Introduction

THINKING CRITICALLY ABOUT VISUAL REPRESENTATIONS: A VISUAL JOURNEY TO UNDERSTAND CRITICAL THINKING

EXECUTIVE SUMMARY

Teachers are searching for ways to solve the perennial problem, how can they improve their craft and improve the quality of the learning and achievement of their students. These case studies present a variety of approaches to the use of visual representations to improve critical thinking; ranging from third grade to higher education, undergraduate and postgraduate education; from classrooms in eight countries. Visual representations like concept maps, mind maps and argument maps are used as displays of understanding, and, most importantly, as a medium for productive collaboration.

INTRODUCTION

Visual representations occupy a very essential, but uneasy place in the toolbox of instructional strategies. Increased access to multimedia environments supports claims that media users see more images, photos, and graphics than ever. Successful participation in a visually saturated environment requires teachers and learners to possess a thorough appreciation of how to use, interpret, and create visual and graphic information. Teachers in these case studies are grappling with the connections between visual representations, in the broadest sense, and critical thinking. The case studies that are in this book are organized into two broad sections, 1) teaching, learning and assessment (Chapters 1 – 11), and 2) visual representations for design and collaboration (Chapters 12 – 19). The first section focuses more directly on classroom teaching experiences, and the second section presents examples of how visual representations are used to promote growth of communities, to assist in the design and development of multimedia, and to provide a more in-depth understanding of visual literacy. Each of the case studies is followed by a brief list of key terms and definitions and resources for further professional development.
In addition there are several themes that characterize these scholarly contributions: 1) a deeper understanding of the connection between visual representations and critical thinking, 2) practical applications of visual representations, 3) development of map-making skills, 4) formative and summative assessment, and 5) cross-cultural communications, critical thinking and collaboration.

CRITICAL THINKING AND VISUAL REPRESENTATION

Critical thinking is identified as an essential component of 21st century skills, along with communication, collaboration and creativity (Shute, Dennen, Kim, Donmez, & Wang, 2010). What we found out in this book is that visual representation becomes an integral part of critical thinking for teachers and learners in a way that expands the types of products, feedback and efficiency for teaching, learning and assessing.

Lenny and I read these papers kept meeting and talking about the topics and our ongoing professional practice of visual representation several themes emerged. First of all, we thought that visual representation indeed has a great deal to contribute to critical thinking. In a surprising way it opened up and expanded the definition and understanding of critical thinking to fit in a wider variety of contexts than we anticipated.

We chose to concentrate on critical thinking as a highly valued competency, an amalgam of thought processes, understanding, analysis, evaluation, and creativity, which can be represented in visuals, graphic organizers, and concept map products. We also chose to use the broad term visual representation to capture the variety of practices used to illuminate and illustrate critical thinking. The authors in this book help us demonstrate the range of strategies being used, from specific argument mapping (van Gelder, 2013) and expressive mind mapping (Buzan, 1996) with illustrations and icons to structured and refined concept mapping (Novak & Gowin, 1984; Novak & Canas, 2006). The Handbook of Research on Collaborative Learning Using Concept Mapping (Torres & Marriott, 2010) focused on concept mapping and included topics like distance learning, e-learning, inquiry maps, online learning, online portfolios, shared concept maps and virtual teams. The book was a collection of primary research on collaborative learning and concept mapping establishing the connection between these group process and visual representations. I co-authored a paper for this book with Polly Wilson in which we examined the concept of visual literacy and formative assessment.

Our express purpose for this book was to provide a forum for teachers who would share practitioner research in the form of case studies, more interpretive and reflective, with more empirical research methods as well. We want to see examples, to know more about how teachers and researchers use visual representations to teach critical thinking, and how critical thinking is affected by visual representations.
In our textbook (Beaudry & Miller, 2014) on research literacy we depict visual representation as a literacy strategy that operates with other literacies to form the construct of research literacy. (See Figure 1) Visual representation as a field is all around us, but has not received enough attention to identify the emerging practices of visual representation and critical thinking, across educational levels and in an international and cross-cultural context. This opening chapter provides a summary of the chapters in the book, in text and visual representations of the key concepts in the field.

As Lenny and I talked and read, and mapped, and talked more about the submitted manuscripts a number of themes emerged for the book. The use of visual representations contributed to: 1) the development and clarity of critical thinking and visual representation, 2) an improved ability to analyze and evaluate complex ideas in speech and writing, 3) the progression of visual representation skills from novice to expert, 4) the improved use of formative and summative assessment, and 5) unique support for cross-cultural communications and collaboration (See Figure 2).

CRITICAL THINKING IS A COMPLEX REASONING OR THINKING SKILL MADE BETTER WITH VISUAL REPRESENTATIONS

Critical thinking and visual representations is a combination of cognitive processes and communication skills. This book explores the use of visual representations, primarily concept maps, as the tangible medium and cognitive catalyst for teach-

Figure 1. Visual representation of research literacy (Beaudry & Miller, 2014)
ers and students to collaborate on the acquisition and consolidation of knowledge for meaningful learning, argumentation, and problem solving. Cognitive student outcomes range from conceptual knowledge to problem solving, and skills include self-regulated learning and meta-cognition, group process and individual and collaborative construction of concept maps, and group leadership. Case studies refer to work by Facione (1995) and the new taxonomy of cognitive objectives by Anderson and Krathwohl (2001), Paul and Elder (2002), and the milestone definition of critical thinking derived from a Delphi process of 46 published experts: it “is the process of purposeful, self-regulatory judgment. This process gives reasoned consideration to evidence, contexts, conceptualizations, methods and criteria” (American Philosophical Association, 1990, p. 2). To that I would add the skill of communications, and visual representations (mind maps, concept maps and argument maps). The mapping tools provide a concrete process and product that allow learners to learn and communicate critical thinking. In their case study Gorman and Heinze-Frey write about the “emerging synergy” of critical thinking and concept mapping” in understanding and using the science education standards “as advance organizers for each succeeding level of the [education] system” (p. 5). I have more to say about these learning progressions in the following sections, learning progressions and concept mapping.

Many teachers prefaced their chapter with the observation that students were having difficulty with critical thinking tasks. As teachers do, there was a search for strategies to engage students in critical thinking and to produce tangible products as evidence. This book presents visual representations as a robust strategy to solve this problem; complementary to oral communications, group processes and written essays and capable of adding unique value to the process of critical thinking.
Critical thinking for teachers consisted of matching student learning targets to the assessment afforded by visual representations and concept maps, constructing exemplars and models of expert visual representations, learning how to read and provide formative and summative assessment of students’ products, and designing technological environments based on the effective use of visual representations. In the paper by Torres et al, critical thinking goes beyond the classroom and prompts us to be critical of our society, as well.

Visual representations are flexible and can be quickly read and revised, creating a new choice for efficient assessment of critical thinking as described by Gomez et al; Shedletsky; and Merrill. A comparison of the time it took an instructor to read and evaluate (mark) visual representations and concept maps to the time it took to read and evaluate an essay for aviation medicine indicated a substantial time-saving for the instructor, not to mention the added value of the concept map as it is transferred to other tasks like group discussion, writing and assimilation of knowledge. A more efficient way to provide feedback sounds great, but needs to be validated with more research.

**MAPPING SKILLS AND A LEARNING PROGRESSION**

Looking at the nineteen chapters in this book overall, critical thinking is an essential goal for life-long learning, and visual representations are a gateway strategy as well as a product to demonstrate this complex reasoning target. The essays in this book extend from early elementary education (Merrill; Bright, & Smith; Goldberg) to adult, professional endeavors (Gomez et al.; Sadik). While this book is a survey of case studies critical thinking and visual representations there are several chapters that provide vivid classroom examples of visual representations, concept maps and mind maps, for grades 3 and above. While we don’t have any papers from early childhood, pre-school up to second grade, this is the stage of development when drawings and marks become letters and words; until that happens pictures (doodlings and sketches) are the primary conveyors of meaning. I would argue that 5-year old children are thinking critically when they are in these transition stages. One of the messages with this book – we need to take drawing and mapping as skills to nurture throughout the progression of learning, both as artistic renderings and visual literacy tools. Goldberg’s case study summarizes her teaching experiences with mind maps and concept maps across the grades, and includes a description of whole school adoption of mapping. Her suggestions are students embed drawing, clip art and graphics in their mind maps and concept maps. Teachers model the creation of mind maps and concept maps but students are constructing their own maps from the earliest grades. Goldberg’s sense of critical thinking includes students’ focus on details, short- and
long-term memory, big picture understanding, essay writing, project planning and reading difficult text. Merrill’s case study relies on the formal structure of concept maps, the node-and-link with verbs as the visual representation strategy in a science unit on watershed systems for third graders. Novak and Gowin’s concept maps are words in shapes, linking lines or arrows, hierarchies (from big concept to supporting details) and cross-links. Evidence from Merrill’s case study suggests that students are ready to move on a mapping progression and acquire mapping skills, which in turn support deeper understanding of complex science concepts.

Looking at the papers in this book it is remarkable to see how many teacher/authors (Shedletsky; Gonzalez & Frumkin; Gomez et al.; Sadik) discovered visual representations in their own quest for improvement, and decided to incorporate visual representations to improve critical thinking with students who had little prior knowledge or skills in visual representations. These structures are natural for some and for others may take getting used to, but the essential feature is that those structures depend on language and spatial thinking. Our sample of papers shows the relevance, impact and synergy of visual representations and critical thinking, but there are scant references to a framework for the development of visual representations, even concept maps, as a coherent, continuous developmental standard. If visual representation is such a powerful tool for critical thinking how do we proceed?

One paper is about science standards, learning progressions and expert concept maps, Gorman and Heinze-Fry use “strand maps” to represent continuity of learning from pre-K to high school level. They use the strand maps to identify 1) unsupported standards, 2) gaps in standards, 3) and patterns of divergence, convergence and cross-linking. In their artful self-assessment Gorman and Heinze-Fry stated: “It certainly took a considerable amount of critical thinking to produce these maps (note the transition of an outline style to a learning progressions style with linkages among concepts)” (p. 6). This paper presents expert skeleton concept maps developed by the teachers, but there is no mention of what a learning progression for concept mapping itself would look like.

If visual representations just pop up at different points in the career of teachers and learners is there value to more explicit development of these skills from early childhood to postgraduate and professional education? Just looking at the case studies in the book the answer is YES! That said, it will take a concerted effort to accomplish this task, but it will be critical thinking for and of visual representation. We already mentioned that our case studies provide in-depth examples from grade 3 to adult learning.

We wanted to use the idea of visual representations as the overarching concept since we did not want to limit the forms of visual representations to a single category. Looking across the 19 case studies the predominant category is concept maps (Novak & Gowin, 1984), followed by argument maps (van Gelder, 2013), mind maps
(Buzan and Buzan, 2006), and Talmudic Diagrams (Ury). This book represents a convergence of these forms of visual representations, and supports speculation that visual representations represent the larger organizing category. Davies (2011) writes from an adult, higher education perspective and contends that the differences among concept mapping, mind mapping and argument mapping reflect the purposes. We agree and add that pictures and structured diagrams are complementary and synergistic with oral and written forms of communication.

So, if you are interested in adopting visual representation strategies to improve critical thinking what should you do? As teachers there should be more explicit acknowledgement of the value of visual representations in teaching standards, and deliberate exposure to all of these forms as young learners and as adults. The case studies provide numerous examples of how teachers introduced new learning strategies based on visual representations: Merrill’s study of third grade science, Shedletsky’s study of undergraduates, Sadik’s study of first-year medical education, Gomez et al. examination of aviation medicine, Gorman and Heinze-Fry’s discussion of learning progressions with high school physics classroom examples, and De Charon’s development of collaborative concept maps.

Depending on the complexity of the content and the skills, training in the characteristics and construction of visual representations by individual students requires at least 4-5 opportunities for students to learn and demonstrate competence. In all these cases a variety of techniques were used to train students to understand the purpose of and to construct visual representations, including teacher modeling, brainstorming and mapping topics as a group, parking lot examples (Novak & Canas, 2006), and expert map templates. While learners may adopt this strategy quickly these case studies show the value for learners of very deliberate, repeated practice of these visual representation techniques, especially if there is an expectation to evaluate the maps with marks and scores. Even if the visual representations are used to support group dialogue and writing visual representation require feedback from teachers and self-reflection and are likely to benefit from collaborative dialogue with student peers.

BALANCING FORMATIVE AND SUMMATIVE ASSESSMENT

Most of the case studies present examples of visual representations as formative assessment products embedded in group process, self-reflection, and teachers’ feedback. The purpose of formative assessment is to keep students focused on self-regulated learning and meta-cognition, especially through peer- and self-assessment. The visual representation products supported frequent self-assessment within lengthy assignments and, as a result were more likely to produce positive effects than instruction focusing only on grading or performance and summative assess-
ment. There are seven strategies associated with formative assessment suggested by Stiggins, Arter, Chappuis, and Chappuis, (2007) that help students and teachers with formative assessment strategies.

- Where am I going?
  - Provide a clear and understandable version of the learning target.
  - Use examples and models of strong and weak work.

- Where am I now?
  - Offer regular, descriptive feedback.
  - Teach students to self-assess and set goals.

- What do I need to do to get there? How can I close the gap?
  - Design lessons to focus on one aspect of the quality at a time.
  - Teach students focused revision.
  - Engage students in self-reflection, and let them keep track of and share their learning. (p. 42)

One of the key findings in research reviews by Black and Wiliam (1998a) and Hattie (2011) is that the quality of feedback from teachers and/or other students can be a very positive component to student learning. In addition Hattie noted that concept mapping is considered to be a teaching strategy which yields a high impact on learning, if done right. These case studies provide examples of visual representations from the first, most novice stage to the end of learning in that unit or course of study, when the students can be considered “accomplished novices” (Sadik). As mentioned, Gomez et al. found that concept maps were superior to essays in formative assessment, instructor feedback to students, and improved summative assessment, more efficient understanding and grading or “marking” of student work.

Mapping and self-assessment is another formative assessment example in many case studies. There are examples of rubrics and scoring guides that use a model (Kinchin, Hay, & Adam, 2000) to differentiate types and qualities of concept maps. Their rubric provides a low score for a chain or list, a mid-level score for a spoke-and-wheel map, and the highest score for a network map with multiple levels, linking words, cross-links and a systems view. In these case studies Sadik developed a scoring guide, as did Gomez et al., but in some cases maps did not receive marks and were not scored; visual representations were used only for formative assessment. Novak and Gowin validated a scoring system for concept maps (1986) and showed how to achieve reliable scores as well. Additional research by Kinchin, Hay, and Adam (2000) developed a model for summative assessment of conceptual development using visual representations with high level of validity and reliability. The model of assessment and the accompanying rubric are incorporated in numerous case studies, e.g., for third grade science (Merrill), and by Gorman and Heinze-Fry for high
school science. Concept maps, mind maps and argument maps can be incorporated into the summative assessments and grading of units and courses. However, the press to use visual representations for summative assessment cautions teachers to insure the opportunity to learn and formative assessment. These case studies showcase the dedication that teachers have to improve their craft, and the care taken to balance the development and improvement of students’ knowledge and skills with the teachers’ need to demonstrate empirical measures of achievement.

CROSS-CULTURAL COMMUNICATIONS AND COLLABORATION

The more I look at these case studies and the visual representations in them the more I understand the essential role of collaboration to elicit the full potential of visual representations to improve critical thinking. Moreover, there is an international, cross-cultural component to collaboration. This book has papers submitted from at least eight different countries; an international sampling of papers signifying a cross-cultural base of case studies. Our case studies recount a similar international response to *The Handbook of Research on Collaborative Learning and Concept Mapping* (Marriott & Torres, 2010). The handbook was dedicated to the exploration of collaboration and there is more in these case studies that secures the role of social as well as individual learning; the papers represented an international array as well.

The case study by Dunsmore described improvements to an undergraduate course in intercultural communication. The instructor wanted to improve the course by making a more appropriate match of the learning target, critical thinking, with the assessment method the learning target. The assessment method of selected response was insufficient to assess the collaborative problem solving in the course.

Snyder wrote her case about an international partnership of elementary and middle school teachers from China and Florida, USA. The purpose of the Gulf Oil Spill Crisis project was to support pedagogical innovation with international collaboration. The concept mapping program, *Webspiration*, and the interactive video program, *VoiceThread*, were used to engage students in collaborative learning to develop cultural sensitivity, self-reflection, divergent thinking and creativity. There is the other evidence that concept maps effective tools for cross-cultural collaboration. Gomez et al. discuss the potential for concept maps to be used in a distance-learning, online course across cultures. While it is a small case study they looked at the potential of concept maps to replace essays, and the results indicated that maps were culture-neutral and much more efficient for teachers to read and score than essays. Dunsmore presented a case for “visual sense-making” approach to intercultural communication supported by “the literature on surface and deep
learning, formation of mental models, visualization, peer learning and on concept mapping” (Dunsmore, p. 3). The emphasis was on the synergy of collaboration and concept mapping to enhance intercultural communication.

CONCLUSION

The visual representations in this collection of case studies provide a fresh perspective on critical thinking, and they provide insights into collaboration and communication. As we assembled this book, reading each new paper Lenny and I were struck by the diversity of contexts, the drive to learn, and the new source of evidence, the visual representations. In our meetings we would often share new maps with each other, some of them our own and some from our students, to answer the essential question, how do visual representations improve critical thinking.

Understanding and mastery of visual representations like concept maps, mind maps and argument maps are essential graphic competencies for educators who seek to utilize and strengthen choices and strategies for learning critical thinking skills. The need is especially important in the elementary school years as learners make the transition from viewing and speaking to formal language acquisition and incorporate the rules of speaking and writing. The key message show an expanded role for visual representations throughout the elementary learning experiences and into upper grades and higher education where visual representations are effective tools for engaged, high-quality critical thinking and products that mark the progression of knowledge for teachers and learners.

The future is a challenge, create and sustain collaborative professional development for teachers in visual representations and critical thinking. The case studies in this book represent new resources, the volume represents a new collaboration, and the visual representations reveal new understandings of critical thinking. We will share our work on our website as we progress https://sites.google.com/a/maine.edu/visualliteracy20/. With this collection of case studies Lenny and I have begun to map out the next steps for our collaboration.

Jeffrey S. Beaudry
University of Southern Maine, USA
REFERENCES


**ADDITIONAL READING**

Beaudry, J. (2014). Visual representations and critical thinking: A repository of resources and collaborative opportunities. [https://sites.google.com/a/maine.edu/visualliteracy20/](https://sites.google.com/a/maine.edu/visualliteracy20/)


**KEY TERMS AND DEFINITIONS**

**Argument Map:** A visual representation of the structure and flow of an argument; an example of how to improve critical thinking.

**Collaboration:** working and learning together in a group; visual representations are effective tools to engage collaborative learning.

**Concept Map:** A very effective type of visual representation developed by Novak and Gowin (1984); a visual arrangement with a focus question, showing nodes (concepts) and links (verbs or connecting words) arranged in a hierarchy with cross-links to show relationships; effective as a tool for oral and written communication and collaboration.
Critical Thinking: Critical thinking is an amalgam of traits and outcomes from conceptual knowledge to problem solving; critical thinking skills include self-regulated learning and meta-cognition, group process and individual and collaborative construction of concept maps, and group leadership. Critical thinking “is the process of purposeful, self-regulatory judgment. This process gives reasoned consideration to evidence, contexts, conceptualizations, methods and criteria” (American Philosophical Association, 1990, p. 2). To that I would add the skill of communications, and visual representations (mind maps, concept maps and argument maps).

Mind Map: A very effective type of visual representation developed by Tony Buzan with a central idea and supporting ideas radiating outward to assist memorization, recall and concept organization; usually drawn by hand with accompanying graphic images.

Visual Representations: Visual graphic organizers like concept maps, mind maps, and argument maps constructed or co-constructed by teachers and learners to understand and communicate concepts, sub-concepts and details, and the relationships of concept.