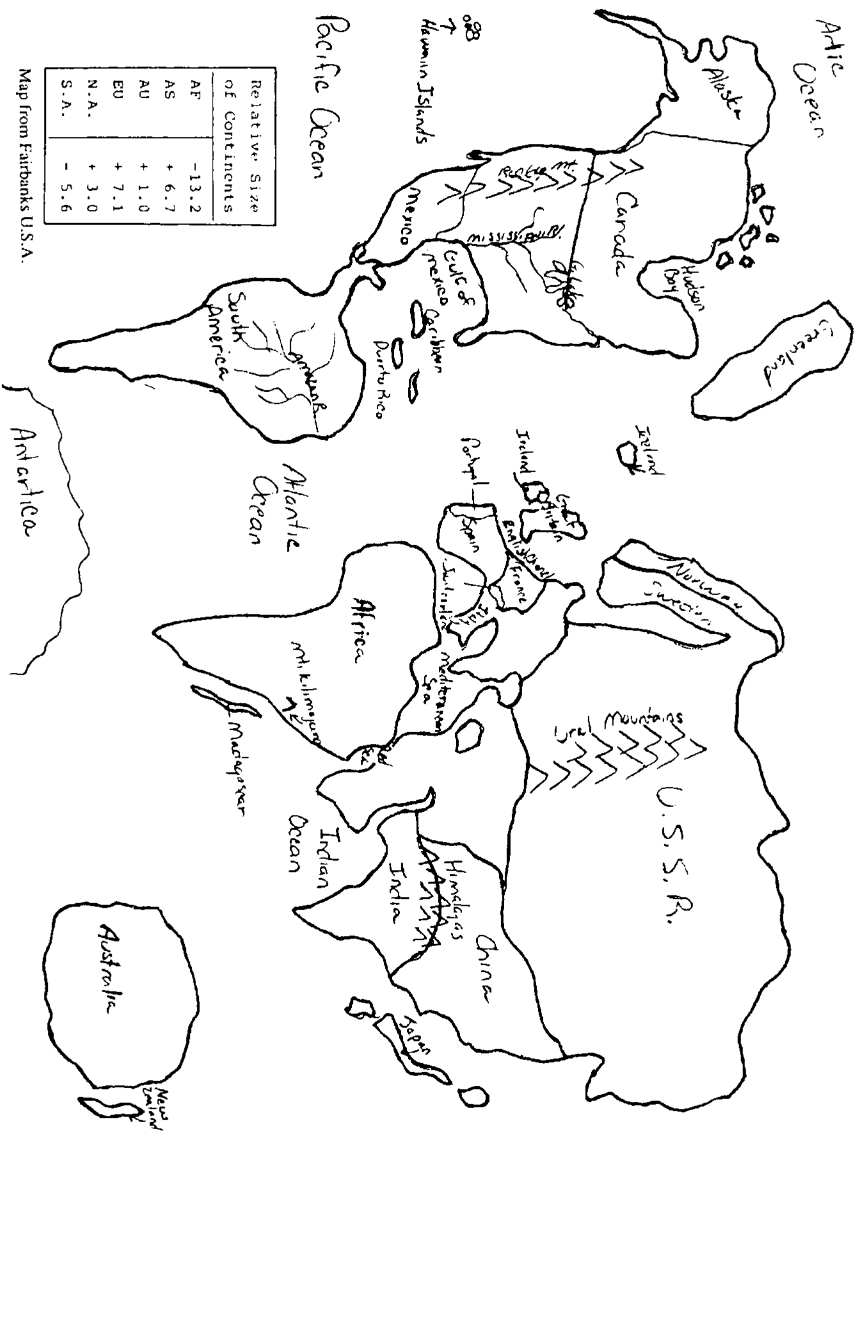
My second objective was to assess map accuracy against a common standard. I elected to use published areas of the landmasses from Goode's World Atlas adjusted to eliminate areas of major islands not included in our tracing of the periphery of the continents. These also were translated to percentages of the combined total, providing a basis for the estimation of deviations from the real world areas.

The physical procedure for measuring the areas of the continents was easy. One map at a time was placed upon the working surface of the table digitizer, secured with tape, and then the margin of each continent was traced. To begin, the magnifying stylus was placed upon the continental margin at an easily recognizable point, usually the same from map to map. For instance, when tracing Africa, beginning at the tip of the horn, or at the north end of the Suez Canal. Then, with the digitizer in recording mode, the outline of the continent was carefully followed with the stylus in a clockwise direction, care being taken to stop at the beginning points. If an error was discovered, the measurement of the continent was completely redone.

For each sketch map the areas of each continent plus Greenland are expressed as a percentage of the total of all the map segments measured. Maps 14, 15, 16, and 17 illustrate the method showing actual measures for individual maps.

It is apparent that for these particular maps there are idiosyncratic differences in the exaggeration or diminishment of the sizes of the continents. Map 14 from Fairbanks has an outsized North America big enough to fit a large Alaska. On Map 15 from Armidale there is indeed a very prominent Australia. On Map 16 from Ottawa, North America is large, South America and Africa much diminished and Europe greatly exaggerated. On Map 17 from Caracas, a glance would suggest that South America and North America are both exaggerated in size. So far my hypothesis would seem to be holding. In all cases the home continent is exaggerated in size.

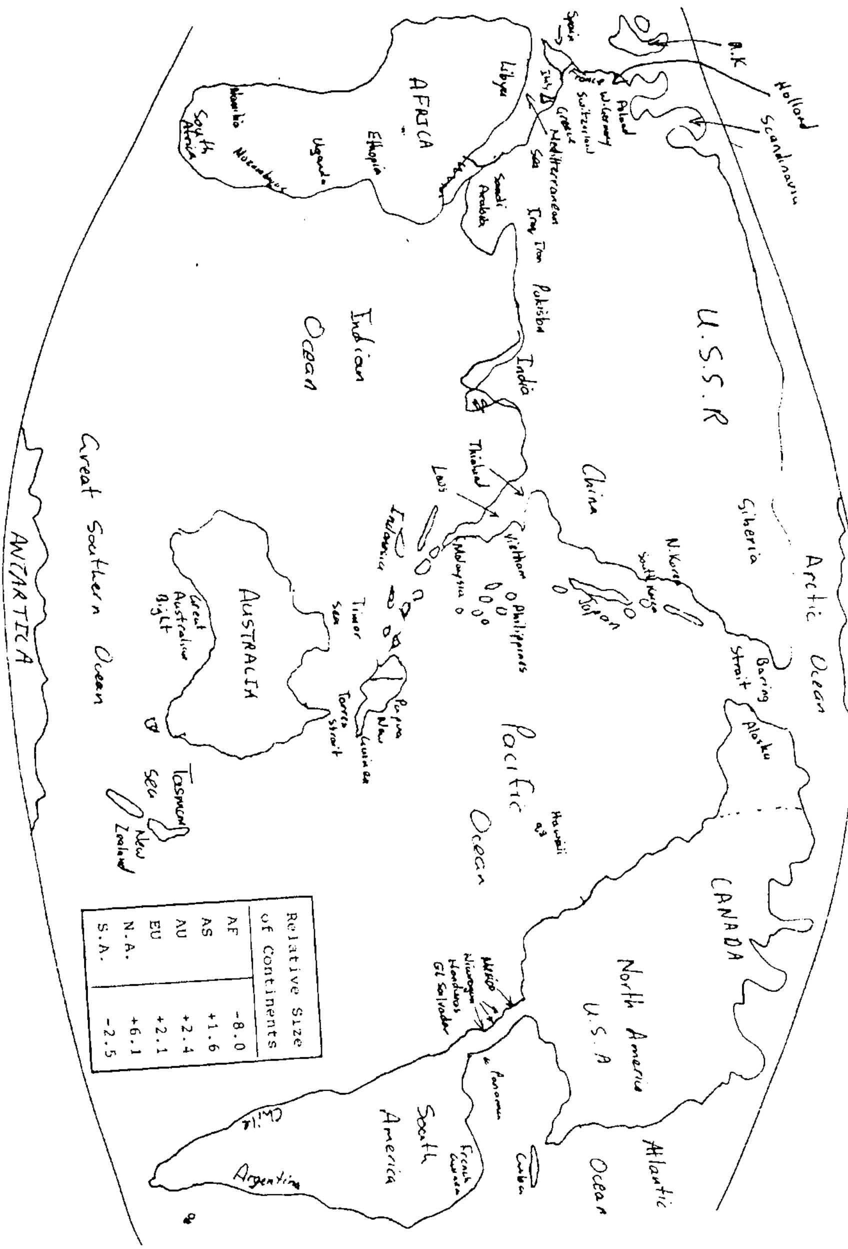
The figures show the proportion of the total map area devoted to each continent and the direction and percent of deviation from actual proportions. The statistics also indicate the total deviation from actual proportions for the entire map. By this calculation the map from Ottawa with greatly exaggerated depictions of North America, and Europe, and much-diminished models of Asia, Africa and South



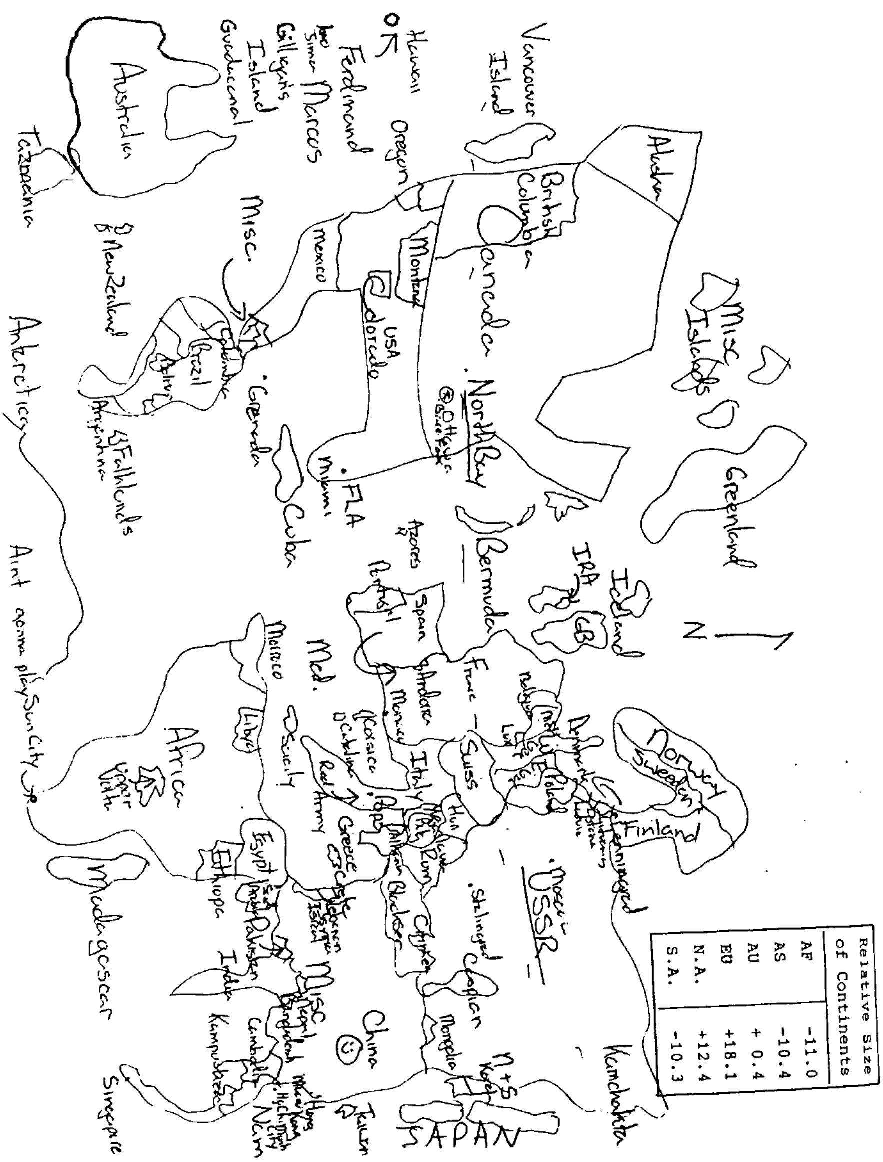
Relative Size of Continents	
AF	−13.2
AS	+ 6.7
AU	+ 1.0
EU	+ 7.1
N.A.	+ 3.0
S.A.	− 5.6

Map from Fairbanks U.S.A.

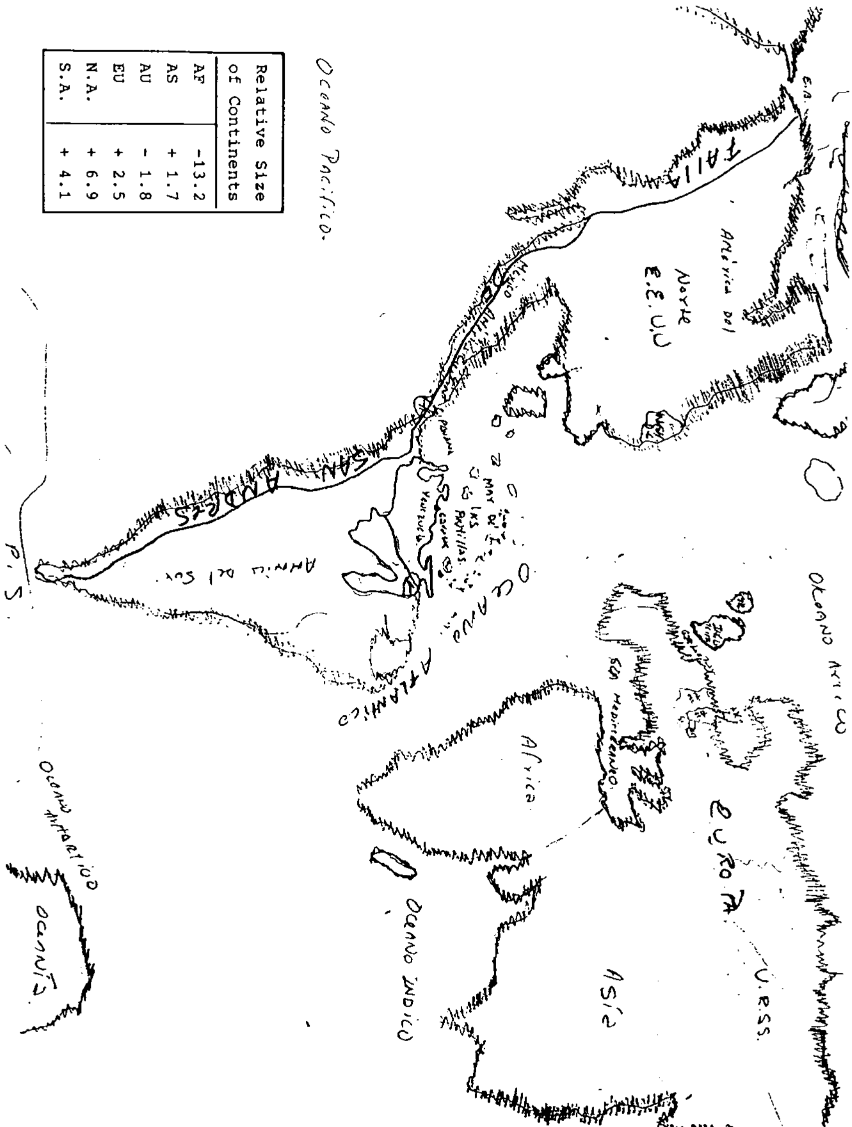
Map 14. World map drawn by a student in Fairbanks, Alaska, USA.



Map 15. World map drawn by a student in Armidale, Australia.



Map 16. World map drawn by a student in Ottawa, Canada.



Relative Size of Continents	
AF	-13.2
AS	+ 1.7
AU	- 1.8
EU	+ 2.5
N.A.	+ 6.9
S.A.	+ 4.1

Map 17. World map drawn by a student in Caracas, Venezuela.

America, is the least accurate in relative size; it has the largest total deviation. The map from Armidale does best in this respect, thus it has the lowest total deviation.

For the purposes of this paper, I am not focusing on such idiosyncratic differences. Rather, I am trying to see whether there are general tendencies, which become apparent when all the maps from one place are grouped. I assume that the totally idiosyncratic approaches should fade into the background and a group image will appear. Group images from different places will reflect the likelihood that any continent will be diminished or exaggerated in mental maps from a particular place. By extension, I could group all the maps in my sample to derive the world image that would indicate which continents are most likely to be exaggerated or diminished in size by the total sample.

The group images do tend to mute the extreme variations of individual maps. Thus, of the four individual maps noted above, the greatest total deviation was 60.2, while the least total deviation was 22.4. The average areas of any continent for any group will smooth the wilder variation, and most group averages show less total deviation from the actual proportions. Thus, there are several group averages with less total deviation than the best individual map shown above, and very few groups with total deviation as high as half that of the most variable one.

Systematic differences appear so that group averages from the same continent appear to bear family resemblances as may be seen in Figure 2.

In Figure 2, the percent variation from the actual proportions for each continent is plotted on a bar graph which allows one to see quickly the variation above and below the mean, which represents the correct proportions of the world area devoted to each continent.

In the five North American samples, the area devoted to Africa, Asia, and Australia is less than the actual proportions of these continents. Europe is greatly exaggerated, as is North America, the home continent. The sample from Nassau, the Bahamas, has the smallest exaggeration of Europe, approximating that of North America.

The South American samples are similar in pattern to those from North America, except that North America is marginally underestimated in size, and there is some exaggeration of South America at

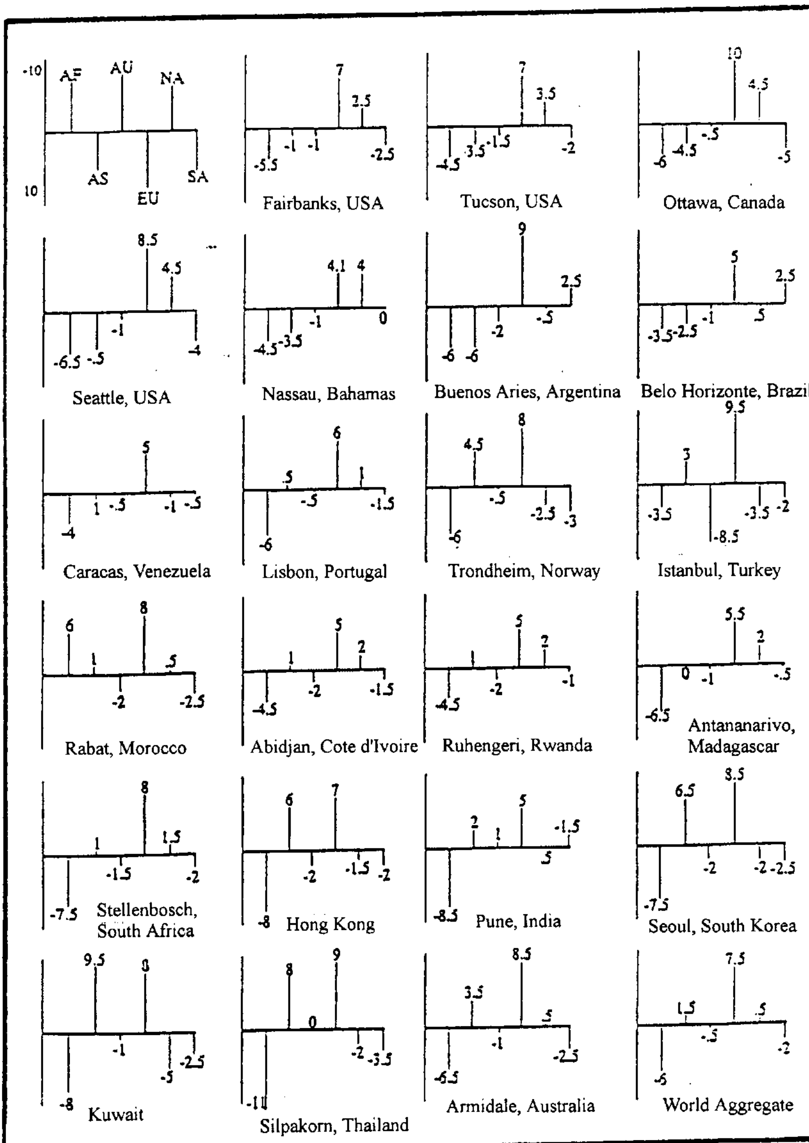


Figure 2. Percent variation from actual proportions for each continent.

two of the three sites.

The three European samples show consistency in substantially exaggerating Europe, the home continent, and, less so, Asia, and in underestimating the sizes of Africa, Australia, and South America. The Lisbon students, farthest from Asia, had that continent just barely exaggerated. The students from Trondheim and Istanbul diminished the size of North America, while those from Lisbon exaggerated it.

The most striking feature of the African samples is that four of the five show an underestimation of Africa, their home continent. At the same time, there is a substantial exaggeration of Europe. Other values are marked by relatively small and consistent deviations.

The five Asian samples are characterized by consistency in results. The greatest exaggeration, as with all previous samples, is of Europe, with the home continent close behind. Africa is substantially underestimated. The Kuwait sample is distinctive in being the only one to exaggerate any continent in the sample, Asia itself, by a greater percentage than Europe.

In the sample from Australia the homeland is diminished in size. As usual Europe is the most exaggerated, along with Asia to a lesser extent, and with North America just above the mean. Africa is the most diminished, then South America.

When results from all sites are averaged, the graphic pattern shown in Figure 1 is closest to that of Armidale, Australia. It provides my best model of student sketch maps of the continents. On mental maps, the size of an area is generally proportional to its perceived importance and how well it is known. If I equate size with amount of knowledge, one continent is by far the best known: Europe. The least known, again by a wide margin, is Africa. This generalization appears to correspond to the percentage of students who named the countries on these continents. Generally, European countries were named; African countries were not. If I equate size with importance, Asia and North America are seen as more important than Australia and South America.

I started with the hypothesis that the size of the home continent would be exaggerated on sketch maps of the world. On 15 of the 22 group images, there was home continent exaggeration. The exceptions came from South America, Australia, and Africa. (Although in three out of the five African samples, the diminishment of Africa was less than the world average). Based on these facts, I concluded that my original hypothesis is generally correct. However, this conclusion is outweighed by some totally new, unforeseen factors.

The general tendency to exaggerate the size of Europe showed up on every set of maps from my subsample. Europe was not only exaggerated in size on every sample, no matter what part of the world its origin, but was also consistently the most exaggerated continent. The Kuwait sample (in which both Asia and Europe were greatly exaggerated in size, with Asia just slightly more exaggerated) is the only deviation from this pattern.

The mental maps indicate that we live in a Eurocentric world. Not only do these maps tend to be centered on Europe (Saarinen, 1988), but the size of Europe was exaggerated and much greater detail was included for it. This is hardly surprising. The concept of world maps first originated in Europe. The most popular of the world maps used to date, the Mercator projection, tends to exaggerate the size of Europe. Furthermore, in much of the world, the textbooks containing geographic information originated in Europe.

All sketch maps in the subsample (except those from Rabat) consistently showed Africa diminished in size. The percentage of diminishment is less than the percentage of exaggeration for Europe. The proportion of the total mental map devoted to Africa is consistently less than its real proportions. As the continent south of Europe, Africa is centrally placed. But the amount of knowledge of Africa, as judged by the percentage of mapmakers who included each African country, is very low. A limited amount of information on Africa is readily available in most parts of the world. The Mercator map depicts Africa as proportionally smaller than more poleward areas. The National Geographic Society recently selected a new map that depicts Africa in somewhat more correct proportions, but many older maps remain, and help form the mental maps of those who use them.

I hypothesized that ethnocentrism would explain our findings. I did discover a general tendency to exaggerate the size of the home continent. But the results also indicate the influence of other factors. The first of these is the Mercator effect of exaggerating the size of poleward areas and diminishing the size of equatorial areas. Hence, Europe, Asia, North America, and Greenland are exaggerated; while Africa, South America, and Australia are diminished in size, in the world aggregated results. One would expect this if students always looked at greatly distorted maps, and apparently, they generally do. Whatever causes these distortions is so powerful that they overcome the ethnocentric effect. As a result, in Africa, South America, and Australia, even local map sketchers generally draw their home continents smaller than the actual size of these landmasses.

The Mercator effect seems to account for the presence of each continent above and below the mean, but does not explain why Europe is much more exaggerated than North America and Asia, which are also greatly enlarged by the Mercator.

Snyder (1993) provides quotations from geographers, throughout this century, who have decried the use of the Mercator as a general world map. Although its use as a world map in atlases has declined, it is still popular as a wall map, in part, because it is familiar.

To visually represent the percentage of world map sketchers in the total world sample who included each nation, a world cartogram was created (Figure 3). Graph paper was used to construct the cartogram, for every one per cent who included a country 5 squares were used. Any country included by fewer than 2 ½ percent was omitted except in rare borderline cases; for example Burundi at 1.8 percent was included with similar neighbor Rwanda.

The size differential between the largest countries on the globe, and the smaller ones is reduced by the cartogram, for it includes no weighting for size. It simply represents the percent of people who included each country on their sketch maps. Thus, Canada, U.S.S.R., U.S.A., Brazil, China, Australia, and India do not dominate quite so much as on the real map, and Europe is enhanced in importance. Most other continents thus seem deflated.

Many islands are prominent on the cartogram. Because they are set apart from the continents providing a clear gestalt, they are remembered and included more frequently. Thus on our cartogram the islands such as Japan, Great Britain, Greenland, and Madagascar; Ireland, Iceland, Sri Lanka, and Cuba, are large and easily seen. Australia, an island continent, was the most frequently included country. New Zealand, nearby, is larger than normal. Below a certain size, small islands are forgotten or not represented.

In North America, Canada, the United States, and Mexico are all

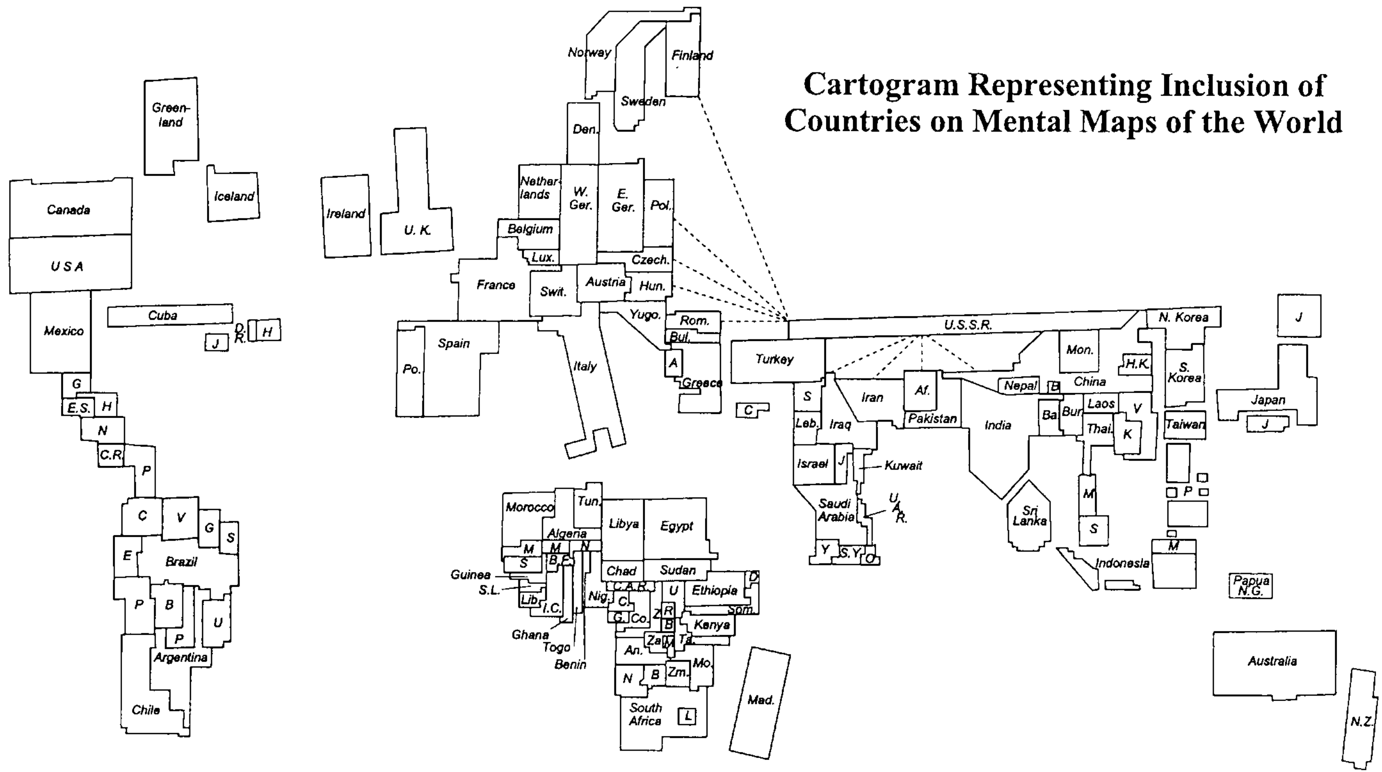


Figure 3. World cartogram of frequency of inclusion of countries on world sketch maps (n=3568).

well-known but are smaller than usual. The continent becomes greatly elongated by the thin line of Central American countries. An enlarged Cuba dominates the Caribbean Sea and a modest Greenland looms in the upper left.

The twelve countries of South America are easy to memorize, and they show up larger than most countries in Sub-Saharan Africa, or South East Asia. Brazil, Argentina, and Chile dominate. The latter, well-known because of its unique shoestring shape, on the cartogram is no longer so slim.

The Eurocentric shared image of the world is obvious in the cartogram. The cumulative impact of many frequently included countries makes the total area for Europe larger than any other continent. U.K. and Ireland, as well as Spain and Portugal, are among the largest pairs of adjacent nations. Given all four in close proximity, along with large masses for France, Italy, and East and West Germany, the impact is great. Even the smallest of the most westerly European nations are frequently included. Judging from the cartogram Netherlands is larger than Ethiopia or Algeria, Belgium is bigger than many South American countries, and even tiny Luxembourg is equal in size to Zaire, Bangladesh and Somalia. Within Europe the drop-off in size from the western fringes to Central Europe is apparent. The Scandinavian Peninsula is less dominant than the Iberian Peninsula, West and East Germany are smaller than France and Spain and the Eastern European countries are the smallest.

Africa is an excellent illustration of the influence of edge and corner positions. The corner positions are the best known. Morocco and Egypt, in the north, South Africa and Madagascar, in the south, are outstanding. To a lesser degree, Ethiopia stands out in the Horn of Africa. North Africa is the best-known broad region with Algeria, Tunisia, and Libya as well as Morocco and Egypt. The sub-Saharan nations are not nearly so well known. Tiniest are the interior countries. The most diminished in size of all, in relation to actual area, are the Saharan states of Mauritania, Mali, Niger, Chad, and Sudan. But almost all the landlocked African states are little known, and are found only by carefully searching the cartogram. In West Africa, Ivory Coast, and Nigeria are the largest, as well known as the much smaller Hungary, Romania, and Bulgaria.

In Asia, the USSR, still a nation when the sketch maps were collected, is stretched thin to make all the connections with neighboring nations in Europe and Asia. The USSR, along with China, Japan, and India, are the best-known nations of Asia. In southwest Asia the impact of current events may be seen. Israel and Lebanon, perennially present in the press at the time the sample was obtained, are magnified. Iran, Iraq, Afghanistan, and the Philippines are likewise large for the same reason. Southeast Asia is small; Vietnam is much reduced from its prominence on mental maps of 20 years ago. The importance of affluence and economic development is evident in the size of Japan, and in the original four tigers of East Asia, South Korea, Taiwan, Hong Kong, and Singapore. All seem large on the cartogram, though all but South Korea are little more than flyspecks on most world maps. Their active involvement in world trade has likely brought them much attention, so they are better known than larger, less active nations. Saudi Arabia is well known for its oil wealth, as well as its central place in the Moslem world. Populous Bangladesh is almost overlooked.

CONCLUSIONS

The majority of the mental maps of the world are Eurocentric. In detail and proportional size, Europe is greatly exaggerated. European nations, as a group, are better known than those on other continents. Thus three separate studies reinforce the strength of Eurocentric images in the minds of university students from around the world.

Europe shows up so strongly in all these measures because of the European hegemony in the modern world system for the past 500 years. The dominant powers are the source of most textbooks, and maps have a powerful effect on the images in our heads. Blaut (1993) in *The Colonizer's Model of the World* challenges this ideology, which he emphasizes is the most powerful and pervasive of our time concerning world history and world geography. Our results confirm the power and pervasiveness of Eurocentrism.

Blaut calls "the doctrine of European diffusionism, the belief that the rise of Europe to modernity and world dominance is due to some unique European quality of race, environment, culture, mind, or spirit, and that progress for the rest of the world results from the diffusion of European civilization..." He rejects this doctrine which, he says, "is not grounded in the facts of history and geography, but in the ideology of colonialism." He calls it the colonizer's model of the world, "the world model that Europeans constructed to explain, justify, and assist their colonial expansion," (Blaut, 1993 back cover).

If I re-examine my results in the light of these ideas everything seems to fit into place. The standard world map is centered in Europe because the dominant world power, at the time of the first International Meridian Conference of 1884, wanted it that way. So now, this is the standard world map and most students in the world use it when drawing a sketch map of the world.

To illustrate the power of Eurocentrism, we show Figure 4, which is an enlargement of the aggregate results of the size of continents study. We used the Mercator projection to explain which continents were exaggerated and which were diminished in size. It serves well to show the direction, but fails to explain the degree of exaggeration or diminishment. For example, in Figure 4, why is Europe exaggerated five times as much as Asia, and fifteen times as much as North America, both of which have much more poleward territory than Europe? It can be understood in light of a pervasive and extended diet of Eurocentric doctrine. This would also explain why the European countries are so well-known.

Why is Africa the most diminished in size? The answer must be a product of the past and present conditions. First, Africa was victimized in the slave trade imposed by, and lucrative for, the dominant countries. Later it was carved up at a conference table, among the European powers. The boundaries placed there by the Europeans bore no relationship to the actual languages and cultures of Africa. Therefore, Africans struggle to create a nation from the very diverse elements within. Throughout it has been the most maligned by racist epithets. Small wonder it is little valued and not well known.

We do have a shared image of the world today. Unfortunately it is a parochial view. It resembles the colonizer's model of the world. Europe and European extensions overseas tend to be well-known. The former colonial world is not so well-known. Sub-Saharan Africa and Southeast Asia are the least known areas, along with Central America, Southwest Asia, and South America.

It will not be easy to remedy the deficiencies of the current world image because the colonizer's model is so well entrenched. But there

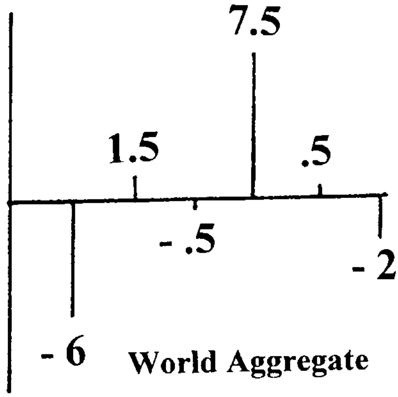


Figure 4. Enlargement of the aggregate results of the size of continents study.

are many signs of change. The book by Blaut and other similar research (Said, 1970; Wolf, 1982; Abu-Lughod, 1989; Lewis and Wigen, 1997) will help create chinks in the Eurocentric monolithic armor. Multiculturalism is sensitizing students to the histories of both genders and many cultures (Nash, 1992; Hollinger, 1995). The Colombian Quincentary also showed that changes are taking place in our thought processes (Butzer, 1992). Columbus Day will no longer be simply a celebration but also protest against the negative consequences of the European conquest of America and colonization of much of the world. To change the current views will require a shift toward a model of the psychological unity of humanity, and away form ethnocentric beliefs and the over-valuing of certain regions and cultures.

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Geographic Education, Universal Mapping, and Public Participation: The Search for Umbrella Theory

David Stea and James M. Blaut

While much has been written in recent years about the ability of pre-school children to comprehend geographic-scale spatial representations, issues of theory and application still remain unresolved. Some of these revolve about the relationship of developmental theory in psychology to geographic education. Two other issues relate to whether progress from one developmental stage to another is fundamentally "irreversible," and to the interpretation of scale errors made by very young children in attempting to read aerial photographs, a surrogate task for map reading. A final question addressed in this article concerns how the legacy of such early spatial learning, and of geographic education, may be applied to participatory planning among groups of adults.

Keywords: *spatial cognition, universal mapping theory, participatory planning*

INTRODUCTION

This paper seeks to tie together, under a common umbrella, a set of three disparate concepts or areas: geographic education; universal mapping, based on studies of the development of spatial cognition in very young children; and public participation in planning and design. The contention here is that the latter two are highly relevant to spatial aspects of the former, namely that geographic education can benefit from lessons concerning spatial learning and development derived from both ends of the age spectrum: very young children, and adult members of pluralist societies. Indeed, that literacy (Morgan, 1997) should be complemented by "graphicacy" in geographic education is not new; it was suggested a quarter of a century ago by Balchin (1973).

This is not meant to be a definitive presentation on theory but rather a summary of the results of a search for theory, a search that began at the end of the decade of the '60s. At that time a group based at Clark University began to discover that very young children could demonstrate, under certain conditions, some rather amazing geographic skills. Until then a widely assumed and promulgated view in geographic education, under the influence of Piaget and neo-Piagetians, was that preschool children cannot cope with maps. This was supposedly derived from Piaget's theoretical postulate (Flavell, 1963) that children do not reach the stage of concrete operations until about seven years of age; these concrete operations presumably include spatial operations. However, data obtained since the mid-1960s in many studies with 3- to 6-year-old children in eight countries (e.g. Blades and Spencer, 1986; Blaut, McCleary, and Blaut, 1970; Blaut and Stea, 1971, 1974; Spencer and Darvizeh, 1981, 1983; Stea and Blaut, 1973) have shown definitively that preschoolers can indeed cope with many aspects of maps, and that they are capable of an operation which we have termed "mapping", that is, of demonstrating map-like thought and behavior by understanding, using, and even making simple maps (Blaut, 1991; Blades et al, 1998). Even more surprising, there seemed to be no marked cultural differences: very young children from industrialized and developing countries seemed to demonstrate the same sets of spatial skills, and to the same degree (e.g. Blades et al, 1998). From such findings it was concluded that Piagetian theory gave an incomplete account of the development of spatial skills, and that an alternative to purely Piagetian interpretations and predictions of children's spatial behavior was therefore needed.

Eine Kleine Nachtteorie

In our search, we found elements of the needed theory in the interdisciplinary and ecological tradition established by major figures in several fields of psychology: Jerome Bruner, Egon Brunswik, James and Eleanor Gibson, William Ittelson, Kurt Lewin, and others (Matthews, 1991), as well as Vygotsky (1960, 1978) in the realm of social learning. Thus, it began to seem that the precursors of children's mapping abilities might actually appear in infancy, with the very early development of shape, size, and object constancies. As children acquire mobility they gradually learn how to integrate their multiple perceptions of landscape features into a cognitive model that is spatiotemporal rather than simply spatial. This cognitive model includes the child's experience of a particular place over time: it is in some sense a spatial narrative, a mental map constantly modified by experience. Such a map begins to represent, first, the locational relations of features to one another, rather than just to the child, and, second, the characteristics of such features when perceived from different vantage points. In certain kinds of experience, notably toy play, very young children discover rules of mapping: what a landscape looks like when seen (or imagined) from overhead and reduced in scale, and how small models can (semantically) represent large landscape features. Even two-year olds engage in place learning (Newcombe et al, 1998). Before the age of four some children demonstrate, in research settings, the beginnings of mapping ability that by 4-1/2 most of them seem to have mastered reasonably well.

This demonstration of unexpected mapping ability is not confined to young children: it also appears in many very ancient preliterate societies and, according to the ethnographic record, among many contemporary non-Western cultures. Indeed, mapping in one form or another seems so pervasive that one major component of the theory for which we search has been termed "universal mapping." Since the theory of "universal mapping" has been presented in some detail elsewhere (e.g. Blaut, 1991, 1999; Stea, Blaut, and Stephens, 1996), it is summarized just briefly below.

First "universal mapping" is "grounded theory." The development of many theories, tenets of orthodox scientific method to the contrary, does not flow primarily from a priori principles, but rather often proceeds from data gathered atheoretically, often based upon no more than raw hunches. This is particularly true of explicit "grounded theory" (Strauss and Corbin, 1990, 1997):

> A grounded theory is one that is inductively derived from the study of the phenomenon it represents. That is, it is discovered, developed, and provisionally verified through systematic data collection and analysis of data pertaining to that phenomenon. Therefore, data collection, analysis, and theory stand in reciprocal relationship with each other. One does not begin with a theory, then prove it. Rather, one begins with an area of study and what is relevant to that area is allowed to emerge. (Strauss and Corbin, 1990, p. 23)

Thus, the search for new theory often stems from anomalous findings, findings that defy explanation in terms of extant theory. Sometimes, as in this case, bits of theory from one area or discipline are grafted onto theoretical bits from another area or discipline to produce an amalgamation.

We call our amalgam "universal mapping." In its broadest terms, based on the above and other related discoveries, "universal mapping" proposes that we should find evidence of the ability to "map" – in the general sense of being able to understand and represent large-scale spatial objects and relationships - developing early in the lives of children throughout the world. Such development is expected to be independent of socioeconomic level, to be present in all contemporary cultures, and to have existed long prior to the beginnings of recorded history. Demonstrating this is obviously a very large order, and there is much yet to do, especially in ethnographic and prehistoric realms.

To date, the most controversial aspect of universal mapping has revolved about whether very young children have, or do not have, certain spatial abilities. According to many educators' interpretations of developmental theory in psychology, particularly the work of Piaget, the findings summarized briefly above are patently impossible. To these educators, accustomed to converting Piaget's general stages to concrete ages, the mapping abilities identified in these studies simply seem to be emerging too early. Later in this paper it is therefore imperative to accomplish certain other tasks. First, some basic aspects of "classic" developmental theory will be presented. Second, considering Piagetian theory as a set of axioms, the consequences and constraints of one axiom in particular will be examined in some detail. Third, the assumption of a unidimensional "spatial ability" will be given further theoretical and empirical attention. Fourth and finally, an issue usually subsumed under the domain of community and regional planning, that of public participation, will be reformulated as a problem in adult geographic education to which some of the same theoretical concepts are related.

Piagetian spatial cognition briefly revisited: supporters and detractors

No attempt will be made here to summarize Piagetian theory in any detail since, as the one psychological theory most quoted and most relied upon by geographic educators, it is undoubtedly familiar to most geographic educators. The central concept of Piagetian theory is that ALL cognition follows a developmental sequence which is divided into discrete development stages which - although this caveat is often ignored by educators - correspond only very roughly to ages. The four principal stages are sensorimotor (0 to 2 years of age), pre-operational (2 to 5 or 2 to 9 years, depending upon the interpretation), concrete operational (7 to 11+ years), and formal operational (beginning at age 11 to 13 and extending onward). At each stage, the child achieves a qualitatively new capacity or set of capacities, the entire sequence carrying the child from egocentric sensory experience and thought, through non-egocentric but wholly concrete thought, to abstract thought. In the specific case of spatial relations, the sequence proceeds through children's spatial geometries based upon, in order, topological, projective, and Euclidean principles. Structural development and behavioral learning are seen as distinct: learning, or environmental experience, produces changes in children's conceptions of space *within the limits established by a particular stage of development.* In Piagetian theory, spatial cognition is linked to other forms of cognition at the same stage of development. Development is "lock-step," in this sense: "all major milestones are yoked, with critical events across different domains...locking into place at the same time..." (Gardner, 1991, p. 28).

Problematic aspects of the Piagetian world view (Gardner, 1991) include certain methodological issues, i.e. how research based upon or supporting Piaget's theory was performed. There are theoretical questions, as well, involving, for example, the child's capacity for abstract thought; the "lock-step" development postulate; Piaget's subordination of cognition to the competences - particularly numerical competence - that characterize scientists such as himself; and the postulate of "irreversibility." The positions on these taken by Piagetians have been criticized by a number of researchers (e.g. Meadows, 1993). Even some researchers basically sympathetic to the Piagetian perspective question certain basic concepts. Concerning the child's capacity for abstract thought, for example, Bower (1979) had this to say some two decades ago:

> ...I believe that babies begin life as very abstract thinkers. In the sensorimotor period, prior to the acquisition of language, this abstract thought is expressed in behavioral responses to specific stimulus situations. Later, at the concrete-operational stage, it is expressed through language representations of possible responses to specific stimulus situations. Just as the child in the concrete-operational stage can think about possible actions without doing them, the child in the formal-operational stage can think about possible stimulus situations without having to experience them. (Bower, 1979, p. 142)

Data obtained by various investigators (summarized in Blaut, 1999) also question, at least implicitly, the "lock-step" postulate: that is, it appears that spatial cognition progresses more rapidly through developmental stages than other forms of cognition, as would be suggested by other aspects of universal mapping theory. It is the "irreversibility" axiom, however, that is addressed here in somewhat more detail.

In the words of one writer, "Piaget made a fundamental error in his contention that the older child's more sophisticated ways of knowing eradicate her earlier forms of knowing the world" (Gardner, 1991, 29). The argument revolves about children's errors in *spatial* cognition tasks, specifically in aerial photo interpretation. While one group of studies (e.g Blaut, 1991, 1999), stressing children's correct identifications of aerial photo elements, is taken as supporting very early development of mapping abilities, other studies (principally Liben and Downs, 1989, 1991; Downs, Liben, and Daggs, 1988) interpret errors in aerial photo interpretation as evidence that children are at a more primitive Piagetian stage of development. The resolution may lie in rejecting the Piagetian "irreversibility" axiom, that which associates irreversibility of stages with irreversibility of all thought and behavior associated with particular stages:

> ...research on ordinary students reveals a dramatically different pattern. For the most part, children's earliest conceptions and misconceptions endure through-

> out the school era. And once the youth has left a scholastic setting, these earlier views of the world may well emerge (or re-emerge) in full-blown form. Rather than being eradicated or transformed, they simply travel underground; like repressed memories of early childhood, they reassert themselves in settings where they seem to be appropriate. (Gardner, 1991, p. 29)

This accords with research on problem-solving, which strongly suggests that under conditions of psychological stress, experimental subjects often revert or regress to earlier-learned and more primitive problem-solving strategies. Returning to the development of spatial cognition and relaxing the "irreversibility" constraint, it may be that young children in developmental stage "x", confronted with irresolvable difficulties, temporarily reverse the developmental trajectory and produce responses characteristic of developmental stage "x-1".

Errors of scale

The issue described in the foregoing may relate to some of the techniques – both methods and materials - used to investigate the purported early development of spatial cognition. For one, children's capacity to demonstrate cognitive abilities is not insensitive to the scale of the stimulus object presented. Liben and Downs (1989, 1991), for example, employed relatively large-scale black-and-white aerial photographs of Chicago, photographs which even some adults have found difficult to interpret. Very young children - whose vocabulary is obviously quite limited - did in fact make many correct identifications but for some of the most difficult stimulus elements produced anomalous responses: responding to a square feature in Lake Michigan as "doors," for example. Liben and Downs interpreted this as overall failure to demonstrate the ability to interpret maps, to achieve, in other words, the requisite stage of cognitive development for map cognition.

In light of the preceding discussion, and of the now-venerable Yerkes-Dodson law (Broadhurst, 1957), an alternative interpretation is that a child faced with an extremely difficult (for the child) "what is this" question - which she feels obligated to answer - may undergo temporal regression in this specific area and produce a response characteristic of an earlier stage of development. The argument is as follows: suppose a child presented with an exceptionally hard photo interpretation task regresses but one presented with an easy task does not. If stress is correlated with task difficulty, and task difficulty in aerial photo identification is inversely correlated with scale, then we would expect larger-scale aerial photo identification to be less stressful and to produce fewer errors of scale – which characterizes quite precisely the results thus far obtained.

Micro- and macro-spatial cognition

Two assumptions, often linked together, characterize both research on spatial cognition and practice in geographical education. The first of these assumptions is that development of, and education in, micro-spatial cognition must precede development of, or education in, macro-spatial cognition (see discussion in Spencer, Blades, and Morsley, 1989). This proposition is explicitly, or sometimes implicitly, incorporated in many texts on teaching geography and social science (e.g. Joyce and Ryan, 1977; Maxim, 1987; Seefeldt, 1977). The second assumption is that micro- and macro-spatial cognition are simply two manifestations of an underlying unidimensional spatial cognition "faculty."

Reformulating these two assumptions as hypotheses, a prediction derived from the first hypothesis would be that micro-spatial cognition scores should be uniformly higher than macro-cognition scores, at any stage of development. A prediction of the second hypothesis would be that micro-spatial and macro-spatial scores are not just highly correlated with each other, but that variation in one explains much of the variation in the other. Suggestions by other researchers (e.g. Pick and Lockman, 1981; Montello, 1993) and results of recent experiments (Pinon et al, 1999) suggest that this is not the case.

AN APPLICATION TO GEOGRAPHIC EDUCATION AMONG ADULTS: PUBLIC PARTICIPATION IN PLANNING

One of the innovative techniques used to study spatial cognition in the late 1960s and early 1970s was through the child's own construction of toy landscapes. By the mid-1970s the success realized through the use of toy landscapes to study environmental cognition among young children of varied cultural backgrounds suggested the possibility that this same technique might be an effective tool for research on environmental cognition among adults. This technique, it seemed, might be especially true where linguistic or cultural barriers made elicitation of freely-drawn maps as pioneered by Lynch (1960) unreliable or impossible. Thus, landscape modelling was employed to index kinds and levels of environmental cognition among poor and affluent people in Tecate, Baja California, Mexico (Stea and Taphanel, 1974) in a study which demonstrated the interactive effects of gender and socio-economic class upon environmental cognition. That adults might reject this process as being too "childish" was of some concern, but the outcome was precisely the contrary. People were enthusiastic about this task, which they found to be engaging, and actually fun.

Application of this same technique to public participation in the planning process began in 1978, when the senior author was asked to facilitate participation of the Tainui Maaori in re-planning the Waahi Marae on the North Island of New Zealand. Our team immediately set to work on a questionnaire, which we were told by a Maaori faculty member of the University of Waikato would not work at all. Going "back to the drawing board," we then conceived the idea of using landscape modeling in a group participation exercise, which proved very successful. People who had previously rejected questionnaires and refused to attend so-called "public" gatherings because they found them to be "tokenistic" and time-wasting, became enthusiastic participants. Moreover, as in the case of the Tecate study, they seemed actually to be having fun. The latter led to a re-evaluation of distinctions we had been taught to make between work and play as well as other assumptions concerning the nature of public participation itself (for more details on these see Stea, 1990, 1999; Wisner, Stea, and Kruks, 1991).

This application of landscape-modeling and related techniques to physical planning has since been replicated in many settings, with many cultures in many countries, and by a number of researcher-practitioners (e.g. Sanoff, 1992; Stea, 1987; Wisner, Stea, and Kruks, 1991). It has led to "effective" participation, and to the production of plans supported by people who have been planned with, rather than planned for. It has also proved to be a good technique for eliciting information about culturally-related environmental issues previously un-noticed by environmental professionals, and which, perhaps, could not have been uncovered in any other way. Included in this series of projects accomplished over the past two decades are participatory planning exercises conducted by various researcher-practitioners with numerous culturally and socioeconomically diverse groups. These groups include U.S. university students, members of the Texas Farm Workers Union in the Lower Rio Grande Valley, Mexican villagers in the Northern New Mexico highlands, various Native American nations, New Zealand Maaori, Native Australians, squatter settlers in Caracas, Venezuela, suburban residents of Canadian cities, black and white South Africans, and scientists working in the Thornton Research Labs of Shell – U.K.

CONCLUSIONS

"Geographic education" is a term often applied primarily to the formal setting of K-12 schooling. This paper has discussed the kinds of informal geographic education that occur before entering school and after leaving. First, it argues that a re-examination of the presumed roots of geographic education is necessary for adults to come to understand how very young children come to understand macro-spatial relations prior to school-entering age. Evidence now available indicates that preschool children know much more about geographical space than was long thought to be the case. Understanding of macro-spatial relations is not all of geographic education, but underlies a great deal of it. Second, this paper argues that a child uses micro-spatial objects to construct macro-spatial representations, in, for example, constructing a toy landscape. Finally, cases are documented in which tools used by children to display geographic *knowledge* are used by adults to display geographic *preferences*, an essential aspect of public participation in physical planning.

The eminent psychologist Kurt Lewin once said something like "there's nothing so practical as a good theory." Theory-building, however, has never been easy. The relative paucity of applications of work on environmental cognition to the areas outlined earlier may be due in part to an insufficient array of "good," original theories about environmental cognition (although some original theoretical directions are outlined in Golledge, 1987, and a few borrowed theories in Gifford, 1997). In part it is also due to a corresponding paucity of theory in environmental education and participatory planning. It is the hope of the authors that this paper may contribute to enlarging the theoretical debate, at least concerning the early acquisition of mapping skills and the application of these skills to geographic education (e.g. Blaut and Stea, 1999). Perhaps we need to go even further - in the words of the great educator John Dewey, uttered more than 60 years ago:

> If the artist does not perfect a new vision in his process of doing, he acts mechanically and repeats some old model fixed like a blue print in his mind (Dewey, 1934, p. 50)

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Book Review

Robertson, Margaret and Gerber, Rod (ed.). 2000. *The Child's World: Triggers for Learning*. Melbourne: ACER Press.

Spatial activities, experiences, and abilities have long been of concern to psychologists and geographers. However, this research is rarely focused on children (Goldberg and Kirman 1990, Liben and Downs 1989). *The Child's World: Triggers for Learning* brings together many educators and scholars from various academic disciplines around the world to examine developmental aspects of environmental cognition, the relationship between spatial ability and spatial behavior and reasoning in childhood, and children's sense of place and sense of self. A main theme throughout this edited volume is the importance of listening to the voices of the children we teach and making their reality a focal point in their education. The authors argue we need to understand how our students construct their own identity and sense of place; how they think and reason spatially; how they view their relationship with the environment; and how they are involved in the time-space compression of the post-modern world.

Although there is a large body of research dedicated to understanding environmental cognition, sense of place, and human spatial abilities (Alyman and Peters 1993, Freundschuh 1992, Catling 1979, Downs and Stea 1973), Hart (1979) clearly demonstrated the importance of observing the environmental experiences of children and listening to their stories of space and place. Several others have followed Hart's inquiry with children (Herman et al. 1987, Webley and Whalley 1987, Golledge et al. 1985, Matthews 1984, 1985). However, there is not a collection of work on spatial cognition and perceptions of children as accessible and applicable as *The Child's World: Triggers for Learning*. Some work, although well intentioned, fails to see the world from the point of view of the child. This is certainly not the case with *The Child's World: Triggers for Learning*. The editors, Margaret Robertson and Rod Gerber, along with the contributing authors, focus on the child throughout the presentation of research on children's thinking, experiences, reasoning, and perceptions.

The book examines issues related to geographic education in terms of pedagogy, curriculum, psychology, learning, and philosophy. Chapters are organized in four parts. Part 1, Perspectives on Children's Thinking, provides a conceptual overview for the rest of the book with discussions on: everyday cognition, imagination and influences on the developing child's cognition (Robertson); environmental cognition as a key component to life-long education (Gerber); cross-cultural views on environmental development, learning, and education (Stea, LeFebre, Pinon and Blaut); and making philosophy a part of children's educational experience in order to encourage construction of self and meaning (Splitter). Part 2, Experiences of Place and Space, examines the worlds which our children inhabit with presentations concerning: the connection between informal geographic learning and non-school, leisure activities (Rikkinen); the role of information technology on learning (Fluck); the influence of a child's sense of place on his/her identity development (Robertson); and how children differ in their memories of place as expressed through writing, drawing, and conversation (Stratford). Part 3, Spatial-Visual Reasoning, presents research on the relationship between a child's spatial visualization ability and his ability to understand and reason about the world. Chapters focus specifically on: using graphics to facilitate learning and construct meaning (Gerber); children's differing experiences using and applying maps and line graphs (Ottosson and Aberg-Bengtsson); the development of a sequence of spatial skills and their application to geographic analysis (van der Schee); and student understanding and application of patterns and relationships in both real-world and mathematical space (Taplin and Robertson). Environmental Experience: Perceptions and Judgements, Part 4, includes chapters which highlight: a child-centered approach in using our student's own world as a trigger for learning (Slater and Morgan); the development of spatial independence outside of the formal educational setting among children with learning disabilities (Beveridge and Wiegand); cross-cultural studies examining environmental knowledge, attitudes, and behaviors (Lee); children's perceptions of the environment and the future from the 'Land-Use—UK' project as an impetus for more school action research projects (Robertson and Walford); and the implementation of environmental workshops in a variety of settings as an educational alternative to reach children and encourage their community involvement (Cuevas, Millan, and Reid).

There are several strengths of this compilation of research and action projects involving children and geography. Two are particularly noteworthy. First, the breadth of the discussion is admirable. While maintaining a focus on children and their worlds, the authors discuss developmental and cognitive psychology, philosophy, and actual applied projects in and out of the formal school setting. Additionally, numerous concrete suggestions for incorporating the child's world in geographic education to make the learning experience more meaningful, relevant, and lively are presented. The authors' inclusion of research from various communities across the globe (among these Australia, Brazil, China, Finland, Hong Kong, Italy, Mexico, the U.K., and the U.S.) reflects the geographic breadth of this book and underscores the importance of incorporating the child's view in our work as geographic educators. A second strength revolves around the theoretical framework of the collection. Rather than viewing education as a transmissive process (teacher bestows knowledge to students), the authors expound on ways to create a transformative experience integrating the student's own world-view and global, environmental, or cartographic understanding. Educators searching for stimulating discussion and examples will reach for *The Child's World: Triggers for Learning* for years to come.

While I appreciated the editors' efforts to introduce each of the four sections, their brief notes did not adequately tie together the chapters theoretically or practically. A more thorough framework at the beginning of each section would have been beneficial by prompting recall of prior knowledge, reviewing the relevant literature, and setting the stage for the chapters that followed. Additionally, the short concluding chapter discussing pedagogical implications, final comments, and recommendations was a bit thin. The clearly identified themes of the book (identity building, space and place connections, everyday lives as keys to cognition, environmental awareness, environmental action in learning, and a curriculum for inclusion) were thought provoking. I was left wanting more discussion as I turned the last page. With this said, however, these shortcomings detract little from the informative and stimulating effect of this volume.

Today, it seems as if the focus in education is more on standardized curricula and testing than on the reality of children's classrooms. This book points to the importance of listening to the children in our classes and using their reality as the starting point of learning. David Ausubel (1968, epigraph) wrote what is still timely advice. "The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly." As the research in this book suggests, much of what our children already know is obtained from their experiences and involvement in worlds quite separate from formal educational settings. As geographic educators, we can discover many applicable lessons within *The Child's World: Triggers for Learning* to help us as we look for meaningful experiences in the lives of our students upon which to build a stronger understanding of the world and themselves.

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ISSN 1529-0085