Preface

The book entitled “Knowledge Visualization and Visual Literacy in Science Education” is a collection of essays written by science related professionals, specialists in selected areas, and digital artists inspiring themselves with science. The book comprises visual and verbal information introducing the work done by individual authors – contributors to this book. Chapters pertain to several scientific fields, digital art, computer graphics, and new media. Co-authors discuss the possible ways that visuals, visualization, simulation, and interactive knowledge presentation can help understand and share the content of scientific thought, research, and practice. Works created by the co-authors, students, and professional artists illustrate their views and concepts.

CHALLENGES AND POSSIBLE SOLUTIONS

The reason for writing this edited book was to create a first-hand, innovative handbook about presenting in visual way the selected science domains. This book comprises visual and verbal information pertaining to particular scientific fields, digital art, programming, computer graphics, and new media. Concepts and processes related to science have been introduced for teachers and learners through graphical interpretation and explanation of science-based occurrences, processes, products, and facts. Physics has been examined at the macro-, micro-, and nanoscale level, for example by telling about the nanotechnology related tools such as biophotonics. Mathematics can be seen through the natural world (Fathauer, 2016); math proofs, works, and animations can be presented in a visual and tactile way without words and numbers (Gurke, 2016; Li, 2016). In this book, knowledge about the events and processes is integrated with visual, literary, and musical achievements related to the theme, facts about human existence on our planet, and the actual global issues.

Concepts and processes are presented as learning projects based on these materials. Information about several fields of science and teaching strategies with visual approach draws from recent developments in the cognitive approach to teaching and learning. A visual approach to learning became necessary because science, education, and media communication unify pictorial and written data. Information is often displayed with the use of knowledge visualization techniques, when computers transform data into information, and visualization converts information into picture form.

The book may serve as a resource book for cognitive learning with the use of visualization, programming, computer graphics, new media, and digital art disciplines. Materials for learning can be used as a resource for art history, scientific visualization, and technology-related education. Topics and projects
preface

presenting life and nature related disciplines in terms of concept visualization draw from the biology-inspired events existing in real life, but familiarize the readers with more complex disciplines and their applications and specialty pursuits.

A rationale for writing on integrative approach to the book’s themes comes from a great need for the inclusion into instruction the familiar concepts and applications used everyday by students, like computers, communication media, TV, multimedia, online protocols, and games. Every medium can be put in service of teaching as the container for stories or narratives, with plots and characters, which allows packaging information into various forms. It seems reasonable to assume that merging verbal and visual ways with communication media makes the central part in scientific visualization and simulation, virtual reality environments, web based environments, web graphics, game design, visualizations of big sets of data, semantic web, data mining, and many other tasks and areas of interest.

Teaching the Science: Art Context with Integrative Approach

The book comprises chapters contributed by cooperating specialists who share their knowledge and insight about communication and learning with the use of relevant graphics, music, and text. Their chapters may serve as an in-depth, timely reference source; they are targeted towards the interests of instructors, fellow researchers, and students, for course adoption, and for university libraries as reference materials.

Effective education involves technology-based communication between teachers and students comprising the verbal, auditory, and visual modes. The multi sensory approach became needed because of the importance of knowledge visualization in teaching and learning, the existing multimodal input from online resources, and the multimedia content of interactive textbooks and online educational materials involving text, audio, still images, animation, and video footage.

Traditional schooling had been focused on developing memory skills. At present, a necessity of coping with large amount of information creates a need to expand abilities of higher order thinking, visualization, and understanding of abstract concepts. This model of learning supports learning by visualization of concepts and shifts the college and high school students’ attention toward imaging processes and products involved in an event under study. It thus stimulates thinking about links between concepts rather than rote-based learning. That means this book develops the functional and conceptual ways of learning, instead of mechanical repetition of concepts to be learned by rote. Research results suggested that students working in a group that visualized concepts scored better at the geology final tests and the lab tests (Ursyn, 1997). In addition, drawings may reveal what are the students’ preconceptions.

Concerns about Science Education

Current disciplines and the fields of study are necessarily based on collaboration of specialists within different disciplines (such as in the domain of archeology) and of people with different types of talents (e.g., in film industry or big entertainment companies such as Walt Disney Company). Hence, division of specific subject areas such as physics, chemistry, or biology, which is practiced in the high school curricula, is not supportive of the scientific concepts’ understanding, nor it is encouraging the learners to further their studies in the more specific but integrative areas such as biochemistry, geophysics, or astronomy.
Many disciplines (such as medicine where a basic background knowledge of chemistry, physics, biochemistry, and physiology is needed) remain almost totally unknown and unexplored for high school students who look for orientation about further studies or a job that would fit their talents and interests. This is so because school curricula do not include these topics into the subject matter under study.

Teaching science with an integrative approach and making learning topics closer to future professional tasks may augment students’ motivation and interest in learning. Developments in new materials result in developments in ubiquitous computing and wearable apps, with huge educational implications. Teaching with the use of current applications and devices may arise motivation and support students’ wish for achievements. Leonard Sax (2009) discusses factors driving the growing epidemic of unmotivated boys and underachieving young men. This author considers five factors: video games, teaching methods, prescription drugs (especially medications for ADHD—attention deficit/hyperactivity disorder), environmental toxins (which he regards as the endocrine disruptors), and devaluation of masculinity being the major agents that cause the decline in numbers of motivated learners and future achievers.

Along with studies on recent advances in the selected fields of science, the Handbook contains learning projects for the readers, both the learners and their instructors, especially teachers from the school districts that adhere to the STEM or STEAM programs. Learning projects offered in this book would comply with the actual trends in education described as the STEM (science, technology, engineering, and mathematics) and the STEAM (science, technology, engineering, arts, and mathematics) programs in education. The book provides background information related to selected projects, and then offers integrative learning assignments designed in the spirit of the STEAM education.

Many educators have been working toward transforming STEM into STEAM as a framework for teaching across the disciplines. A growing number of schools move from STEM to STEAM (STEM to STEAM, 2014; Gonzalez & Kuenzi, 2012). The STEM fields of study are becoming the STEAM fields in education (science, technology, engineering, arts, and mathematics) (Maeda, 2012). This trend results from the presence of technological literacy in small children who can now use software teaching them science, mathematics, programming, and storytelling. Not only we should integrate scientific, technical, and artistic topics, but also construct, envision, and explain through visualizations and interactivity (Honey, Pearson, & Schweingruber, 2014). Involving programming and solving problems through knowledge visualization should enhance programs for Studio Art. Students should learn, create, and play together globally through games, VR, apps, social networking, and meaningful communication. K through PhD (DeVry University, 2014). The innovative ideas and timely research will create beneficial contribution to the research community.

Developing imagination may happen due to digital animation and filming techniques that make that the impossible actions of Superman or Batman look real. However, fantasy and imagination presented in digitally created stories rarely surpass accomplishments of the pre-computer works such as Gulliver’s Travels (1726) by Jonathan Swift, Frankenstein (1818) by Mary Shelley, Alice’s Adventures in Wonderland (1865) by Lewis Carroll, The Lord of the Rings series (1954-55) by John Ronald Reuen Tolkien, and fictional characters such as Count Dracula, Nosferatu, Dr Jekyll and Mr Hyde (1886, by Robert Louis Stevenson), Dorian Grey (1891, by Oscar Wilde) or The Little Prince (1943, by Antoine de Saint-Exupéry). It is not surprising that authors of comic books, games, animations, and movie scenarios remake these works in many ways, with the results that overshadow many other attempts.
ORGANIZATION OF THE BOOK

The book is organized in four sections that are introduced shortly below.

Section 1, entitled Cognition and Visual Literacy comprises four chapters. In Chapter 1, Teaching and Learning Science as a Visual Experience Anna Ursyn discusses teaching and learning across the disciplines by introducing topics and activities pertaining to science, computing, and graphic arts as a unified cognitive and visual learning experience. Theoretical framework is presented, to support designing integrative projects for cognitive learning, and then the ways to communicate knowledge, visual thinking, visual literacy, and knowledge visualization. Concerns about science education draw attention to a need of including into curriculum new developments in science and information about currently emerging disciplines. Greg P. Garvey examines in Chapter 2, Exploring Perception, Cognition, and Neural Pathways of Stereo Vision and the Split Brain Human Computer Interface research from psychology of perception, cognition, and the visual arts, and describes the experimental the split-brain user interface. Chapter 3, Better Visualization Through Better Vision by Michael Eisenberg discusses the developing of animated simulations, interactive interfaces to large information spaces, or embedding aural cues within diagrams as the way to improve scientific visualization. Jean Constant offers in Chapter 4, Visual Approach to the 4th Dimension in Mathematics, Computing and Art an overview of the different schools of thought in the humanities and science about the concept of 4th dimension, especially in mathematics and visual imaging.

Section 2, Visual Communication and Knowledge Visualization describes instances of knowledge visualization in selected areas: biology, mathematics, digital media, and music. Authors present their conceptions of visualization with the use of implements used in their domains. Maura Flannery describes in Chapter 5, Visualization in Biology: An Aquatic Case Study algae – photosynthetic organisms that live in aquatic environments, as a good subject to explore the intersection of art and science with students, and discusses observation, comparison, and drawing as key tools in learning about the living world. In Chapter 6, Visualisation and Communication in Mathematics, Hervé Lehning offers the ways of communication in mathematics using the aesthetic drawings to set a problem, to understand it, to find a method to tackle it and to illustrate it. In Chapter 7, Understanding Collage Strategy as a Learning Method and Its Use in Digital Media Dennis Summers analyzes and defines collage in some of its many forms including artists’ books, cinematic film, and digital media; he reviews the use of digital software and the pedagogical implications of collage. Robert C. Ehle examines in Chapter 8, How we Hear and Experience Music the occurrences and events associated with composing, playing, or listening to music, virtual music, and then recounts an experiment on the nature of pitch and psychoacoustics of resultant tones. Then he discusses the prenatal origins of musical emotion as the case for fetal imprinting.

Section 3, Computing and Programming delves into selected methods aimed at assisting the learners in acquiring computing and programming skills with the use of video tutorials and metaphorical visualisation. In Chapter 9, Using Video Tutorials to Learn Maya 3D for Creative Outcomes: a Case Study in Increasing Student Satisfaction by Reducing Cognitive Load, Theodor Wyeld describes the transition from traditional front-of-class software demonstration of Autodesk’s Maya 3D to the introduction of video tutorials, and finds that the introduction of video tutorials for learning Maya 3D reduced frustration and freed up time for more creative pursuits. Anna Ursyn, Mohammad Majid al-Rifaie, & Md. Fahimul Islam offer in Chapter 10, Metaphors for Dance and Programming: Rules, Restrictions, and Conditions for Learning and Visual Outcomes an overview of programming with ready to follow codes, and visual explanation on how to code using dance as a metaphor.
Section 4, *Educational Applications and Cognitive Learning* provides theoretical and practical materials supporting teaching and learning science. In Chapter 11, *Optimizing Students’ Information Processing in Science Learning: A Knowledge Visualization Approach*, Robert Zheng & Yiqing Wang discuss a theoretical framework for designing effective visual learning in science education, and identify the variables in visual learning and the instructional strategies that aim at the improvement of visual performance. Chapter 12, *Integrative Visual Projects for Cognitive Learning* by Anna Ursyn comprises integrative studies on selected processes, events, and related technologies associated with several science categories, and offers learning projects designed around the themes derived from the nature and science in terms of concept visualization, including selected subjects pertaining to physics, chemistry, biology, geography, and biology-inspired computing and modeling. Donna Farland Smith, & Kevin Finson *Visualizing Scientists & Engineers: Uncovering How Children View Science Related Careers and it’s Importance to Science Identity* discuss in Chapter 13 multiple tools for analyzing children’s representations of scientists and engineers.

REFERENCES


