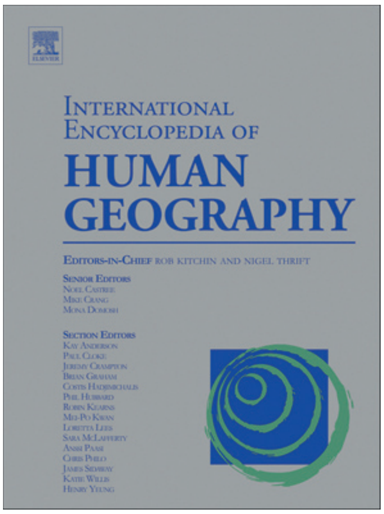

Filippakapoulou. 2009. Children and Mapping. In Kitchin R, Thrift N (eds) International Encyclopedia of Human Geography, Volume 1, pp. 50–57. Oxford: Elsevier
ISBN: 978-0-08-044911-1

Children and Mapping

V. Filippakopoulou and B. Nakos, National Technical University of Athens, Athens, Greece

Introduction

The topic of children and mapping is a special subject within the broad area that examines the ways people see and interpret maps. Children are a special case of map users for two reasons. The first one pertains to the relation between the development of children's conception of space and that of cartographic understanding. The theories of the children's spatial development, mainly deriving from psychological studies, have provided the theoretical basis for approaching the way children use maps. The second reason is the educational perspective of school maps and atlases. Most elementary or high school textbooks contain a large number of maps, mainly the textbooks related to geography and humanities courses.

Among the various kinds of maps that children are exposed to, school atlases are the most noticeable examples, being traditional educational tools that help children acquire spatial knowledge and mapping skills. Their origins are traced in 1697, as part of an atlas published by Louis Courcillon de Dangeau. In 1753, an atlas by the great mathematician Leonard Euler was one of the earliest German atlases explicitly made for use in schools. From the beginning of the nineteenth century, school atlases were systematically produced in Europe and North America. In our technological era, the atlas form has been changed and consists of packages, which are electronic atlases both software and spatial data, and characterized by various degrees of interactivity.

At the beginning of the 1980s, a discussion started on how to approach maps from the point of view of children. It was the beginning of a new perspective into cartographic research, approaching the meaning of maps from the user's viewpoint. The next three decades were productive as far as the theoretical and experimental work done in this area is concerned. Children and mapping became a research topic in the fields of psychology, geography, education, and cartography. Children's understanding of maps has been approached from different theoretical perspectives: the nativist views, Piaget's theory, Vygotsky's theory, and the cognitive perspective. Depending on the theory they are based on, the research and experimental studies in cartography can accordingly be distinguished as nativist, Piagetian, developmental (or neo-Piagetian), culturalist, and cognitive. Many psychological studies have focused on spatial cognition and mental representation of space, and, as a consequence, maps have been used in these studies as means of accessing children's spatial thinking. Research on this topic from a strictly cartographic perspective has been less forthcoming and nonsystematic. So, there is a lot of research evidence concerning preschool and early-primary-age children's spatial thinking with large-scale maps, though the evidence is rather limited on issues such as: children's understanding of cartographic concepts, the development of spatial thinking with small-scale maps, how secondary school children deal with maps, the kind of maps that are more effective for children, the kind of maps children prefer, and the actual contribution of computer mapping to geographic education.

The following paragraphs summarize the theoretical perspectives of cartographic understanding, give some research evidence on the development of understanding spatial representations, refer to the basic characteristics of maps and the evidence as regards the children's development of associated concepts, and, in closing, address the contribution of computer technology in children's dealing with maps.

Development of Cartographic Understanding

The development of cartographic understanding has been approached from four different theoretical perspectives.

The Nativist Approach

The first one, the nativist, posits that cartographic understanding is innate. Three kinds of argument have been advanced for this perspective. The first one comes from a particular view concerning evolutionary development, according to which much of the structure of human mind is innately specified, evolved through natural selection during the evolutionary history of the species. The second argument in support of this view is based on conclusions from experimental studies, which claim that children develop mapping abilities at a very early age, before receiving any cartographic education, and also, the mapping abilities expressed by people in early stages of human history. The maps, made 5000 years ago, suggest that all people develop an understanding of the geographical space as well as the ability of representing it through available materials. A third argument comes from a 1986 study of the performance of a 4-year-old girl, blind from birth, who could encode a tactile map and navigate between objects in a room. The girl demonstrated an understanding of the correspondence between the map and real space, even though she had no experience either with the space or with maps. But, it has been argued that this is just one case, while other studies suggest that blind children show delays in spatial abilities.

Of support to this perspective are similar views that have been expressed about the knowledge of language. Darvine in 1871 was the first one to argue that language is an instinct. Almost 100 years later, in 1965, Noam Chomsky, based on linguistic analyses, argued that human language is a biological object, internal to the human mind/brain, and the knowledge of language is individualistic. Chomsky's ideas had a great influence on linguistics and cognitive science. Following Chomsky's views, Steven Pinker argued in 1994 that language is an instinct. Among other scholars, Chomsky's ideas have been also disputed from George Lakoff, who along with Mark Johnson in 1980 argued that human language is not entirely a genetic innovation, but rather central aspects of language arise through evolution from the neural systems that are present in nonhumans. A central point of Lakoff's ideas is that the mind is inherently embodied, and thought is mainly unconscious. In 1987, Lakoff expressed his belief that humans' abilities to conceptualize the world are grounded in human–environment interaction. So, he claims, reason is not an essence that separates humans from nonhumans, but it is an essence that places all on a continuum.

There have been several counter-arguments to the nativist approach to map understanding. One is that the theory cannot explain why there are many adults having difficulty in map reading. Another is that many researches concluded that engagement with maps at an early age does not necessarily mean that children can understand cartographic concepts. On the contrary, there is evidence that map understanding progresses slowly and gradually from easy to difficult tasks. The productive result from this perspective is evidence that children can have some engagement with maps at an early age and can be introduced to cartographic concepts, starting from easy to more difficult ones. Neural studies in the first years of twenty-first century give evidence for continuity between mental capacities found in humans, such as attention, memory, and learning, and those of other species of primates, thus giving new potential to the nativist theory.

Piaget's Theory

The second perspective accepts that cartographic understanding follows the stages of intellectual development. Jean Piaget's theory on psychology of intelligence and Jean Piaget's and Barber Inhelder's theories on child's conception of space and child's conception of geometry determined the research on maps and children for almost three decades (from the 1970s and afterward).

Piaget and Inhelder proposed that children's environmental adaptation develops in a sequence of coherent and qualitatively different stages: the sensori-motor, the preoperational, the concrete operational, and the formal operational. In the sensori-motor stage, children (from about birth to 2 years) do not have any mental function, and only at the end of this stage develop inner representations of the outside environment. At the pre-operational stage, children (from 2 to 7 years) cannot focus their thinking on more than one thing. They perceive space from an egocentric point of view and understand only topological spatial relations. At about age 3–4, they can recognize shape as the first topological spatial relation, also open and closed figures, but they cannot differentiate between closed figures (circle, square). They are not able to form a straight line. By about age 5–6, they begin to discriminate straight and curved lines, sizes of lines and angles (Euclidean properties), but, they cannot organize landmarks in an objective spatial whole, rotate a plane 180°, describe changes of position, and reconstruct a route in reverse direction. At this stage, there is nonconservation of overall distance, and only at the end of this stage children start to learn how to measure, qualitatively, without unit iteration. At the concrete operational stage, children (from about 7 to 11 years) can use operations (mental processes) which enable them to classify, arrange objects in series, and understand projective properties of space. However, children of about 7–9 years are unable either to coordinate a system as a whole, or to describe a route. At a mean age of 7.5, they show conservation of distance between two objects, and at a mean age of 8.5 they are capable of one-dimensional measurements in an operational form and empirically discover the two-dimensional measurement. They also show conservation of area. Children of about 9–11 years can coordinate landmarks and changes of position, they can construct a topographical schema in a coordinate system, and they have a full appreciation of two-dimensional and three-dimensional measurements. Finally, at the formal operational stage (above 11–13 years), children are capable of more abstract and logical thinking, they are able to understand Euclidean properties of space, they establish relations between lines and areas, and they understand volumes of objects in relation to the surrounding space.

At each stage, children's mental abilities are rather stable. The mental structures of knowledge and understanding are developed into new ones because of new experiences and adaptation to new information. In recent years, many psychologists reject the authenticity of

Piaget's theory and mainly the idea of discontinuous stages of development. According to them, many skills seem to develop more gradually and continuously. The distinction of spatial relations in topological, projective, and Euclidean is criticized as not being helpful to an analysis of spatial thinking. The theory is criticized for being focused on the level of the individual, ignoring the important role of the social processes involved in cognitive development. Another point of argument is the implication of Piaget's theory that adults are accurate in spatial understanding, which seems to be wrong.

Piaget's theory had a great influence on the research on children's mapping abilities. The Piagetian approach to cartographic understanding accepts cognition as the basic factor in the development of mapping competence. Children actively construct their knowledge about maps. This construction of knowledge is a continual interaction between children and related experience. This is a fundamental issue which determined both theoretical and experimental work on this topic. Children's perceptual abilities, at each stage, were a guide for the introduction of cartographic concepts gradually and according to the degree of difficulty involved. Piaget's experimental work using graphic representations and spatial models greatly helped predict how children conceptualize space through maps. The results of many experimental studies on what children dealing with maps can understand do agree with Piaget's theory, while other experimental studies suggest that children can do more with maps than what Piaget's theory suggests. In 1989, Lyn Liben and Roger Downs based on the Piagetian approach – although critically – proposed a developmental approach to children's understanding of maps. Based on many experiments in the 1990s, they concluded that map understanding is a complex procedure that develops gradually depending on the cognitive level and experience of the individual, and it has to be approached both from a developmental and a cartographic perspective. They also argue that children show competence in a few mapping activities at an early age, but cartographic competence improves slowly in tasks concerning more advanced spatial thinking.

Vygotsky's Theory

The third perspective considers the social factor as playing a central role in cartographic understanding. Among the psychologists that criticize the individualism of Piaget's theory is Lev Vygotsky. His theory on learning and cognitive development, as expressed in his work on thought and language and mind in society, has offered the theoretical basis in studies on cartographic understanding in recent years. The relation between the biological roots of behavior and the human activities in the social environment is a critical issue in every theory of development. Vygotsky used a key point in his approach of this relation, mainly, the functional system of learning, which differentiates the concepts of learning as defined in other theories. According to him, there are two kinds of concepts: the spontaneous results of everyday experience and the scientific results of systematic school learning. The first ones are concrete and unsystematic, while the second are systematic and hierarchically structured. There is a gap between spontaneous concepts (children's own learning) and scientific concepts (taught by teachers), which is wide in very young children and is gradually bridged after systematic learning. Scientific concepts are easier to learn, and it is better for children to formalize concepts in school with the help of skilled learners before experiencing them unsystematically. So, according to Vygotsky, school must play a central role in cognitive development.

Investigations in 1989 and 1991 demonstrated that guided participation may be important in the development of spatial thinking. In experiments in 1991, children were able to plan routes on a map more effectively when collaborating with adults. In experimental studies in 1998, children of 12–13 years of age working in groups showed a slightly better understanding of cartographic concepts than the ones working individually. In 2000, it was admitted that Vygotskian views have been prominent in research on spatial competence and also in a study in 2003, it was said that collaborative teaching in solving cartographic problems needs further development. But it has also been argued that Vygotsky's theory overemphasizes the role of the social environment in the development of mind.

The Cognitive Perspective

The fourth theoretical perspective to cartographic understanding is based on theories of cognition that developed the last decade of the twentieth century and is growing at an exponential rate. In the context of developmental cognitive neuroscience, studies from various disciplines give evidence about brain processes and resulting mental functions. The use of electrophysiological recording systems to record the human brain opened new horizons toward understanding cognitive development. These brain-scanning techniques opened up the possibility to view the brain in action and localize the regions of the brain activated during different activities. Several regions appear to be devoted to spatial thinking, and it is concluded that these regions develop in very early childhood, contrary to what was believed. Based on these findings, suggestions have been expressed for starting cartographic literacy in kindergarten.

In the context of the cognitive perspective, there is another approach to cartographic understanding based on the theory of information processing. Information-processing approaches (which first appeared in the 1960s) use models of the human cognitive system based on computer operations, where the hardware is the perceptual and cognitive human system (eyes and brain), and the algorithms are the mental activities by means of which information is processed (perceived, encoded, stored, and used for problem solving). The major goal of this psychological approach is to describe the nature of thought, how the human mind represents and handles information, and how knowledge is processed and organized. The developmental changes are proposed to be gradual and continuous. What children know is not that important. Instead, of importance is how cognitive processes change with age and experience. Children are seen as being active in interactions with the environment, because they perceive objects and events and then remember and draw inferences from them.

The cartographic perspective on the information-processing theory is a new approach. The earlier cognitive models related to cartographic concepts appeared around 1985. Since then, knowledge structures of map-related information have been proposed, and in several studies models of cognitive structures have been used in experiments related to children's activities with maps. The strength of the approach is that it offers insight into children's thinking as to how they handle information while using maps. On the other hand, it approaches understanding from the individual point of view, ignoring the social parameters involved in this process.

Recent Views

The aforementioned theoretical approaches to cartographic understanding differ mainly as to the point they consider as dominant in the development of spatial thinking. This consideration determines not only each theoretical position but also the experimental work on which it is established. As to what approach has to be followed in future research, the prevailing view is that there is no single scientific approach as to how children learn with maps. In order to face the educational map material from a critical point of view and maps as means that produce knowledge, the approach has to be holistic, taking into account the fact that children are individuals who perceive the geographical space and its representations through their senses, and at the same time, they are members of a society, inevitably influenced by their social environment as well as by the educational procedures. Such an approach to spatial development has been proposed by Nora Newcombe in 2000. She advocates that her approach: encompasses nativism by considering early infancy as the starting point for spatial development but denying that the competencies of infants are so fundamental to spatial development as nativists argue, is interactionist without being Piagetian, and it encompasses interactions of the child with the skilled adults but denying their dominant role in development. In 1995, McEahren had proposed a similar holistic approach to map understanding. He considers maps as spatial representations and contends that the concept of representation is fundamental to all approaches that can be taken to cartography. In his detailed analysis, he approaches maps at multiple levels: lexical, semiotic, cognitive, and social.

Understanding Spatial Representations

Using Models

According to Piaget, children of about 7 years of age start to appreciate the model as a representation. Experimental studies in 1991 with children of ages between 2.5 and 3 years found that children appear to appreciate the correspondence between a room and a model at the age of 3 years, having more success when the room is familiar to them and when the model is a photograph or a drawing. Another study in the same year suggests that very young children recognize just unique objects and their representations in the models rather than fully appreciating the model as a representation. Other experiments in 1997 indicate that children from about the age of 3 are able to use a model to find a location. In 2000, a review study concludes that children after 3 years possess the idea that models are tools of thought, suggesting that the use of models by children needs initial support.

Using Aerial Photographs

Aerial photographs are considered means of introducing children to spatial representations. Without being abstract and symbolic representations as maps are, large-scale photographs remind one of geographical space. By photo-interpretation procedures, children can be introduced into the concept of looking at the Earth from above. The results of the rather few experimental studies with preschoolers using photographs are contradictory. In 1970, the results of the experiments with 5–7-year-old children showed that all children were able to understand that the photograph was the view of a landscape from above, but they could recognize just a few features. In 1980, experiments with 3–5-year-old children concluded that they were able to recognize many features on the photos. Contradictory results have been derived from studies with preschoolers in 1991. Very young children seemed to interpret successfully very large-scale photographs of space familiar to them, as was found in two studies in 2002 and 2003. The results suggested that young children view aerial photographs as a collection of features and not as a representation of an area. In experiments in 1971 with older children of ages 6–11 years, it was concluded that below age 9, children had problems in recognizing features, and only the older ones of ages 9–11 years seemed able to identify many characteristics. Even then, they were able to identify mainly the familiar ones and the ones whose image in the photograph looks like their view from the ground. However, they find it difficult to identify the area presented on the photo. Difficulties seem to appear when using small-scale photographs. An experimental study in 1983 showed that many students aged 16 years could not successfully relate small-scale photographs and corresponding maps. The same results were found in another study in 1979, in which high school students aged 15–16 years had difficulties in relating oblique aerial photograph with the map. It has been argued in 2006 that more systematic experimental research is required on this issue.

Using Maps

In the context of the developmental approach to cartographic understanding, the understanding that a map is a spatial representation can be distinguished as accomplished at two levels. At one level, the so-called holistic, children understand the relationship between the map as a whole and the whole of the real-world space to which it refers. At another level, the so-called componential, children understand the symbol–referent relationship for each individual symbol. At the componential level, two things have to be understood: the first one is the geometric correspondence between the position of each individual symbol on the map and the location of the referent feature in the real space. The second is the representational correspondence, which refers to the symbolic representation of feature characteristics as recorded in the legend.

Experimental studies in 1987 and 1996 suggest that children from about the age of 4 understand that maps represent spatial information, but it seems that they do not have a full understanding of the representational correspondence between the map and the represented space. As was found in a study in 1996, children about 8-years old think that the map is only a small-scale map used for finding ways and unknown places. Gradually, older children understand that the term map includes many different kinds of spatial representations. At the componential level, there is evidence from experiments in 1979 that children from the age of 3 years can use information from a simple map in order to identify a location. Other experiments in 1989, 1989, and 1996 concluded that kindergarten children can indicate their own location on the map but have difficulty in locating other locations. Moreover, they have significant difficulties in location and orientation tasks when the map is unaligned to the environment that it represents. The orientation task using unaligned maps is difficult, and only children about 10–11-years old succeeded in it. Representational correspondence appears to be achieved by about 6 years of age, as indicated in experiments in 1997. Other studies in 1979 and 1994 give evidence that 4-year-olds appear to be able to understand representational correspondence in the case of pictorial symbols. The lack of systematic investigation of early understanding of symbols has been mentioned in many recent literature reviews.

Understanding the Basic Characteristics of Maps

The achievement of cartographic understanding has, as a prerequisite, the understanding of the basic characteristics of maps. Scale, map projections, generalization, and symbolization are common to every map and are considered as basic characteristics of maps. Since map literacy is not systematically included in the school curriculum, there are no definite and clear results referring to children's understanding of these basic map concepts. On the other hand, the results of experimental studies give some evidence as regards children's development of concepts associated with the map's basic characteristics.

Scale

Map scale is the ratio between the dimensions on the map and on those of reality. According to Piaget, understanding scale requires the understanding of proportionality, concepts achieved at the formal operation stage. Experimental studies in 1999 show that children around 3–4-years old are able to encode proportional distance. Other experiments in 1996 show that 7-year-old children make substantial errors in map-scale tasks. Also, in another study in 1995, 10-year-old children perform worse than children of 11–13-years old in map-scale tasks. In 2000, a review study of the above experiments suggests that the contradiction of the results leads to a reconsideration of Piaget's view that scale depends on acquisition of proportionality.

Scale is indicated on maps both in numerical and graphical representations. Graphic scale representations are more useful for young children in distance-estimation tasks. In maps addressed to children, different graphic scale representations support different learning levels. In a study in 1971, difficulties and misconceptions were identified in tasks involving children's use of graphic scale such as: confusion by the use of different graphic scales in different maps, difficulty to measure long distances as easily as short ones, inability to understand that the outcome of the measurement is a true distance on the ground, and having problems in countries where the units of measurement are different from those on the map scale.

Map Projections

Through map projections, the spherical surface of the Earth is transformed into a plane. A map projection is a mathematical relationship of geographical coordinates (φ, λ) and plane coordinates (x, y). Whatever is the mathematical relationship applied to the transformation process, distortions are inevitable. The distortions of the geometric relationships on the sphere (distances, areas, angles, directions), when projected onto the plane, can be controlled by a suitable choice of projection.

Understanding map projections involves constructing the image of the graticule on the map. Children must be able to visualize the form of the graticule and the way it looks from different perspective views. Having achieved this knowledge, children are able to evaluate projections by comparing the geometry of the graticule as it is on the spherical Earth with the grid on the map. Gradually, they come to understand the effects different transformations have on the representation of landmasses as well as the importance of choosing the best projection for a particular map. Children of around 9–11 years of age (depending on different school curricula) are introduced to the concepts of the spherical Earth, the equator, the meridians and parallels. According to Piaget's views, children are able to use coordinates at about 8 years of age. But experiments in 1965 report that children of 10–14-years old have difficulty in using coordinates in mapping tasks. The use of dynamic representations of the globe and its perspectives from different points of view as well as its transformation to a plane through various kinds of map projections can be a strong educational tool for introducing children to the concepts of map projections.

Generalization

All maps are abstractions of the real world. As the scale gets smaller, the map content gets less. The information portrayed on maps has been chosen according to the scale and the purpose of the map. The chosen information has been subject to the generalization processes, which are: classification (order of features by their attributes), simplification (portrayal of important feature characteristics and elimination of details), exaggeration (enhancement of important characteristics), symbolization (graphical coding of information), and induction (inferences from the interrelations among the features on the map). All the processes of generalization are done by the cartographer, except that of induction for which it is the user who makes logical extensions of the portrayed data, so it depends a lot on the symbolization.

The extent to which the generalized information presented on maps affects the way children interpret maps has not been studied systematically. From the few experimental studies in 1972, 1980, and 1981, there is evidence that children of primary and also of secondary school make misinterpretations, thinking that what is presented on a map is all that exists in the real world. A review study in 1998 recognizes the need for children's introduction to the concept of generalization and to the processes involved in it. Generalization is a key step toward successful map interpretation.

Symbolization

Maps use symbols that stand for the features of the real world they portray. Since 1967, when Jacques Bertin introduced a semiotic approach to cartographic symbolization, cartographers have followed a systematic symbol design, developing typologies of symbol categories. The visual variables (shape, size, orientation, hue, value, chroma, pattern, and texture) were the basis of symbol design assigned to represent quantitative and qualitative variations of the data represented on maps. Although the use of visual variables in symbol design is practically a standard procedure, it has not been considered as a prerequisite knowledge for map use.

Relatively little is known about how young children interpret symbols in maps. According to Piaget, children are able to recognize shape at sometime after 3 years. In 2000, another scholar underlined the fact that children with appropriate guidance could appreciate the symbol–referent relation earlier. It is argued in many experiments that children have greater difficulty in understanding the geometric correspondence than the representational one. In 1996, experiments found that kindergarten children show great variation in symbol identification. Children are able to identify shape variable and show difficulty in color naming. They easily identify both pictorial and abstract line symbols, but they show difficulty with point and area symbols. In other experiments in 1996, very young children aged 5–7 years found pictorial symbols attractive and easier to interpret. Many of them were able to identify abstract symbols using a legend. Size is easily identified. The understanding of color as a variable is cognitively complex, since it requires matching color differences with object characteristics, and this ability improves by age. The level of knowledge (experience) and the level of development (verbal ability and amount of attention) are mentioned as responsible factors.

Elementary school students are gradually exposed to maps that apply abstract symbols and the use of legend. Matching symbols between the legend and the map involves holding the symbol characteristic in memory, so this task develops gradually. Experiments in 1984 show that children understand qualitative symbols first, and quantitative ones later. Size is easily identified as a variable, but it is difficult for children to compare the size of symbols whose area is proportional to a quantity.

School atlases addressed to children older than 11 years comprise thematic maps representing quantities that occur at points, lines, or areas. When quantities occur over an area, a statistical surface is created. The concepts of the statistical surface, of ratio, and proportionality are very important in thematic mapping and a prerequisite knowledge for understanding thematic maps like dot maps, choropleth, and isarithmic common to all school atlases. Experiments in 2003 show that students even of third and fourth year of secondary school do not fully understand the concepts of ratio and proportionality.

The Relief

The relief can be represented in maps by various methods, such as symbols of stylized form (appear not only on early maps, but also today on maps addressed to very young children), hachuring (lines representing the greatest slope), hill shading, layer tinting (hypsometric coloring), and contouring. Relief can also be represented through perspective pictorial maps (block diagrams, oblique views, and schematic maps). There are two aims of relief representation: first, the visualization of relief by the user when seeing the map as a whole and, second, the interpretation of elevation data. The methods of representation that are effective in the visualization task have poor results in the interpretation tasks. Contouring gives measurable data, but is poor in visualizing. Hill shading gives a realistic visual representation but nonmeasurable data. Recently, topographic maps represent relief by using contours and hill shading, and the result is very effective.

According to Piaget, children are able to understand the relief representation not earlier than 9 years of age and the concept of contouring not earlier than 11 years. In experiments in 1979, it is argued that only at the age of 11 can children interpret simple landforms. But even younger secondary school students show difficulties in height estimation and relief interpretation in cases where contours are not closed. Their performance improves with maps in which contouring is combined with layer tinting. Experiments in 1983 argue that limitations on language development seem to be a serious problem in understanding the relief on maps, since children do not know the geographical terms. The understanding of contours appears to be a difficult task as well. Slope estimation seems to be the most difficult task, even for 14-year-olds, as reported in studies in 1979 and 1989. For younger children, three-dimensional models seem to be helpful for an introduction to landscape surfaces, as reported in experiments in 1997. Three-dimensional representations and pictorial maps are more effective for primary school students to visualize landforms.

Children as Map Users in the Information Technology Era

Cartography at the beginning of twenty-first century is facing a technological revolution due to the widespread use of electronic media and especially of computers and information technology. In many countries, individuals have access to a computer usually connected to a worldwide network everyday. Such a technological advance not only affects the technical frame of cartography, but it also changes decisively the relation between cartography and society. During the long history of cartography, the latter faced significant technological revolutions that changed the methods of map construction dramatically. But in every case, the cartographic processes needed specially trained staff (cartographers) in order to be performed. As a result, the knowledge of how to construct a map was related to a very small section of the society, that is, the cartographers. The existence of such advanced technological tools is transforming any member of the society, and especially children, into a cartographer by offering electronic systems able to construct any kind of map.

Indeed, children have a more privileged place by being familiarized with the use of the computers. Children can easily convey the knowledge acquired from playing a computer game into an effective construction of a map. Two issues are important for the children's proper assimilation of the present technology. The first one is related to the dramatic change of the available educational tools provided by information technology. Software packages provide the ability to simulate several spatial phenomena (construction of models, walkthrough, and fly-through) and to construct virtual worlds and examples, while at the same time their function is characterized by interactivity. Thus, using electronic media, children can be exposed to map skills and to map concepts (i.e., generalization, map projections, and spherical Earth) by means of various and effective communicative ways. The second issue refers to children as mapmakers. In the past, children were constructing an analog map of a continent, for example, by tracing (from a published map) the coastline on a piece of paper. With a computer, they can construct a detailed map of the same continent by retrieving data from a spatial database and symbolizing various features in alternative colorful ways. A critical question is raised here as to whether these maps made by children are effective in developing cartographic knowledge, or are they just drawings. Specialists on children and mapping persistently ask for map literacy.

See also: Atlases; Children/Childhood; Cognitive Geography; Internet/Web Mapping; Maps.

Further Reading

Carswell, R. B., Leeuw, G. A. and Waters, N. M. (eds.) (1987). Atlases for schools. *Cartographica*, 24/1, Monograph 36.

Castner, H. W. (1990). *Seeking New Horizons: A Perceptual Approach to Geographic Education*. Montreal and Kingston: McGill-Queen's University Press.

Cohen, R. M. (ed.) (1985). *The Development of Spatial Cognition*. Hillsdale, NJ: Lawrence Erlbaum.

Downs, R. M. and Stea, D. (eds.) (1973). *Image and Environment: Cognitive Mapping and Spatial Behavior*. Chicago, IL: Aldine.

Gersmehl, P. J. (2005). *Teaching Geography*. New York: The Guilford Press.

Golledge, R. G. (ed.) (1999). *Wayfinding Behavior: Cognitive Mapping and Other Spatial Processes*. Baltimore, MD: Johns Hopkins Press.

Kraak, M. J. and Brown, A. (2001). *Web Cartography*. London: Taylor and Francis.

Kraak, M. J. and Ormeling, F. J. (1996). *Cartography: Visualization of Spatial Data*. Harlow: Addison-Wesley-Longman.

Kosslyn, S. M. (1994). *Image and Brain: The Resolution of the Imagery Debate*. Cambridge, MA: MIT Press.

Liben, L. S. and Downs, R. M. (1989). Understanding maps as symbols: The development of map concepts in children. *Advances in Child Development and Behavior* 22, 145–201.

McEahren, A. M. (1995). *How Maps Work. Representation, Visualization, and Design*. New York: The Guilford Press.

Newcombe, N. S. (2000). *Making Space: The Development of Spatial Representation and Reasoning*. Cambridge, MA: MIT Press.

Wiegand, P. (2006). *Learning and Teaching with Maps*. London: Routledge.

Wood, C. H. and Keller, P. C. (eds.) (1996). *Cartographic Design: Theoretical and Practical Perspectives*. Chichester: Wiley.

Relevant Websites

http://lazarus.elte.hu
Commission on Cartography and Children, Eötvös University, Department of Cartography and Geoinformatics.