Preface

If you know a bit
About the universe

It's because you've taken it in
Like that,

Looked as hard
As you look into yourself.

Seamus Heaney (2010, p. 43).

This book is a collection of essays written by specialists in related areas and digital artists inspiring themselves with science. In the following chapters, professionals in selected fields of science and art discuss knowledge visualization applied to their fields, with the focus on the knowledge visualization content rather than the technical solutions. The book comprises six sections pertaining to: Perception and Cognition; Art-Math-Science Connection; Cognitive Computing and Programming; Visual Interpretations; Cognitive Creativity; and Visualizing Teaching and Learning.

 Chapters of this book are directed at professionals and students keen on comprehending and enhancing the role of knowledge visualization in computing, sciences, design, journalism, media communication, film, social networking, advertising, and marketing. Depicting relations between processes and products may become an interesting and challenging opportunity for people working in computer science, engineering, and sciences. These features make this text of service to potential instructors because of its novel approaches to the visual way of learning, using the Internet by students, and making knowledge visualization an integral part of the learning process.

The title Handbook of Research on Maximizing Cognitive Learning through Knowledge Visualization contains notions of ‘learning’ and ‘cognition.’ Both processes are complex and they are described in many ways depending on a discipline in which they are studied. For this reason these notions are always open to discussion. The same may be said about some other concepts such as ‘mind,’ ‘consciousness,’ or even ‘art.’ This book examines cognitive tools for learning about scientific concepts, and the ways multisensory visualizations of such concepts may serve for computing solutions in ever-changing technology that targets more of our senses.
The topic of cognitive learning is relevant to the use of computers and computing. We can see programming and computing as significant revolutions in science. Before developing instruments and technologies people were describing the world and predicting scientific laws (including micro-macro relations) in mathematical terms. While mathematics has been enabling people to delineate and explain the world, advances in computing and programming move knowledge into action, which results in further progress in science and practical applications.

The general goal of the book is to discuss a possibility of fortifying the learning of science, programming, and computing. This book aims at applying everyday analogies and metaphors related to our various senses to create visual strategies that link fragments of notions into cohesive structures.

Visual learning projects combine computing (a tool) and knowledge (a goal) with visual arts (the means). They use forms of a written text, mathematics, social, and physical sciences. Topics support cognitive learning by interlocking familiar concepts with selected fields of science through visualization of processes and products. Graphics and visuals display practical applications to technology-based creativity, computing, and programming. Projects bridge a gap between science and everyday problems by imaging data and concepts with knowledge visualization techniques.

Learning any human or computer language comes easier for a young, still developing mind than for an already formed one. Since young minds are not yet shaped by stereotypes and rules, exploration can be seen as creation and natural inventiveness. Exploration becomes a valid tool in education based on cognitive learning. Visual coding is a logical beginning. A need for coding for visuals (practical apps for phones, tablets, or the gaming for education) makes programming skills profitable. Many students feel lost about choosing their future profession. The coding might become their passion and thus solve their tiresome career choice dilemmas. This approach supports also the collaborative venues, and can possibly motivate people to become more curious. Startups seek talents through testing the skills, flexibility, character, learnability, and reactivity in various individuals, thus talented, motivated people often find suitable jobs despite of their lack of training or experience.

The existing and potential possibilities of exchanging information exceed those relating only to a text. The idea of going beyond the verbal implies seeking for the progressive, proactive, and inclusive ways of thinking about achieving knowledge, creating meaning based art, or providing amusement and enjoyment. Non-verbal communication through the digital and virtual media includes visual ways of displaying, sharing, and organizing the data. Techniques may involve both portable devices and an installed program, software, or database stored in a computer; they may include equipment for the games, virtual simulations, augmented reality images, online communication software, such as like Skype or many other kinds of applications. Information technology, computer graphics, visualization, animation, digital storytelling, and digital photography may support visual learning.

The leading theme is an inquiry about visual presentation of knowledge through art inspired by science-related themes. This theme starts where books on computer graphics usually stop. It tells what can be done with skills in computer graphics in order to present concepts and info with visual power. For many, collaboration with visual artists opens new opportunities, while others strive to develop communication by applying ready clipart images, stock photos, or backgrounds. An opinion is now well established that art, graphic design, visual storytelling, and the use of signs, icons, and metaphors support technical presentations and conceptual diagrams. Visual literacy is seen essential in producing knowledge visualization.
The role of sensory perception grows in importance because of the pervasive presence and common use of cell phones, apps, tablets, boards, bots, and games. They are in most cases networked, interactive, and often supported by augmented reality techniques relying on many senses. Like in a Newton’s cradle, each application unites its digital content with the physicality of the device, thus addressing our various senses. Cognitive tools for understanding scientific concepts and multisensory visualizations of such concepts might have an impact on interactive communication and social networking. The book also examines biologically inspired computing in relation to technical solutions and the aesthetics of presenting data and information in a visual way.

Computing somehow inspires the brain. Computers added a lot to our thinking. There also come biology-inspired computing, art, and technology. We can study human brain and human condition, but we still have problems with studying human mind. It’s difficult to draw a distinction between cognitive thinking and unconscious thinking, insight, iconic thinking, metaphorical thinking, and many other functions of our minds. The notion of ‘mind’ has been examined by many in different ways: from application of tools, through parapsychology, Buddhism or Zen, to different visualization techniques. In the history of human thought we may find many cases where we cannot tell whether the synthetic thought results from mind-brain cooperation, visualization, subconscious processes or other factors. We do not know whether Pythia, Joan d’Arc, leaders, healers, wizards, witches, saints, paranormal healers, tarot card future tellers, and geniuses in science had unnatural qualities of their brain, talent, visualization, holistic approach versus detailed analysis or possession of senses unknown to us. In such cases, we think about ‘mind.’ We do not know how the migraine and maybe epilepsy aura may change the brain functions and why a migraine aura may make one’s brain or mind more sharp and inventive. Studies on mind engage interest of specialists in various fields such as anthropology, sociology, mathematics, physics, astronomy, statistics, probability and predictability specialists, neuroscientists, and others. We know too little about sleep and dreaming; the same is with the role of emotions and preferences of different types as motivators changing the efficiency of our thought processes.

Our cognition requires the reason-based thinking and demands a proof for everything. This book connects visual, artistic, mathematical, philosophical, and metaphysical concepts with knowledge visualization through technology. There are many notions we cannot define, knowing that thinkers from countries such as Persia, ancient Greece, or China may see these notions differently. Structures such as mandala are not completely explored and take various dimensions. We even cannot fully define what is balance, good or bad qualities, beauty, ugliness, or evil. To delve into this matter more deeply, scientists examine fractal structures, chaos, natural phenomena, math (Fibonacci sequence, golden section, symmetry, numbers) but also alchemy, knowledge about herbs and stones, Fen Shui, a wabi sabi world view, the role of mind in genius, savant syndrome and special talents in autistic people, eidetic memory, ‘eureka’ moments, sexual orientation, etc. Maybe that is the reason there are so many religions. Many of these ambiguous terms, if discussed by particular specialists, might be defined differently. We do not know what does it mean to have talent, giftedness, focus, predisposition, magic, absolute hearing, color predisposition, and inheritance of an artistic, mathematical, or scientific talent. From thousands of years various cultures and civilizations in various geographic places approach cognitive activities differently: they use, dwell upon, hire, explore, support, punish, restrain, prohibit, constrain, exclude, prohibit, or outcast them in different ways.
CHAPTER DESCRIPTIONS

Section 1 of this book contains three chapters that examine the notions of Perception and Cognition. Anna Ursyn explores in Chapter 1, “Cognitive Learning with Electronic Media and Social Networking,” the ways of exchanging information through knowledge visualization and possibilities of the verbal or nonverbal ways of communication occurring in a classroom and online. Cognitive activities under discussion include cognitive thinking, cognitive science, and cognitive learning with knowledge visualization with the use of computer technology, carried out through the social networking, and conducted with the use of educational games. Description of learning with communication media and discussion about criticism and assessment with respect to digital art and graphics conclude the chapter. Michael Eisenberg and Ann Eisenberg describe in Chapter 2, “Sensory Extension as a Tool for Cognitive Learning,” how educational technology, not limited to computers, may serve as a means of sensory extension rather than classroom instruction. They explore the potential of sensory augmentation for science and arts education, viewing sensory extension as complementary to the existing traditions in educational design; also, in the light of the previous sections, they are revisiting the discussion of metaphors, and how they structure educational design. Marcin Brzezicki presents in Chapter 3, “Simultaneous Perception of Parallel Streams of Visual Data,” a study of the perceptual processes that could become a design tool that allows the designers to manage the transfer of information. The author combines knowledge from the fields of cognitive science, geometrical optics, graphic design, and architecture to examine the perceptual processes involved in the parallel processing of visual data.

Section 2, “Art-Math-Science Connection,” comprises four chapters focused on visualization of knowledge in several fields of mathematics and science. Hervé Lehning presents in Chapter 4, “Visualisation and Mathematical Thinking,” examples showing how proofs, concepts, and ideas are easier to understand with the help of a small drawing, and how visualisation in mathematics is helpful not only to illustrate but also to create ideas. Anna Ursyn describes in Chapter 5, “Duality of Natural and Technological Explanations,” visual interpretations of natural and human-made events as examples of cognitive solutions for knowledge visualization and indicates the importance of the visual part of knowledge presentation for cognitive learning. The leading theme is integration of multiple disciplines toward developing an interdisciplinary way of delivering knowledge through visualization-related electronic visuals, nowadays needed in probably every discipline. Chapter 6, authored by Jean Constant and entitled “Random Processes and Visual Perception: Stochastic Art,” examines stochastic processes that are associated with the concepts of uncertainty or chance. The author explores in visual terms a model of recursive thinking applied to a stochastic problem, using a graph theory reference model called the ‘shortest route problem.’ In a Chapter 7, “Science of the Archives: Visual Learning about Plants,” Maura Flannery argues that in a visually rich world, which is available at the Internet, one way to create visual literacy and sophistication in the use of visual information is through the informed use of digital archives.

Section 3 includes three chapters pertaining to Cognitive Computing and Programming. In Chapter 8, “Visualization by Coding: Drawing Simple Shapes and Forms in Various Programming Languages,” Anna Ursyn and Mehrgan Mostowfi introduce readers to basic programming concepts through coding visualization of a horse rider – a simple 2-dimensional shape and then a 3-dimensional form. Authors encourage computer scientists to apply visual ways of dealing with concepts and objects to be programmed. They also present how the more complicated digital art can be produced through transformation of the same selected image using several programming languages. In Chapter 9, “Building a Computer,” Andrew Liccardo and Cameron Grimes describe the philosophy and task of building a computer to provide
students with the understanding of the structure and functions involved in computing. The process of
planning, acquiring, and building a computer is discussed as a cognitive way of learning and sharing
Visual System and Method for Teaching and Learning Programming and Problem Solving through
Knowledge Visualization,” the programming visualization accessible through the web for teaching,
learning, programming, and problem solving, and accomplished through steps such as plan abstraction,
plan composition, language constructs, and program execution. VPCL can be applied to other problem
solving tasks such as mathematics, science, physics, chemistry, biology, or linguistics.

Section 4, “Visual Interpretations,” consists of four chapters concerning visualization. Chapter 11,
entitled “Connecting the Dots: Art, Culture, Science, and Technology,” presents an interactive graphics
installation built with an open source programming language, which visualizes real-time data, multi-
cultural mandalas, scientific imagery, and cosmological symbols. This interactive revolving graphical
system is an exploration into uncharted territories of the human soul sculpted by our present time. Mod-
ules of the architecture underlying Living Mandala comprise the interactive vector graphic system, the
color alternation and movement determined by algorithm, live video feed, motion and audio detections
of its surroundings, and online weather data of the local temperature. Theodor G. Wyeld describes in
the Chapter 12, titled “Re-Visualising Giotto’s 14th-Century Assisi Fresco ‘Exorcism of the Demons at
Arezzo,’” a process of creating an interactive 3D model of Giotto’s fresco, which provides a source for
analysis of Giotto’s depth of knowledge and understanding of spatial concepts. In this study, Giotto’s As-
sisi fresco was modeled and analyzed in three-dimensions. The process revealed that Giotto’s techniques
for creating the illusion of depth in his paintings were more advanced than previously reported. The
3D modeling of the fresco revealed much that could not be deduced by other means. Veslava Osinska,
Grzegor Osinski, and Anna Beata Kwiatkowska emphasize in Chapter 13, entitled “Visualization in
Learning: Perception, Aesthetics, and Pragmatism,” that information visualization techniques are being
more and more widely applied in education as a data analysis tool and considered a way of communicat-
ing knowledge. Process implementation of visualization maps should be supported and developed in
e-learning platforms. Mapping of information requires interdisciplinary collaboration between researchers
in different fields who can perceive and apply contemporary trends in visualization including natural
shape perception, 3D representation problems, as well as the aspects of neuroaesthetics. In a Chapter 14,
“Analyzing Disney’s Early Exhibits as Installation Artwork,” Jonathan Lillie and Michelle Jones-Lillie
compare several Disney exhibits to explore the importance of narrative and textual reference in creat-
ing powerful immersive installations as presentation of technological and scientific knowledge through
multiple media. They discuss how some educational institutions have used experiential education instal-
lations, especially for teaching scientific concepts.

Section 5, “Cognitive Creativity,” contains three chapters authored by digital artists. Chapter 15,
“Digitally Mediated Art Inspired by Scientific Research: A Personal Journey,” written by John Antoine
Labadie is an account of the author’s artistic practice from pre to post-digital activities showing a range
of influences, activities, and experiences that demonstrate the progress in scientific illustration, computer
science, and the author’s artistic practice from pre to post-digital activities. Joohyun Pyune examines
in Chapter 16, “On Creativity of Asian and American Asian Students,” the ways of encouraging Asian
and American Asian students to apply their creativity and independent cognitive thinking. The author
describes exercises aimed at combining ideas from both their cultures. The author proposes discus-
sion that would analyze the presumed students’ thought processes and define future assessment of the
efficiency of particular exercises by testing students’ solutions and abilities. Chapter 17, “AiryLight:
Ambient Environmental Data,” by Annelie Berner explores the practice of combining ubiquitous computing—information in everyday objects with the approach of calm technology—designing ambient, intriguing presentations of information. The AiryLight is a combination of visualization and art; it creates an opportunity to reflect upon the issue of air quality through an object such as AiryLight. The author presents the concept of combining three sensory methods to strengthen learning in unexpected situations.

Section 6, “Visualizing Teaching and Learning,” discusses data visualization methods as an approach to enhancing student learning. Pamela G. Taylor focuses in Chapter 18, “What Does Learning Look Like? Data Visualization of Art Teaching and Learning,” on data visualization principles and design thinking methods/categories as possible approaches for mining and representing new and old technological data associated with teaching and learning in the visual arts. The author’s research positions the visual arts as a common thread throughout disciplines and discusses the ways to implement authentic embedded assessment processes across education disciplines and grade levels. Lihua Xu, Read Diket, and Thomas Brewer discuss in Chapter 19, entitled “Bringing the Arts as Data to Visualize How Knowledge Works,” the ability of field specific and domain-centered batteries of tests to work as indicators of progress in knowledge and skill. The authors state, data visualization affords a means of comparing findings across national assessment subject areas in ways that audiences can understand.

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REFERENCE