

Table 1. Summary of links between spatial thinking and mathematics/science standards

Mathematics Standards	Spatial Thinking	Science Standards
<p>[Measurement] Learning how to choose an appropriate unit is a major part of understanding measurement. . . . Students at all levels should learn to make wise choices of units or scales, depending on the problem situation.</p> <p>[Measurement] They might use transparent grid paper to approximate the area of a leaf.</p> <p>[Data Analysis and Probability] Students should learn how to collect data, organize their own or others' data, and display the data in graphs and charts that will be useful in answering their questions.</p>	Condition (Site)	[Earth and Space Science] Younger students can draw a daily weather picture based on what they see out a window or at recess; older students can make simple charts and graphs from data they collect at a simple school weather station.
<p>[Geometry] . . . in trying to minimize the distance an ambulance would have to travel to reach a new hospital from any location in the community, students in the middle grades might use distances measured along streets. In high school, students can be asked to find the shortest airplane route between two cities and compare the results using a map to the results using a globe.</p>	Connection (Situation)	[Physical Science] An object's motion can be described by tracing and measuring its position over time.
<p>[Measurement] Grades 6-8 students should extend their understanding of scaling to solve problems involving scale factors. These problems can help students make sense of proportional relationships and develop and understanding of similarity. High school students should study more-sophisticated aspects of scaling, including the effects of scale changes on a problem situation.</p> <p>[Data Analysis and Probability] As they move through the middle grades into high school, students will need new tools, including histograms, stem-and-leaf plots, box plots, and scatterplots, to identify similarities and differences among data sets.</p>	Comparison	[Unifying Concepts and Processing] Rate involves comparing one measured quantity with another measured quantity, for example, 60 meters per second. Rate is also a measure of change for a part relative to the whole, for example, change in birth rate as part of population growth.
	Aura (Influence)	[Physical Science] The position and motion of objects can be changed by pushing and pulling. The size of the change is related to the strength of the push and pull.
<p>[Problem Solving] The second class began with a discussion of what "the same area" means. They used large-grid paper squares and taped them to their map to allocate the maximum space for gardening, counting carefully to be certain each class had the same number of squares even though the shapes of the regions were different. This group also needed to learn about scale to actually make a plan for marking off the gardens outside.</p>	Region	[Science in Personal and Social Perspectives] Causes of environmental degradation and resource depletion vary from region to region and from country to country.

<p>[Geometry] Students must carefully examine the features of shapes in order to precisely define and describe fundamental shapes, such as special types of quadrilaterals, and to identify relationships among the types of shapes. ... A Venn diagram like the one shown in figure 6.14 might be used to summarize observations that a square is a special case of a rhombus and rectangle, each of which is a special case of a parallelogram.</p>	<p>Hierarchy</p>	<p>[Life Science] Biological classifications are based on how organisms are related. Organisms are classified into a hierarchy of groups and subgroups based on similarities which reflect their evolutionary relationships. Species is the most fundamental unit of classification.</p>
	<p>Analog</p>	<p>[Earth and Space Science] Global patterns of atmospheric movement influence local weather.</p>
<p>[Geometry] Such an investigation might include finding the slopes of the lines containing the segments that compose the shapes. From many examples of these shapes, students could make important observations about the slopes of parallel lines and perpendicular lines.</p>	<p>Gradient</p>	<p>[Earth and Space Science] As children become more familiar with their world, they can be guided to observe changes, including cyclic changes, such as night and day and the seasons; predictable trends, such as growth and decay, and less consistent changes, such as weather or the appearance of meteors. Children should have opportunities to observe rapid changes, such as the movement of water in a stream, as well as gradual changes, such as the erosion of soil and the change of the seasons.</p>
<p>[Algebra] Preschoolers recognize patterns in their environment and, through experiences in school, should become more skilled in noticing patterns in arrangements of objects, shapes, and numbers and in using patterns to predict what comes next in an arrangement. [Algebra] Teachers should help students develop the ability to form generalizations by asking such questions as "How could you describe this pattern?" or "How can it be repeated or extended?" or "How are these patterns alike?"</p>	<p>Pattern</p>	<p>[Physical Science] By recording data and making graphs and charts, older children can search for patterns and order in their work and that of their peers. [Earth and Space Science] By observing the day and night sky regularly, children in grades K-4 will learn to identify sequences of changes and to look for patterns in these changes. ... Students can discover patterns of weather changes during the year by keeping a journal. [Earth and Space Science] By plotting the locations of volcanoes and earthquakes, students can see a pattern of geological activity.</p>
<p>[Algebra] The study of patterns and relationships in the middle grades should focus on patterns that relate to linear functions, which arise when there is a constant rate of change. Students should solve problems in which they use tables, graphs, words, and symbolic expressions to represent and examine functions and patterns of change.</p>	<p>Association (Correlation)</p>	<p>[Science in Personal and Social Perspectives] Populations grow or decline through the combined effects of births and deaths, and through emigration and immigration. Populations can increase through linear or exponential growth, with effects on resource use and environmental pollution.</p>
<p>[Reasoning and Proof] People who reason and think analytically tend to note patterns, structure, or regularities in both real-world situations and symbolic objects; they ask if those patterns are accidental or if they occur for a reason; and they conjecture and prove. [Reasoning and Proof] Beginning in the elementary grades, children can learn to disprove conjectures by finding counterexamples.</p>	<p>Exceptions</p>	<p>[History and Nature of Science] Evaluation includes reviewing the experimental procedures, examining the evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations.</p>
<p>[Data Analysis and Probability] Students also need to think about measures of center in relation to the spread of a distribution.</p>	<p>Diffusion</p>	<p>[Life Science] The distribution and abundance of organisms and populations in ecosystems are limited by the availability of matter and energy and the ability of the ecosystem to recycle materials.</p>

