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Integration of VRs into Teacher Education Programs

Past, Present, and Future

Having presented the rationale for explicitly integrating visual literacy and in particular visual pedagogical content knowledge into teacher education in the previous chapter, I now proceed here to review theory, research, and an Internet survey on past and present teacher education programs with regard to the implementation of VR-related curricula up to the present. Then, I recommend the key aspects of visual literacy that should be implemented in future program designs.

Past and Present Views of VRs in Teacher Education

During the first half of the twentieth century, teacher education programs mentioned VRs mostly as related to implementing audiovisual tools in classrooms. The goals of such educational practices were to raise students' interest and motivation, aid in learning, and exhibit to students a variety of different processes, experiments, or objects not accessible to observation in reality. For example, in 1957, Headd already called for teacher education programs to recognize their own "Achilles heel" – their lack of varied experiences with audiovisual materials. To prepare teachers adequately for future audiovisual instruction methods, he recommended the need for wide usage of such materials as films, tapes, flannel boards, or occasionally lantern slides, in addition to the regularly used chalkboard, maps, globes, charts, and pictures of the time. Yet Headd cautioned against the overuse of films, which could be considered entertainment rather than teaching, or their use as a cure-all for every educational ill: "The audio-visual minded teacher is different from the gadgeteer who thinks of his tools of instruction as devices to speed the slowly dragging hours of a too-long school day. The competent teacher thinks of them as new avenues to broader and richer learning experiences for his pupils" (p. 418). Headd's suggestions for teachers – to explicitly study how to

incorporate audiovisual materials in students' lesson plans, how to select such materials, when to use or not use certain materials, and so forth – still hold true today even after the cognitive and computer revolutions.

Over time, in the second half of the previous century – with the growing understanding of the individual, social, cognitive, and affective dimensions of learning – the role of visual aids increasingly became a major means for improving learning rather than merely a means for stimulating students' interest and attention. Those decades were characterized by the rapid development of user-friendly, inexpensive, and common technologies, together with many educational software (e.g., simulations, inquiries) and VR-rich textbooks in all kinds of subject-matter domains. However, teacher education programs continued to assume that the VRs and visual materials being introduced into educational systems were obvious to observers, and that their represented information could be readily and effortlessly absorbed by students.

Even as recently as 2005, in a most insightful and comprehensive book about preparing teachers for a changing world (Darling-Hammond & Bransford, 2005), the issues of VRs and visual literacy were not fully treated as a part of the prominent discourse of program planners and policy makers. The book, written by leading researchers in the domain of instruction and teacher education, responded deeply and coherently to the question of "what teachers need to know and be able to do and what teacher education is expected to accomplish" (p. 11). This cornerstone volume for planning teacher education comprehensively addressed questions concerning the kinds of knowledge about subject matter, teaching-learning processes, and student development that effective teachers must acquire; the kinds of skills needed for providing diverse learners with productive learning experiences and for providing them with informative feedback regarding their ideas; and last, the need for teachers' own lifelong learning and continued acquisition of knowledge and skills.

However, the need for teachers to become visually literate received much less attention in Darling-Hammond and Bransford's book. The book did relate, for example, to the need to become scientifically and technologically literate, suggesting that technology may expose students to scientific visualization, enable engagement in professional practices like dynamic modeling, and make dynamic feedback tangible for students. Yet, such suggestions explicitly linked visualization with science and technology, hardly explicating its broader relations to other domains vis-à-vis curriculum textbooks, worksheets, assessments, comprehension, memory, and so forth. Indeed, VRs cover large spaces in today's textbooks in the humanities and social sciences too, and numerous computer software programs in these subject-matter domains also rely prominently on VRs to promote student learning.

Obviously, VRs are also found in art curricula and textbooks, where the VRs constitute the content itself rather than an addition to the text. In the same manner, students' visual abilities were not mentioned as part of what teachers have to know about their students. Although the book indicated that students must have mature visual abilities for focusing on text and for tracking small print, and that they need to comprehend abstract symbols for easier text decoding, these highly significant perceptual abilities were discussed regarding text alone, without attending to the domain of understanding and interpreting VRs.

The importance of three-dimensional modeling of phenomena in relation to effective teaching and learning was also emphasized, and an example of the importance of visualization was presented using Jenkin's tetrahedral model (in Darling-Hammond & Bransford, p. 19). The authors even asserted that the appropriateness of applying a certain teaching strategy for three-dimensional modeling depends on four main changeable factors: (1) the nature of the information to be learned – the modality in which it is represented (e.g., text, visual, auditory); (2) learners' characteristics (e.g., their prior knowledge, cognitive abilities, motivation); (3) the kind of task assigned and its characteristics and goals (e.g., recall, problem solving, transfer); and (4) the teaching-learning activities (e.g., lecture, simulation, hands-on). However, the book did not continue to explicitly spell out how teachers and students may develop the competence to employ this mode of VR. Such visualization abilities are far from self-evident to teachers and learners, as discussed in two recently published books on visualization in science education (Gilbert, 2007b; Gilbert et al., 2008; see also Chapters 2 through 4).

In sum, despite a great deal of implicit attention to visual issues in teaching and learning within research and practice, teachers' visual literacy remains deficient as a wholly explicit theme in present-day educational discourse.

Internet Overview of Current Teacher Education Web Sites: Existing Lacunae

To map out some aspects of the current state-of-the-art regarding visual literacy in teacher education internationally, I searched the Web[1] for programs and curricula provided in the last 5 to 10 years by educational institutions

[1] The main search words/phrases entered separately and together using the Google® search engine comprised: teacher education, teaching training, preservice programs, in-service programs, visual literacy courses/training, visual representations, curriculum/a, university, courses, workshops. In addition, specific university names in various countries were entered, and their educational programs were scanned. Sites were scanned in English, Hebrew, and some in Arabic.

and faculties in various countries on several continents. Initially, my search located a number of general undergraduate and graduate university courses that may be related to visualization (as far as one can infer from their description). However, the vast majority of these were in departments of communication, taught from the perspective of advertising, or in departments of art, addressing "visual culture" and related multiliteracies, as well as a few courses in departments of educational technology, which touched on visualization only very partially and only among many other topics. Moreover, most of these courses aimed to present knowledge about a departmental discipline to students with a domain-specific background, rather than providing them with visual literacy in the more global sense as described in this book. The located courses certainly did not deal explicitly with the skills or pedagogies needed for the instruction of visual literacy to others.

One example was an interdisciplinary program of visual literacy, taught in a department of art and art history at a well-known U.S. university. The program faculty spanned four colleges with different domains: architecture, fine arts and performing arts, journalism, and education and human sciences. It may be inferred from the Web site and these topics that most visual literacy acquired in this program differed inherently from that required for school teachers. Another example was a course entitled *Visual Sociology and Anthropology* at a sociology and anthropology department in a smaller U.S. college. This course included topics like uses of visual imagery, production and interpretation of visual images, analysis of messages in photographs and videos produced by students or others, and digital manipulation of imagery. It is quite clear that these contents carried different aims than I suggest here, although specific issues may overlap.

As a result of this initial search, I narrowed the ensuing search to education faculties and departments only, including teacher education programs. This stage of the search revealed that different issues of visual literacy were treated within the following frameworks (elaborated next): instruction of disciplinary knowledge; visual culture; educational technology; teacher education programs focusing on visual literacy; in-service programs, workshops, or conferences; and national reports on visual literacy.

Instruction of disciplinary knowledge. My Internet survey revealed that explicit instruction of visual literacy as defined here was not a part of the instruction of disciplinary knowledge in any online education faculty/department, suggesting that these institutions' treatment of VRs falls mostly into the area of VRs accompanying disciplinary knowledge rather than teaching about them. This lacuna is striking in view of the fact that VRs are constantly used within each specific disciplinary domain for teaching, for drawing data, for

representing data collected by students, and so forth (e.g., teaching foreign languages with pictures). VRs such as tables, graphs, and images – common to almost all disciplines – are considered inherent prerequisites for conceptual growth, higher order thinking, the ability to make predictions, and so on. Education departments' lack of instruction in disciplinary-specific VR knowledge unfortunately suggests the following: First, student teachers usually encounter only very small variations of the most common VRs in their field. Second, they seldom learn to explicitly ask pertinent questions concerning such representations' characteristics, appropriateness for representing specific referents, affordances and limitations, or preferred audiences (see Chapter 2). Transfer and interpretation of somewhat new representations is frequently difficult in these cases.

Visual culture. The Internet survey did not show that the larger topic of visual culture appeared in courses in departments/faculties of education; however, it was prominent in the art education faculties/departments, designed to serve the aims described earlier. Such art courses lack many important educational issues like VRs' symbolic language or properties, and they relate mainly to products of the visual culture: art, video, photographs, pictures, advertisements, and so forth.

Educational technology. Courses in the wider topic of educational technology appeared in the Internet survey frequently, at many universities around the world in the East and the West, bearing names like *Educational Technology for Teachers* or *Computers in Education*. According to the online descriptions, these courses granted students knowledge about technology and its software, pedagogies for teaching with different types of technologies, production of multimedia, and Internet uses. Thus, although these courses seemed to be VR-dominated, they appeared to focus on the applications of technology in instruction and its implementation in schools rather than squarely on the topic of visual literacy.

Teacher education programs focusing on visual literacy. The Internet survey uncovered very few programs dealing with visual literacy per se internationally. It may be assumed that typical visuals are discussed in method courses (e.g., map reading in teaching geography). It can also be assumed that VRs may be implicitly touched on, interpreted, or created within different courses of the program, as means for the instruction of specific topics (e.g., graphs, tables, pictures, and charts in a course on educational psychology). However, explicit instruction in VRs was scarce. In one rare reference to VRs in an Eastern European university, students were required in their teaching practices to "use a variety of verbal and nonverbal means to illustrate the

meaning, such as repetitions' rephrasing, gestures … analogies, representations, and visualization. Explanations should be accompanied by the use of visual and multimedia aids." It may be that in this program students were introduced to visuals as means for promoting teaching and learning rather than as teaching aids alone.

My survey of Israeli professional development programs for teachers revealed that, as a general rule, they currently lack specific focus on VRs, usually treating VRs and visual literacy as part of the general issues of multimedia and communication skills. However, several exceptions emerged. For example, one center for teachers' professional development in central Israel now contains a special institute for organizing the teaching-learning space in schools, paying attention to visual components. Another such university center offers a course on *Pedagogical Uses of Multimedia in Classrooms* that includes knowledge and skills for analyzing visual texts in teaching social sciences and humanities. This course is both theoretical and practical, accompanying teachers in their attempts to plan teaching episodes using multimedia, especially VRs.

Another example involves the courses in Holocaust-related visual literacy offered by Yad Vashem's special school in Israel for teaching about the Holocaust (at the Martyrs' and Heroes' Remembrance Authority). Inasmuch as teaching the Holocaust requires a large extent of VRs and highly affect-laden themes, such courses focus on reading and analyzing "visual texts" from different points of view: personal, historical, critical, and so forth.

A striking exception to the general rule of lacunae regarding visual literacy is the M.Ed. program at one Israeli college of education, which includes a special division on "Theoretical and Methodological Aspects of Visual Literacy" in its art departments such as cinema, filmmaking, and photography. Their list of courses – including Issues of Perception and Cognition; The Interaction of Verbal and Visual Representations, from Structural, Cognitive, and Developmental Viewpoints; Visual Representations in New Media and Their Impact on Learning and Teaching in Diverse Social Contexts; and Critical Approaches in the Study of Visual Literacy – does seem to provide M.Ed. students with knowledge and skills for integrating VRs in the school culture. The question remains, however, as to how this knowledge reaches the practice of teaching and learning and how teachers interpret it.

I may count my own courses taught in our teacher education program. One course in the curriculum domain only partially touches on VRs in the curriculum. Another (Teaching and Learning with VRs), taught for about 10 years now in our Master's programs for teachers, is completely devoted to the explicit and intentional teaching of visual literacy. The syllabus includes topics like representing, representations, teaching and learning with VRs, theories

of learning with multimedia, and affordances and limitations of learning with VRs. My students experience the application of various related skills, consider diverse learners, observe peer teachers' classroom uses of VRs, interview them and the students, examine and analyze textbooks in their own subject area for visual elements, and create representations for specific information. Some of these experiences are presented in Chapters 2 through 4 (students' and teachers' ideas about VRs and learning with VRs), 13 (analyzing textbook VRs), and 15 and 16 (the curriculum framework for teacher education).

Visual literacy in in-service programs, workshops, and conferences. I also surveyed the Internet to investigate the prevalence of visual literacy as a topic of interest in in-service frameworks and professional meetings, which constitute a common mode of updating knowledge in all domains for those teachers already teaching in the educational system. The survey showed that indeed some special workshops dedicated to visual literacy were organized in different countries. One example was an international workshop on Visual Representations and Interpretations held over several days in 1998 at a British university. Its organizers described its aim as encouraging the free flow of ideas between scholars in different disciplines, who were actively researching VRs and their interpretations; yet, no direct impact on teaching and learning in schools was expected. Themes of lectures were highly diverse, from semiotics to visuals in domains like mathematics, biology, science education, physics, and architecture.

Several workshops did offer knowledge regarding the use of VRs in teaching with multimedia or for promoting thinking. However, they were limited in scope, probably because of time shortages or their position as one in a series. For example, a workshop on Multimedia for Teaching conducted at a well-known British university focused on multimedia uses in the classroom in relation to students' individual learning styles. However, this workshop limited its focus to digital cameras, photographs, and videos. Likewise, another university workshop on Visual Learning and Thinking Tools focused only on the graphical representation of contents and its components through brainstorming, concept maps, diagrams, and so on. One interesting venue for spreading visual literacy emerged through a traveling one-day workshop on visual literacy, Tools for Teaching and Learning with Images, offered by the National Institute for Technology in Liberal Education for accreditation at North American colleges. It was not clear what contents it addressed, but a one-day workshop could certainly not accommodate the whole topic of visual literacy.

A sign of growing awareness regarding the need to cultivate visual literacy for twenty-first-century learners was the conference organized by the International Visual Literacy Association, hosted by a U.S. university in

2009. Presentations at this conference explored the educational applications of a visual world for learners at different age levels. Sessions were devoted to diverse topics, including Visual Literacy in the Science Classroom; Be Not Afraid: Connecting Visual Principles and Emotions; Engaging Students in Critical Viewing and Using Visual Literacy Skills with Illustrated Texts; Investigating Visual Literacy Integration: Extending Research to a Global Audience; Multimodality, Multiliteracy, and Visual Literacy: Where Does Assessment Fit?; In Search of a Visual Literacy Theory; and A Survey of Two Classroom Teachers' Use of Visuals and Visual Strategies. This richness and diversity of presentations reflected the growing interest and engagement of scholars in issues of visual literacy. Nevertheless, these burgeoning insights, knowledge, and interest in visual literacy do not necessarily reach teachers and classrooms as I advocate here in this book, to prepare teachers and learners for the twenty-first-century visual world.

National reports on visual literacy. One important exception to the gloomy portrayal of the current state of visual literacy in teacher education is Lee's (2010) article describing Australia's national review of visual education in light of the decision to include art in the national curriculum. This report argued for "a broadly conceived visual education that is complementary to literacy and numeracy" (p. 25), involving the ability to generate, process, critique, and appreciate visual phenomena, and relevant to all curriculum areas. The claims were that visual literacy should be recognized as a core skill area; a curriculum for it should be developed for each of the compulsory years of schooling – apart from the arts and performing arts curricula; and that teachers' should be given appropriate preservice training and ongoing professional training in the domain. The report called for a national visual education research agenda to be established, with an implementation plan and timelines. Lee regarded the idea of visual education as "misconceived," claiming that visual education (i.e., VRs) had already been incorporated into all subject domains. In spite of the criticism, Australia should be applauded for its national discussion of the matter. Such discussions offer leverage for planning and doing.

Core Aspects of Current Teacher Education Deserving Explicit Future Incorporation of VRs

Tensions always exist around teacher education curriculum because it involves assumptions about the goals of education, the nature of knowledge, the social context, the complexity of teaching, and learners' development – all contentious areas. Teacher education is also always subject to political pressures

inasmuch as policy makers, politicians, and individuals often uphold that improving teacher education may ameliorate many other arenas in a country. For example, teacher education may seem likely to foster students' continuation to academic studies and pursuit of professional careers in different domains or to enhance students' social values, characteristics, and norms (e.g., tolerance, nonviolence). In addition, teacher education must contend with rapid environmental shifts that require adjustments to curricula, especially technology developments, the knowledge explosion, students' interests and attention span, and – of particular interest here – the growing dominance of VRs.

To cope with such curricular planning issues, political pressures, and environmental shifts, today's teacher training programs do reveal some relevant adjustments and modifications in skill and knowledge foci. However, according to Pearce and Pickard (1987, p. 42): "No checklist of skills or body of theory can correlate with the complexity of what it is to be a teacher, because what teachers do is necessarily bound up with what teachers are" – referring to each teacher's existing knowledge and experiences, life expectancies, perceptions of teaching and learning, abilities to relate to their students and understand them, and so on.

Generally speaking, most teacher education programs consist of a qualitative and quantitative combination of four core components believed to advance preservice teachers' ability to construct relevant professional knowledge (Ben-Peretz & Eilam, 2008; Feiman-Nemser & Norman, 2000):

1. Knowledge of the disciplines to be taught (e.g., mathematics, English, geography), sometimes acquired separately in the relevant faculties.
2. Knowledge of the foundation disciplines, conceived as deepening the understanding of teaching and learning (e.g., philosophy, psychology, sociology).
3. Knowledge of the teaching profession, which attempts to integrate theoretical knowledge and the practice of teaching into holistic pedagogical content knowledge (e.g., method courses, curriculum knowledge, courses concerning multicultural classrooms, classroom management).
4. Experiential, conditional knowledge constructed during the practicum, while under supervision in concrete teaching situations, usually based in the field (e.g., direct experience in schools or indirect practice in classrooms or workshops in the teacher education institutions).

Yet structures of teacher education programs may vary in accordance with individual programs' different orientations and epistemologies (e.g., Tom & Valli, 1990), probably affecting programs' outcomes.

As I show next, although it seldom becomes explicitly acquired and practiced in contemporary teacher education programs, the knowledge base required for developing visual literacy is implicitly contained in many core aspects of teacher preparation, including the disciplinary, the foundations, the pedagogical, and the conditional aspects. As asserted next, I call for explicitly and systematically incorporating all of these aspects of VRs' symbolic language into future teacher education programs, and thereby extending them to school students, as in other cases of literacy.

Disciplinary knowledge. The first aspect of teacher education that calls for explicit and systematic training in VRs is that of disciplinary knowledge. Subject-matter knowledge inherently contains relevant VRs, which promote knowledge retention and comprehension and which represent information that is difficult or impossible to represent through words. In different disciplines, VRs are often termed uniquely in accordance with the subject-matter's specific goals; for example "visual mediators" are utilized when discussing discourse in the field of mathematics (Sfard, 2008), and "inscriptions" as used in the sciences, referring to external VRs as distinct from inaccessible mental representations (Roth & McGinn, 1998).

Foundation courses in psychology. The subject of cognition is part and parcel of the theoretical knowledge lying at the foundation of teacher education; it is usually taught as a part of a foundation course in cognitive psychology. However, such courses generally focus on the information-processing system alone rather than on perception as well, and therefore do not focus explicitly and systematically on the perceptual and cognitive implications of VRs. Awareness of issues like why humans perceive information in a certain way, how people process visual information, and what limitations and constraints act on these capacities may promote processes of instruction and learning and the efficiency of learning materials and pedagogies (see Chapter 8).

Pedagogical content knowledge. VRs as knowledge representations constitute an inherent part of teachers' pedagogical content knowledge. Namely, because teachers may represent certain information in diverse representation modes, they need to select the most efficient VR for the instruction of a specifically targeted content to specific students having certain characteristics, with the aim of promoting students' learning. In this sense, this visual pedagogical content knowledge is the blending of pedagogy with content for teaching students of specific abilities (Shulman, 1986). To efficiently and mindfully use VRs in the practices of instruction and learning and in curriculum design, teacher education should incorporate the development of pedagogy based on

theoretical knowledge concerning VRs, their characteristics, their affordances for learning, and the constraints they may place on cognitive processes. I contend that this element of teacher education should become an explicit part of the professional knowledge of teaching – what Shulman (1986) termed the pedagogical content knowledge, as described fully in Chapter 6.

Conditional knowledge. Teachers' practical work inherently contains another aspect of VRs – the ability to translate theoretical declarative knowledge concerning VR use into an application of procedural knowledge. Thus, the practicum in teacher education may provide important opportunities to achieve fluent applications of the skills involved in visual literacy in any context. To do so, students must construct clear and coherent mental models of the skills, their possible usages, and the products of their application, and must undergo explicit, systematic training in their application in many diverse situations (Anderson, 1993; Perkins, 1987; Perkins & Salomon, 1989). Such training results in an efficient application of skills as fitting particular contextual conditions regarding students' characteristics, the information to be presented, or the task at hand. Hence, the practicum enables the development of conditional knowledge regarding the use of VRs. Learning materials are inherently loaded with VRs (i.e., school textbooks, computer programs, media); therefore, experiences gained during the practicum in teaching with VRs, interpreting them, assessing students' comprehension of their messages, and so forth may be of great value for present and future teachers.

Dual, integrative visual literacy. I would like to propose the merit of adding an integrative aspect to teachers' desired knowledge base – a dual visual literacy. This integrative, dual knowledge of VRs can be considered wider, deeper, and more comprehensive in scope than any of the aforementioned single aspects of knowledge and teaching practice with VRs.

The *dual* facet refers to the twofold roles of visual literacy for teachers as expounded in Chapter 1. That is, on the one hand, education programs should help teachers become expert as consumers of diverse VR-rich information sources and as interpreters of the vast visual information they encounter in the visually rich world – in the Internet, movies, journals, newspapers, books, and so on – both in general knowledge domains and in their specialized teaching subject-matter knowledge, in a lifelong independent process of personal learning and professional development. On the other hand, education programs should also grant teachers a wide repertoire of skills and promote their ability to develop pedagogies for better creating and teaching visually represented information to diverse student populations and for developing their students' visual literacy.

The *integrative* facet of visual literacy refers to the comprehensive theoretical and practical knowledge, understanding, and abilities that teachers construct about visual symbolic language (which has its own rules and grammar – see Chapter 9) and about VRs' creation, use, manipulation, and interpretation, as an inherent part of the teacher education program. The construction of this integrative theoretical and practical knowledge can best be realized by combining all four components of teacher education programs: disciplinary and foundation courses, the construction of pedagogical content knowledge, and the practicum. Only such integration can promote teachers' ability to regard VRs as an additional language, like the language of verbal text or numbers, instead of viewing images as discrete, specific tools for teaching certain contents. Incorporation of the different visual literacy skills as an inherent element in each of the four program components would result in preservice teachers' ongoing and multilayered knowledge acquisition and training.

Together, the dual roles of visual literacy for teachers and the integrative construction of visual pedagogical content knowledge should help realize VRs' potential for students' and teachers' learning and self-development.

Recommended Timing of Teacher Education in VRs

As previously suggested, I assert that teacher education programs constitute the most suitable framework for teachers to acquire an organized body of knowledge concerning all the aspects of declarative, procedural, and conditional knowledge relating to the development of visual literacy. Cox Rollins (2003) warned about the paucity of evidence concerning such activities' intentional focus in current teacher education programs, suggesting that visual literacy be embedded into professional standards, education degree programs, and evaluation of student-related abilities as part of teacher training curricula.

Naturally, the introduction of visual literacy should not be limited to preservice programs alone. Teachers at all stages of their career may acquire these skills and knowledge in in-service programs, while studying for a higher academic degree or on their own. All it takes is veteran teachers' awareness of this need and motivation to accomplish this goal.

Proponents of visual literacy suggest its instruction at all grade levels, because of its importance, in order for students to gain critical use of visual sources (Avgerinou & Ericson, 1997; Burbank & Dennis, 1983). Therefore, teacher education in interpreting and utilizing visual materials should address teachers at all grade levels.

Summary and Food for Thought

The current chapter's review of VR-related curricula implementation up to the present clearly portrays the vast lacunae facing educators who undertake a visual agenda. Up until now, teacher education programs across the board have not yet addressed the dual, integrative incentives for systematically introducing visual literacy. First, programs have not yet been helping teachers promote their students' visual literacy, and thus their learning and thinking abilities, or their mindful consumption of media while avoiding falling prey to VR manipulations. Second, programs have not yet helped teachers promote their own personal VR consumerism and professional development by fostering their direct instructional skills and their ability to assess students' visual knowledge and understanding. In this chapter, I endeavored to recommend the key aspects of visual literacy that should be implemented in future program designs to facilitate teachers' own learning and ability to continually update the subject matter they teach, enabling them to devise new relevant and efficient pedagogies, and thus influence their students.

Such recommendations may pose myriad difficulties for teachers and students alike in achieving full awareness of their own visual abilities, VRs' properties and potential contributions to diverse students' learning, the need to construct VR-related knowledge through many experiences in a variety of contexts, or the need to reflect on the products of each application of visual abilities in order to enable future monitoring of their efficient use. Such explicit, holistic knowledge of the "visual language" should constitute an inherent and active part of teachers' knowledge, one that is accessible and easily retrieved when necessary in diverse situations. For teachers to deeply understand how learning occurs, knowledge of texts is insufficient. To make visual encounters meaningful and effective, all educational stakeholders must be explicitly, systematically exposed to these implicit aspects in their many forms, characteristics, and principles of use.

Thus, researchers should investigate VR-related topics to advance understanding of visual literacy; curriculum designers should make mindful decisions regarding VR selection in accordance with curricular objectives; teachers should develop visual pedagogical content knowledge in order to be able to design efficient VRs and use them in appropriate diverse contexts as necessary to improve practices and outcomes; and students, the citizens of the future, may then become more alert and informed media consumers – "multilingual" learners who master not only verbal but also visual language. As I outline later in this book, multilayered explicit visual training, integrated

into all components of teacher education programs, may fill the gaps existing in today's teacher education.

In the next part of this book (Part 4), I present core theoretical issues that should constitute the basis for introducing visual literacy into teacher education. These issues includes human perception, signs and sign systems, the types and characteristics of VRs, and what research says about the affordances and constraints of learning with multimedia.