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978-0-521-11982-5 - Teaching, Learning, and Visual Literacy: The Dual Role of Visual Representation

Billie Eilam

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TEACHING, LEARNING, AND VISUAL LITERACY

Visual literacy is an increasingly critical skill in a globalizing, digital world. This book addresses the core issues concerning visual literacy in education, underscoring its importance for the instruction of students and educators. Professor Billie Eilam argues that the incorporation of visual skill development in teacher training programs will help break the cycle of visual illiteracy. Understanding the pedagogical benefits and risks of visual representation can help educators develop effective strategies to produce visually literate students. Eilam presents a broad overview of theoretical knowledge regarding visual representation, as well as a discussion of best practices for the use of visual elements in schools. In addition to theory, Eilam includes practical exercises for introducing visual literacy into teacher education, offering strategies for analyzing visualization in curricula and for increasing awareness of visual culture.

Billie Eilam is Head of the Department of Learning, Instruction and Teacher Education at the University of Haifa, Israel. Professor Eilam's research focuses on cognitive aspects of visualization in teaching, learning, and curriculum, particularly in the science domain, and on applying theories to authentic learning situations. She has co-authored several books in Hebrew on the subjects of ecology and inquiry skills, presents regularly at international educational conferences, and publishes widely in leading refereed journals including *Learning and Instruction*, *The Learning Sciences*, *Curriculum Studies*, *Teaching and Teacher Education*, and *Contemporary Educational Psychology*. Her latest published work examines visualization in biology. Professor Eilam has been actively involved in education reform efforts throughout her career, serving as the Head of the Department of Teacher Education and guiding several grant-funded curriculum development projects.

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Teaching, Learning, and Visual Literacy

The Dual Role of Visual Representation

BILLIE EILAM

University of Haifa



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To Gerry, my beloved husband, who is always at my side

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Foreword

The Role of Visualizations in Learning and Teaching

Richard E. Mayer

University of California, Santa Barbara

Although verbal representations – such as printed or spoken words – hold a privileged place in education, there is growing consensus among educators that the concept of literacy should be broadened to include visual representations such as illustrations, photos, animation, and video (Coiro, Knobel, Lankshear, & Leu, 2008; Mayer, 2009; Pailliotet & Mosenthal, 2000). *Teaching, Learning, and Visual Literacy* by Billie Eilam is an impassioned and informed call for educators to consider the role of visualizations in education – that is, a call for teachers to increase their interest in visual literacy.

In this book, Prof. Eilam talks about the “dual function” of visual literacy, by which she refers to the idea that when teachers increase their visual literacy they improve as teachers because they are better able to select, construct, and use appropriate instructional communications that include visualizations, and they improve as learners because they are better able to make sense of communications that include visualizations. Consistent with the teaching-learning duality proposed by Prof. Eilam, I have defined multimedia literacy as “being able to generate multimedia communications that others comprehend and to comprehend multimedia communications that others generate” (Mayer, 2008, p. 359). In short, this book asks teachers to recognize that they can improve as teachers and learners when they improve their knowledge of how to use and interpret visual representations.

The central characters in *Teaching, Learning, and Visual Literacy* are visual representations, which Prof. Eilam lovingly refers to as VRs. She notes that the term “visualization” can be used to describe the external representation (e.g., a graphic that is presented to a learner) or the internal representation (e.g., the learner’s mental representation of the graphic in working memory). An important role for teachers involves understanding how students process VRs (i.e., convert them from external to internal visualizations) and helping students do so more effectively. Importantly, she posits that interpreting VRs

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involves both cognitive and affective processes. Thus, the internal-external dimension and the cognitive-affective dimension can be seen as two additional facets of duality, among several others described in the book.

Prof. Eilam's call for an increased focus on the visual side of teaching and learning is consistent with my own program of research showing that people learn more deeply when they learn from words and graphics rather than from words alone (Mayer, 2009). I refer to this idea as the *multimedia principle*, and it has been supported across more than a dozen experimental comparisons, yielding an effect size greater than 1 (which means that people's performance on tests is more than one standard deviation higher when graphics are added to a purely verbal lesson).

In her analysis, Prof. Eilam separates VRs into static and dynamic types. Static visual representations include printed text, photos, pictures, diagrams, charts, maps, graphs, and tables. Dynamic visual representations include films, video, and animation. According to Prof. Eilam, teachers need to help students learn how to make sense of these kinds of VRs and how to use them to help other people learn.

If you are interested in how VRs are currently being used in schools, you will find some fascinating examples in this book. If you are interested in students' and teachers' conceptions of VRs, you will also find some fascinating case studies in this book. If you are interested in the cognitive science of how people process VRs, you will find a useful overview of evidence-based cognitive theory. Prof. Eilam's book also provides you with an excellent review of research and theory on how to help people learn with words and graphics, including research-based principles of multimedia instructional design.

Teaching, Learning, and Visual Literacy reflects yet another duality because it is both scholarly and practical – that is, it proposes a teacher education program for visual literacy that is grounded in research and scholarship in the field. By building on the existing research and scholarship base in multimedia learning, Prof. Eilam is able to offer a potentially valuable framework for how to incorporate visual literacy into teacher education programs.

In conclusion, not only does this book survey research on visualizations in education and provide a rationale for visual literacy; it also proposes a curriculum framework for incorporating visual literacy into teacher education programs. Prof. Eilam offers a “vision of the visually literate teacher” and calls for developing teacher education programs aimed at this goal. The core theme of this book is that “teachers must develop visual literacy themselves, as learners and consumers, and also must concurrently undergo explicit training to enhance such competencies among their students.” To the extent that this

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book causes improvements in teachers' visual literacy and in their ability to foster visual literacy in their students, it should be considered a success.

References

- Coiro, J., Knobel, M., Lankshear, C., & Leu, D. J. (Eds.). (2008). *Handbook of research on new literacies*. New York: Erlbaum.
- Mayer, R. E. (2008). Multimedia literacy. In J. Coiro, M. Knobel, C. Lankshear, & D. J. Leu (Eds.), *Handbook of research on new literacies* (pp. 359–376). New York: Erlbaum.
- Mayer, R. E. (2009). *Multimedia learning* (2nd ed.). New York: Cambridge University Press.
- Pailliotet, A. W., & Mosenthal, P. B. (Eds.). (2000). *Reconceptualizing literacy in the media age*. Stamford, CT: JAI Press.

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Preface

We live in a visual world, consume visual messages daily, and produce them through internal and external representations as an inherent part of communicating and clarifying thoughts and ideas to ourselves and to others, as beautifully expressed by Gould in his book *Dinosaur in a haystack: Reflections and natural history*: “The central role of pictures, graphs, and other forms of visual representations [lies] in channeling and constraining our thought. Intellectual innovations often require, above all else, a new image to embody a novel theory. Primates are visual animals, and we think best in pictorial or geometric terms. Words are an evolutionary afterthought” (Gould, 1995, p. 249).

Within all facets of Western society, the ever-growing reliance on visual representations calls for special efforts to understand their meanings and to use and create them for communication. Representational systems of signs and symbols help people make sense of phenomena in the world around them and reach shared meanings for these phenomena, hence contributing to the production of common cultural practices.

Visual Representations in Education

This book addresses an important yet hitherto mainly overlooked educational issue: the introduction of visual literacy into teacher education. The term “visual literacy” relates to individuals’ knowledge about various visual representations and the individuals’ abilities to interpret them, use them efficiently, and even create them for communicating information (see Chapter 5 for elaboration on this term). Visual representations like charts, graphs, maps, artworks, photographs, and so forth form an inherent part of the cognitive, cultural, and social aspects of learning and instruction for both students and teachers. As such, visual literacy deserves thorough examination regarding

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representations of universal information and of culturally driven information as well as in specific subject domains.

In educational contexts, teachers use an array of different visual representations for promoting their students' understanding of concepts, processes, structures, interactions, dynamic phenomena, and more. Visual representations permeate textbooks in all subject domains, frequently exceeding the space allocated to texts. Students are increasingly required to interpret visual representations in learning materials or in the media, to use them for problem solving in homework or exams, or to generate their own representations in the course of learning. Likewise, teachers use visual representations both for teaching and for their own professional development, as consumers.

Throughout the history of education, classroom instruction and learning have always involved various representations, but today's classrooms depend on them. It is almost impossible to teach science, math, or technology without graphs, tables, schemas, diagrams of processes, as well as three-dimensional (3D) models or pictures of molecular entities and processes. Some have contended that through the use and generation of various representations, and by watching others use them, students learn what science is and how to make scientific arguments (Roth & McGinn, 1998). Thus, it is not enough to engage learners in analyzing a preformed table or in drawing a graph from a given table of numbers. Instead, they need to be exposed to processes that lead to thinking with various visual representations in order to understand their nature and purposes (diSessa, 2004; Greeno & Hall, 1997).

The use of diverse representations is not limited to science; visual representations are used in almost all instructional domains. Geography relies on maps for the spatial organization of information regarding political issues, topography, minerals, plant or animal distribution, and population densities, or on 3D models of earth or the solar system. History and biblical studies rely on 3D models and pictures to describe life in different periods, but also timelines, historical maps depicting situations and processes, tables, and so on.

In most cases, teaching and learning rarely involve direct interactions with phenomena; instead, indirect interactions predominate – through external representations of those phenomena. After acquiring such external visual representations, learners may manipulate them in abstract forms. As suggested by Bruner (1961), learning progresses through three experiential phases: the enactive phase, the iconic phase, and finally the symbolic phase. Learning in the first, enactive phase is mostly based on individuals' haptic sense. In the second, iconic phase, learning occurs through observation of reality and reality-similar representations like photographs and realistic drawings. In the last phase, individuals are able to interpret and learn from symbolic

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representations. The many diverse forms of visual representations help facilitate these phases' progression from the concrete toward the abstract.

Despite the crucial role played by visual representations in everyday human life and particularly in education, it seems that in the Western world today, knowledge about representations is acquired implicitly – absorbed through individuals' rich visual experiences – rather than being taught formally as recommended for the instruction of cognitive skills. Sporadic random absorption, contrary to formal intentional learning, does not usually result in the construction of systematic and metacognitive knowledge that can be consciously and mindfully applied and transferred to a wide range of circumstances. It lacks individuals' full awareness of its properties and how they may be utilized in specific situations, for achieving particular, defined goals.

In recent decades, visual tools in education have come a long way from the multipurpose, generic instructional aides like slides, 8mm films, or transparencies that teachers once applied as secondary material to break up the monotony of verbal lessons and to trigger additional sensory channels. Back then, special courses in teacher education programs were devoted to training in how to use these predecessors to the current technology age in the classroom. Today it is time to move forward and expand educators' understanding of visual representations, not only to include at teachers' disposal appropriate usages of the vast range of visual tools based in technology and multimedia, textbooks, or human gestures, but also to enhance literacy in the powerful roles and functions of visual representations. Teachers must understand the diverse potential impacts of visual materials – as the primary route for directly representing information, as emphasizing and pointing out specific details of particular information, as a means for improving students' cognitive learning abilities, as enabling students to interpret information presented in various forms or to understand difficult phenomena, and so on. Furthermore, teachers must learn to design and adapt visual representations in line with the targeted learners' ages and specific characteristics; with the particular topics, issues, or learning goals; and with the given learning context. The need thus arises to develop pedagogy for the instruction of personal visual literacy for teachers on the one hand and for preparing teachers for this instruction with their students on the other hand.

Challenges in Teaching Visual Literacy

Acquisition of knowledge about representations poses difficulties. Phenomena and concepts have multiple, complex properties – concrete or abstract, visible or invisible, structural or functional. No one representation can represent

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all of these properties. Therefore, any given phenomenon can be represented in many different visual ways, each emphasizing only a few of these properties, depending on the specific learning context and goal. Teachers must be aware of these characteristics when considering the incorporation of visual representations for their own or their students' needs. For example, a graph representing a plant's growth rate over a year provides information only on this one specific plant, in the location and circumstances in which its data were collected; this graph does not provide any information on the plant's anatomy, physiology, evolution, and so forth. In the same manner, a chart representing a process can tell us nothing about its temporal characteristics, and so on.

Moreover, it is difficult to evaluate or predict the potential contribution of a particular visual representation to specific learning situations. This difficulty results from the many different global and situational factors inherent to learning contexts, such as students', teachers', and tasks' characteristics; the given knowledge domain; or the pedagogy applied. As just one example, research by Kozma and colleagues showed that teachers' experience level affected their ability to integrate visual representations with their other non-VR teaching representations (Kozma, Chin, Russell, & Marx, 2000; Kozma & Russell, 1997). Novice teachers, differently from experts, tended to use only the surface features of representations, which limited their ability to integrate them evenly and to promote students' understanding of the concepts taught. In contrast, expert teachers identified the deep principles embodied in representations, showed cognitive flexibility regarding them, and were able to move freely across representations, using them interchangeably and collectively in order to explain phenomena. Moreover, teachers who were well accustomed to using multiple representations found they could not effectively teach complex concepts when prevented from using their constructed visual representations to accompany their oral explanations (Kozma & Russell, 1997).

The Present Book

In view of all the aforementioned, my central claim in this book is that comprehensive knowledge of visual representations must become an inherent part of teachers' professional development. This knowledge base must incorporate visual representations' characteristics and inherent properties, their educational relevance, their advantages for learning or the constraints they may place on students' understanding, their interpretation or their generation, and principles of design related to stakeholders and contextual factors. I uphold that teachers, as the main agents of change in educational systems, should

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become visually literate by acquiring this knowledge through formal explicit learning of a curriculum offered in teacher development and in-service programs. My own experience with teachers leads me to believe firmly that such formal and comprehensive learning would promote both teachers' personal capacities to manipulate and consume today's visual world, thus producing visually literate teachers, as well as their continued professional development, especially their teaching abilities, thus producing a generation of visually literate students.

Thus, this book's focus on teachers' acquisition of visual literacy advocates gains not only in declarative content knowledge, but also in procedural knowledge. This focus emerges from a conglomeration of several contemporary phenomena: the sheer predominance of the visual world around us; the many evidences that abound indicating that teaching and learning do benefit from the use of diverse visual representations; increasing recognition of the central, inherent role that visualization plays in human thinking; the need to protect future citizens from the global threat of easily manipulated visual materials; and mostly the fact that the vast cumulative research knowledge on visualization's affordances and limitations for individual development has not successfully reached novice and expert teachers working in schools.

In this book, I present and discuss theoretical, empirical, and practical issues related to teachers' visual literacy. First, in Parts 1, 2, and 3, I outline the book's rationale, describe the current state of the art for visual literacy in teacher education programs, relay students' and teachers' voices and views about visual representations and about their role in learning and teaching, and clarify the dual function of visual literacy in the teaching profession. Next, Part 4 presents an overview of the available research on key aspects of this field, including perception, symbolic languages, properties of visual representations, and learning with them. Then, in Part 5, I discuss visual representations in textbooks, consider their possible influence on curriculum concepts and theories, and present a comprehensive schema for analyzing visual representations in textbooks. The sixth and main part of the book (Part 6) proposes a curriculum framework for integration of visual literacy into pre-service teacher education programs as well as into ongoing in-service professional development programs. I close the book with a vision of the visually literate teacher (Part 7). It is my hope that this volume will support educational researchers, teacher educators, textbook designers, and practitioners in their efforts to prepare visually literate generations who are ready to take on the challenges of our future, highly visual world.

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