Chapter 1
Knowledge Visualization as a Teaching Tool

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ABSTRACT

There are many applications and techniques where art makes the inherent component. Knowledge visualization is one of such instances, as a group of techniques for creating visual communication through images, graphics, and animations. Applications of visualization may include data-, information-, and knowledge visualization; scientific visualization; visual analytics; educational visualization, and many other ways to create sensory, often interactive representation of abstract data. This chapter introduces basic visualization concepts and then discusses several related issues including metaphors in visualization, bio-inspired applications and apps, knowledge visualization based on visual literacy, visualization aesthetics, and criticism of visualization, product design and product semantics. Further part of the chapter puts forward a proposition of introducing knowledge visualization and programming from the beginning of schooling, and then discusses teaching with knowledge visualization and visual problem solving.

INTRODUCTION: BASIC VISUALIZATION CONCEPTS

Almost all people agree that visualization is useful in all disciplines and that communication is difficult without it. In educational psychology visualization means the ability to create symbols that allows communicating knowledge, conveying meaning, and changing tacit knowledge into explicit one by expressing it as mental representations and images. The most important domains in visualization are the data-, information-, and knowledge visualization. Multinational software developers create virtual, 3D reality, augmented reality interactive software, as well as immersive 3D displays and mobile applications. Rapidly evolving 3D printing (No author, 2016) technologies support developing visually rich materials.

Visualization has been usually described as the presentation of pictures showing easy to recognize objects that are connected through well-defined relations. It means the translation of mental, abstract, formal concepts into images by looking and seeing objects and processes. "Ability to perceive objects

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and events that have no immediate material existence made possible the visualization and creation of tools" (Ittelson, 2007, p. 279). According to Vickers, Faith, & Rossiter (2013), a general framework for understanding visualization includes: relationships between systems, data collected from those systems, renderings of those data in the form of representations, the reading of those representations to create visualizations, and the use of those visualizations to create knowledge and understanding of the system under inspection.

Visualization enhances cognition, reasoning, hypothesis building, and problem solving. Simulation often serves for education, for example in teaching coding, 3D modeling, and training drivers or pilots with flight simulations. Simulation allows designing scenarios for disastrous events or military training. Research and educational materials often present scientists and students with multi-dimensional presentations. Visualization techniques make an important part of the data science, which serves for extracting knowledge and insights from data (Wickham & Grolemund, 2017).

As it's generally known, visualization refers to changing the numerical data (which may be 1D, linear, 2D, or 3D) into graphs, clouds, tree visualizations (Chen, 2010, Shneiderman, 2014), and metaphorical visualization designs (Lima, 2011, 2017). Visual analytics, educational visualization, and many other visualization techniques create sensory, often interactive representation of abstract data. Information visualization that links art, nature, and science, shows the data interactively in many dimensions. Scientific Visualization was established in 1985 at the National Science Foundation panel and deals with physically-based data defined, selected, transformed, and represented according to space coordinates, such as geographic data or computer tomography data of a body for medical use. Researchers utilize visualization tools to understand better the massive amount of complex biological data and provide new biological insights. To visualize something that is one nanometer large and to compare it to one inch, we may think about comparing a dice to the whole Earth. Moreover, current visualizations became dynamic, interactive, and web accessible. D3 (data driven documents) is a JavaScript library created by Mike Bostock, which serves for building web accessible data visualization. D3 enables developers to create interactive, animated, online data visualizations, and to tie them to existing page elements (Meeks, 2017; Murray, 2013; King, 2015).

Designing visualization tools that support research requires collaboration between biology and computing science specialists. The traditional way of presenting a double helix of amino acids is one of the most popular educational applications of scientific visualization. Especially, the popular biological visualization on the molecular or nanoscale level is a colorful, often rotating, animated picture of a DNA (deoxyribonucleic acid) structure. Several authors, for example Manuel Lima (2011, 2017) and Nathan Yau (2011, 2013) published collections of aesthetically stunning visualizations. Authors, for example, Przemyslaw Prusinkiewicz (1996) or Clifford A. Pickover (2015) transform visualization techniques into art works. Photonics, and especially biophotonics offer visualization possibilities in nano-scale. With a hybrid approach, integrated circuits use silicon as substrate for electronics and another material for photonics. Such biophotonic probes provide real-time imaging and sensing; they can stimulate neurons or provide targeted drug delivery. Micro-endoscopes make possible to guide surgical tools (Lan Luan et al., 2017). A light-sheet microscope enables watching living specimens such as a growing fruit fly embryo with a nervous system labeled fluorescently. Christian Orfescu introduces NanoArt as a visual aid for education in nanoscience and nanotechnology.

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