

SPATIAL THINKING



SPATIAL THINKING ABOUT MAPS: DEVELOPMENT OF CONCEPTS AND SKILLS ACROSS THE EARLY YEARS

Spatial thinking is arguably one of the most important ways of thinking for a child to develop as he or she grows. All individuals, to greater or lesser extents, use this type of thinking as they interact with the world around them. It is a unique way of thinking *about* the world and interacting *within* the world. Spatial thinking involves visualizing, interpreting, and reasoning using location, distance, direction, relationships, movement, and change in space. A student who has acquired robust spatial thinking skills is at an advantage in our increasingly global and technological society.

Providing quality instructional resources and activities for learning how to think spatially during the formative school years is critical. It is even more important that such resources and activities are not simply “flashy” software or fun and games, but instead are learning experiences designed with research on spatial concept development at their core. This report synthesizes spatial thinking research with respect to mapping concepts and skills as a first step toward making recommendations for improvements in instructional resources and activities used in Grades preK-5.

GRADES PRE-K THROUGH 1 (AGES 3 TO 6)

SPATIAL CONCEPTS	CONCEPTUAL UNDERSTANDING	POSSIBLE MISCONCEPTIONS	CURRICULAR IMPLICATIONS
	<i>Students:</i>	<i>Students:</i>	<i>Materials:</i>
Identity and Location	Identify places on maps, landscape features on maps and aerial photographs, and locate familiar places on maps	Can identify places on maps, but may be limited by vocabulary development in their ability to describe the place or location	<ul style="list-style-type: none"> • Provide sensory experiences and tactile, hands-on, active mapping activities and puzzle maps • Provide opportunities to practice with maps of familiar places (e.g., classrooms, homes, schools, neighborhoods) and to make maps, both real and imaginary • Tap into students' interest in learning about extremes such as the largest continent and the smallest country • Provide simple maps large in size (tabletop or larger), as opposed to an atlas, to allow children to explore with their whole bodies • Provide pictorial and panoramic views, which are common ways that children represent their views of the world and connect to it
	Use landmarks as a way to identify where places or items are located on a map	Can confuse locations on maps if the map is not well aligned to their real world	
Magnitude	Understand magnitude of objects and associated vocabulary (e.g., bigger, smaller)	May confuse the scale of an object with the number of objects (numerosity)	
Relative Distance and Direction	Understand relative distance, such as <i>near</i> , <i>far</i> , and <i>next to</i> , and begin using relative direction on maps, such as for navigating mazes	Struggle with knowing which way to "hold a map" and get easily confused if it is not aligned to the real world	
Symbols	Understand concrete symbols that represent an object or place in the real world	May not understand abstract, unrelated symbols, large numbers of symbols, or complexity of symbols (e.g., a map with U.S. represented as a pink country might be seen by some students to literally be a pink country)	

Research shows that young children ages 3 to 6 appear to acquire the ability to understand spatial relationships such as *on*, *in*, *inside*, *in the middle*, *between*, *around*, and *beside*, regardless of cultural group or background experience with maps. Often, children in the earliest grades who are reasoning about maps may only have those concepts to rely on. However, even if these basic spatial concepts are acquired at a young age, some children still struggle with them.

A set of effective instructional resources for Grades K-2 should focus on hands-on activities and an introduction of basic spatial thinking concepts. During activities, these resources should encourage the use of blocks, toys, or puzzle maps that naturally lead to more use of spatial language. Young children should work with maps of familiar places (such as home or the schoolyard) that are large in size and scale. Symbols should be realistic representations that children can easily interpret. Complex or visually busy atlas pages using small fonts and abstract symbols should be avoided. Preschool children in particular learn more when there is social interaction or real-world action involved in spatial activities.



(Map illustration by National Geographic Learning/ Cengage Learning)

Activities for them should have children create and then analyze their own self-made maps of familiar places before they engage in tasks where they are using maps developed by others.

EXAMPLES

See National Geographic Education's collection, Map Skills for Elementary Students (NatGeoEd.org/elementary-map-skills).

MATERIALS THAT PROVIDE SENSORY EXPERIENCES AND TACTILE, HANDS-ON, ACTIVE MAPPING ACTIVITIES:

- Textured maps
- Exploring Maps and Models of the Earth, a National Geographic Education activity (NatGeoEd.org/exploring-maps-and-models)
- Map puzzles
- Simple tabletop or larger maps, such as painted playground maps
- Sand trays or water tables
- Montessori geography materials

MATERIALS THAT PROVIDE SIMPLE MAPS LARGE IN SIZE TO ALLOW CHILDREN TO EXPLORE WITH THEIR WHOLE BODIES:

- Giant Traveling Maps (nationalgeographic.com/giantmaps)
- State Alliances Giant Traveling Maps (NatGeoEd.org/alliances)
- State Tabletop Maps (NatGeoEd.org/state-mapmaker-kits)
- Carpet maps

MATERIALS THAT PROVIDE OPPORTUNITIES TO PRACTICE WITH MAPS OF FAMILIAR PLACES:

- Mapping the Classroom, a National Geographic Education activity (NatGeoEd.org/mapping-the-classroom)
- Places in the Park, a National Geographic Education activity (NatGeoEd.org/places-in-the-park)
- Using a Grid with a Zoo Map, a National Geographic Education activity (NatGeoEd.org/grid-zoo-map)

GRADES 2 THROUGH 4 (AGES 7 TO 9)

SPATIAL CONCEPTS	CONCEPTUAL UNDERSTANDING	POSSIBLE MISCONCEPTIONS	CURRICULAR IMPLICATIONS
	<i>Students:</i>	<i>Students:</i>	<i>Materials:</i>
Identity and Location	Accurately locate places and landscape features on a map, but perform better with familiar locales rather than foreign locales	Inconsistently use landmarks to verify locations	<ul style="list-style-type: none"> Expose students to a broader world beyond the familiar. Begin including birds'-eye views of maps, but a combination of pictorial and panoramic views Encourage students to explore the world but at the continent and country level Include maps that use grid systems with limited amounts of information Provide active and hands-on activities that allow children to manipulate maps when possible Introduce more complex spatial concepts, but provide explicit support in doing so as many concepts are not yet learned Encourage students to produce their own maps and use maps and models that allow active exploration (e.g., 3-D topo maps, landscape models, "layers" found on a map)
	Demonstrate improvement with map alignment issues		
Distance and Direction	Transition from topological concepts of distance to metric measurements and scale	Still need guidance to transition to metric measurements	
	Readily use metric distances and scale by the end of Grade 4		
	Use landmarks and relative direction, but are ready to learn cardinal directions		
Symbols	Transition from iconic real-world symbols to abstract symbols	Still may make errors and need explicit guidance on what symbols mean	
Reference Frames	Can begin to understand grid systems (the coordinate system) and absolute location	Still need guidance with map features; they may become distracted by features that are not useful and may neglect useful features on maps	
Hierarchies	Do not yet have a well established concept of hierarchy (or nesting)	Should be introduced to the concept of hierarchy with close guidance	

Prior to the ages of 7-8, most children have limited mapping abilities because they have only mastered basic spatial concepts and language. More complex spatial concepts, such as metric distances and cardinal directions, begin to emerge in early elementary, but children may not be proficient until upper elementary (around 9 years old). Educators need to incorporate additional spatial terms beyond relative terms such as *near*, *far*, and *beside*, and geographic terms should be introduced.

Resources for students in Grades 2-4 should continue with spatial language but also begin to focus on helping students understand and practice basic spatial relationships. Students should construct maps collaboratively and use discussion to reason about their decision-making when choosing certain elements on maps, such as scale, grid systems, and symbols. Activities should use different types of maps of the same area so that students can discuss the similarities and differences of each type of map (for example, political versus topographical versus aerial) and their projective strengths and weaknesses. Students should observe their environment with adults asking questions about what they see; unique physical characteristics of the environment should be pointed out. Students begin to place themselves on the map and begin to make spatial connections. Because they are making the transition between realistic and abstract symbols, students may make mistakes when interpreting maps, so educators need to explicitly model how to read maps and show how symbols are developed and used.

EXAMPLES

See National Geographic Education's collection, [Map Skills for Elementary Students \(NatGeoEd.org/elementary-map-skills\)](https://www.natgeo.org/elementary-map-skills).

MATERIALS THAT PROVIDE BIRDS'-EYE VIEWS OF MAPS:

- Maps of Familiar Places, a National Geographic Education collection ([NatGeoEd.org/maps-of-familiar-places](https://www.natgeo.org/maps-of-familiar-places))
- Adventures of Amelia the Pigeon, NASA (science.hq.nasa.gov/kids/imagers/Amelia/)

MATERIALS THAT PROVIDE PICTORIAL AND PANORAMIC VIEWS OF MAPS:

- Map Journeys, Oregon Natural Resources Education Program (weedinvasion.org/pdfs/Mapping/map_journeys.pdf)

MATERIALS THAT PROVIDE ACTIVE AND HANDS-ON ACTIVITIES THAT ALLOW CHILDREN TO MANIPULATE MAPS:

- Make a Topographic Map, NASA (spaceplace.nasa.gov/topomap-clay/en/)

MATERIALS THAT INTRODUCE MORE COMPLEX SPATIAL CONCEPTS, WITH EXPLICIT SUPPORT:

- A Latitude/Longitude Puzzle, a National Geographic Education activity ([NatGeoEd.org/lat-long-puzzle](https://www.natgeo.org/lat-long-puzzle))

MATERIALS THAT ENCOURAGE STUDENTS TO PRODUCE THEIR OWN MAPS AND USE MAPS AND MODELS THAT ALLOW ACTIVE EXPLORATION:

- Analyzing a Community Map, a National Geographic Education activity ([NatGeoEd.org/analyze-community-map](https://www.natgeo.org/analyze-community-map))
- Many Ways to Name a Place, a National Geographic Education activity ([NatGeoEd.org/many-ways-to-name](https://www.natgeo.org/many-ways-to-name))

GRADES 5 THROUGH 6 AND BEYOND (AGES 10 AND OLDER)

SPATIAL CONCEPTS	CONCEPTUAL UNDERSTANDING	POSSIBLE MISCONCEPTIONS	CURRICULAR IMPLICATIONS
	<i>Students:</i>	<i>Students:</i>	<i>Materials:</i>
Identity, Location, Distance, and Direction	Need to be primed to use all the resources available to determine locations. They should be encouraged to explain decisions in order to prompt their thinking about landmarks, distances, and directions.	May not readily use map scales, metric distances, and cardinal directions to help determine locations, but are able to do so with some guidance	<ul style="list-style-type: none"> • Explore and compare different projections and viewing angles • Use measured distances, cardinal directions, and abstract symbols with support including the introduction of longitude and latitude • Use multiple map formats (e.g., reference maps, thematic maps, digital maps) at multiple scales • Introduce more complex spatial concepts, such as projection and overlay • Allow students to begin to confidently navigate the world
Symbols	Use abstract symbols and understand symbols do not always “look like” the referent		
Overlay and Complex Spatial Concepts	<p>May incidentally understand the concept of overlay without formal instruction (about half of all Grade 6 students do so)</p> <p>Can move on to complex spatial concepts such as distribution, patterns, overlays, and projection with support if mastery of the basic spatial concepts of location, distance, direction, boundaries, and regions is achieved</p>	May not understand “layers” without direct instruction, support, and guidance	

In these grades, elementary-age and preadolescent children are developing the ability to reason logically and make concrete connections to their world. They are able to solve realistic problems, classify objects by a variety of characteristics, and use maps with different symbol systems. These symbol systems may include color and abstractions, different projections, and different themes. During these grades, students become less egocentric, are able to understand one another’s perspectives, and are inquisitive about people and places around the world.

Resources for students in Grades 5-6 should review basic spatial language but focus mainly on advancing students’ knowledge of spatial understanding. Students should complete tasks in which they compare and contrast two different representations or maps and explain their own understanding of the relationship between the two. However, educators should not make assumptions about students’

spatial reasoning and understanding of spatial representations.

For example, students may not necessarily use map scales and cardinal directions without prompting, so explicit instruction and support will be needed. Educators should anticipate substantial student-to-student variation in accuracy and complexity of reasoning.



(Photograph by Auremar/Shutterstock)



(Map by National Geographic Education)

EXAMPLES

See National Geographic Education’s collection, [Map Skills for Elementary Students \(NatGeoEd.org/elementary-map-skills\)](https://www.natgeoeducation.org/elementary-map-skills).

MATERIALS THAT INCLUDE DIFFERENT PROJECTIONS AND VIEWING ANGLES:

- [Selecting a Map Projection](https://www.natgeoeducation.org/selecting-map-projection), a National Geographic video (NatGeoEd.org/selecting-map-projection)

MATERIALS THAT USE MEASURED DISTANCES, CARDINAL DIRECTIONS, AND ABSTRACT SYMBOLS WITH SUPPORT:

- [Latitude, Longitude, and Temperature](https://www.natgeoeducation.org/lat-long-temp), a National Geographic Education activity (NatGeoEd.org/lat-long-temp)
- [Adventure Island](https://www.natgeoeducation.org/adventure-island), a National Geographic Education game (NatGeoEd.org/adventure-island)

MATERIALS THAT USE MULTIPLE MAP FORMATS AT MULTIPLE SCALES:

- [Mapping Your State](https://www.natgeoeducation.org/mapping-your-state), a National Geographic Education activity (NatGeoEd.org/mapping-your-state)
- [Population and Resource Distribution](https://www.natgeoeducation.org/population-and-resource-distribution) from Annenberg Learner’s *Social Studies in Action*