

### Research on Student Learning

Before instruction, many elementary- and middle-school students are not aware of the bipolarity of batteries and light bulbs; do not recognize the need for a complete circuit to make a bulb light; and do not succeed in making a lamp light when given a battery and a number of connecting wires. [1] However, many high-school and university students also fail at this task. [2]

Progress from one of Van Hiele's levels to the next is more dependent upon instruction than age. Given traditional instruction, middle-school students perform at levels one or two. [3] Despite that, almost 40% of high-school graduates finish high-school geometry below level two. [4] Further research will help identify what levels of geometric thinking students can attain at different grades given effective instruction that takes account of their difficulties in learning geometry. Some evidence suggests it is possible for students to understand the abstract properties of geometric figures by 5th grade [5] Some evidence suggests it is possible for students to understand the relations that connect the properties of shapes or make simple deductions by 8th or 9th grade. [6]

Research on students' development of the ability to construct proofs reflects somewhat conflicting views. [7] Piagetian research suggests that students can reason deductively from any assumptions once they reach the formal operational stage (roughly age 12 and beyond). Other research, however, suggests that the ability to construct proofs depends on the amount and organization of particular knowledge they have. For example, this research indicates that students are not likely to understand and construct geometric proofs before they can see the relationships between classes of figures. [8] Still other research suggests that students may need to understand the nature of proof and how it differs from everyday argumentation before they are able to construct proofs. [9] Clearly, further research is needed to identify how students can come to understand what it means to prove something in geometry and what such a proof entails. [10]

### References

- [1] Van Hiele, P. (1986). *Structure and insight*.  
Clements, D., Batista, M. (1992). Geometry and spatial reasoning. In Grouws, D. (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 420-464).
- [2] American Association for the Advancement of Science, Project 2061 (2007). *Atlas for Science Literacy*, 2, 66.
- [3] Clements, D., Batista, M. (1992). Geometry and spatial reasoning. In Grouws, D. (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 420-464).
- [4] Burger, W., Shaughnessy, J. (1986). Characterizing the van Hiele levels of development in geometry. *Journal for Research in Mathematics Education*, 17, 31-48.  
Clements, D., Batista, M. (1992). Geometry and spatial reasoning. In Grouws, D. (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 420-464).
- Suydam, M. (1985). The shape of instruction in geometry: Some highlights from research. *Mathematics Teacher*, 78, 481-486.
- [5] Clements, D., Batista, M. (1989). Learning of geometric concepts in a Logo environment. *Journal for Research in Mathematics Education*,

20, 450-467.

Clements, D., Batista, M. (1990). The effects of Logo on children's conceptualizations of angle and polygons. *Journal for Research in Mathematics Education*, 21, 356-371.

Clements, D., Batista, M. (1992). Geometry and spatial reasoning. In Grouws, D. (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 420-464).

Wirsup, I. (1976). Breakthroughs in the psychology of learning and teaching geometry. In Martin, J. and D. Bradbard (Ed.), *Space and geometry: Papers from a research workshop* (pp. 75-97).

[6] Clements, D., Batista, M. (1992). Geometry and spatial reasoning. In Grouws, D. (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 420-464).

[7] Clements, D., Batista, M. (1992). Geometry and spatial reasoning. In Grouws, D. (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 420-464).

[8] Senk, S. (1989). Van Hiele levels and achievement in writing geometry proofs.. *Journal for Research in Mathematics Education*, 20, 309-321.

[9] Clements, D., Batista, M. (1992). Geometry and spatial reasoning. In Grouws, D. (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 420-464).

[10] American Association for the Advancement of Science, Project 2061 (2007). *Atlas for Science Literacy*, 2, 4.