

Investigating the Underlying Processes of Visualization Experiences
David N. Rapp
University of Minnesota

The major goal of my research has been to examine the processes underlying discourse comprehension (e.g., Rapp & Gerrig, 2002; Rapp & Taylor, in press). Discourse comprehension requires the construction of a mental representation built from the information in text, speech, images and multimedia sources. Much of my work has focused on the role of the reader in comprehending text. Currently I am extending this work beyond text to assess how reader expectations and strategies influence spatial and multimedia comprehension. It is this interest which is most directly related to the use of visualization as a tool for learning.

I am currently working in conjunction with the Perseus Digital Library group at Tufts University and the GEOWALL group at the University of Minnesota to examine the utility of multimedia systems for facilitating learning (an area which has traditionally ignored the processes, expectations, biases, and belief systems that are brought to such situations). Our projects examine whether theories of text comprehension are useful for outlining the potential effectiveness of these presentation systems in educational situations. To this end, we have focused on how users construct and apply mental models for multimedia experiences. Digital libraries and multimedia systems provide a fertile test-bed for implementing theories of comprehension in the design of educational software, as well as for evaluating the cognitive processes necessary for comprehension during hypermedia and multimedia experiences (Rapp, Taylor, & Crane, 2003).

In collaboration with the GEOWALL group, I am currently investigating whether 3-dimensional presentations of map information (constructed using stereo visualizations) may influence the speed with which students learn to read and use topographic maps, and the resulting memory representations that are encoded into long-term memory as a function of those experiences (Rapp & Kendeou, 2003). This work is largely exploratory, as we are concerned with the degree to which stereo visualizations may help students learn information beyond that conveyed using traditional flat map presentations found in most earth science coursework. Despite an increasing use of GEOWALL as a tool in earth science curricula, it has remained, up until this point, largely untested. This project begins a formal evaluation of the educational implications of the system. Visualizations have been offered as worthwhile tools for helping students understand complex systems and processes in science classrooms. The nature of scientific visualizations on cognition remains unclear, and as such we anticipate our collaboration will begin to outline the underlying cognitive processes that are influenced by multimedia visualizations.

In a related vein, I am particularly interested in addressing techniques that effectively reduce students' misconceptions about scientific principles and theories. As readers encode information into memory, this information continues to exert an influence on ongoing comprehension. While this is usually not a problem (and in fact, critical to ongoing comprehension), it can easily create difficulties if the initial information is

incorrect and is revised at a later point in time. In addition, the inaccurate prior knowledge that students may bring to learning situations are often resistant to change in a similar way (see Kendeou, Rapp, & van den Broek, in press, for a review). Specifically, evidence in psychology and education has demonstrated that students often have difficulty overcoming such naïve beliefs in domains such as physics, biology, and chemistry. Figuring out how to overcome or replace such misinformation is a major challenge; restructuring them requires focused attention, an awareness of errors, the motivation to make changes, and an explicit understanding of why the misinformation is incorrect. Therefore, we are currently investigating whether 3-dimensional visualizations can help students revise faulty prior knowledge for geological information. Of course, the effectiveness of these visualizations will depend not only on the types of visualizations presented, but also whether students' misconceptions are essentially 'visual' in nature. Examples of these types of misconceptions may include the rotation of the earth, earthquakes and plate tectonics, and the eruption of volcanoes.

To date, my research has focused on the cognitive processes necessary to understand language, texts, maps, and integrated multimedia. By focusing on these processes, I hope to develop more robust, naturalistic theories that account for comprehension across a variety of situations and experiences. The components of such a theory have important implications for describing the content, structure, and application of mental representations that are critical for higher-order cognitive processing. They also have direct implications for diverse research areas including the geographical sciences, human-factors design, and educational technology.

References

- Kendeou, P., Rapp, D.N., & van den Broek, P. (in press). The influence of readers' prior knowledge on text comprehension and learning from text. In *Progress in Education*. Nova Science Publishers, Inc.
- Rapp, D.N., & Kendeou, P. (2003, December). *Visualizations and mental models - The educational implications of GEOWALL*. Invited talk at the American Geophysical Union Fall Meeting, San Francisco, CA.
- Rapp, D.N., & Gerrig, R.J. (2002). Readers' reality-driven and plot-driven analyses in narrative comprehension. *Memory & Cognition*, 30, 779-788.
- Rapp, D.N., & Taylor, H.A. (in press). Interactive dimensions in the construction of mental representations for text. *Journal of Experimental Psychology: Learning, Memory, and Cognition*.
- Rapp, D.N., Taylor, H.A., & Crane, G.R. (2003). The impact of digital libraries on cognitive processes: Psychological issues of hypermedia. *Computers in Human Behavior*, 19, 609-628.