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Technology's Role in Constructing Meaningful Knowledge

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Abstract

This paper discusses technology's role in meaningful knowledge construction, which hinges on ways computer tools can be used to improve pedagogy through actively engaging learners. At the center of this discussion is the difference between stand-alone technological literacy that serves as an end in itself, and educationally defensible information literacy that represents a technology-assisted means to the end of metacognitive reflection as a salient component of an undergraduate liberal education. Drawing on learning principles embodied in the theoretical frameworks of Seymour Papert's constructionism and Gordon Pask's conversation theory, personalized computer applications of concept maps, mind maps, and repertory grids are presented.

Keywords

Technology, knowledge construction, pedagogy, constructionism, conversation theory

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Abstract. This paper discusses technology's role in meaningful knowledge construction, which hinges on ways computer tools can be used to improve pedagogy through actively engaging learners. At the center of this discussion is the difference between stand-alone technological literacy that serves as an end in itself, and educationally defensible information literacy that represents a technology-assisted means to the end of metacognitive reflection as a salient component of an undergraduate liberal education. Drawing on learning principles embodied in the theoretical frameworks of Seymour Papert's *constructionism* and Gordon Pask's *conversation theory*, personalized computer applications of concept maps, mind maps, and repertory grids are presented.

I.

Balancing Technology with Teaching and Learning

Technology plays an increasingly prominent role in contemporary higher education, leading to dramatic changes in the teaching and learning landscape. In the face of a widening expanse of technological advancement, however, questions continue to crop up regarding the place that technology should ideally occupy in modern-day college classes. A particularly important question is, "Does technology really fortify pedagogy by engaging learners in learning?" (Leung, 2010, para. 2). Where it does in today's technology-rich classrooms, the educational spotlight shines on learning as opposed to technology itself (Campoy, 1992). According to Leung (2010), technology "must not be used to fill up vacant time, but must be used to serve for meaningful purposes in both teaching and learning inside and outside the classroom" (para. 7). In short, it is not *what* technology is used, but *how* it is used to foster teaching and learning that merits weightier consideration (Strommen & Lincoln, 1992).

II.

Technological vs. Information Literacy

Along with discussion that stems from identifying the most appropriate ties among technology, teaching, and learning, questions also arise about technological literacy as it pertains to "digital natives" (Prensky, 2001, p.1), comprising the first generations to grow up immersed in digital technology. Digital natives, who significantly populate the rolls of present-day college classes, think and process information differently from earlier generations of "digital immigrants" (Prensky, p. 2), some of who are educators who seek to teach digital natives in a pre-digital language. According to Prensky, digital natives:

> are used to the instantaneity of hypertext, downloaded music, phones in their pockets, a library on their laptops, beamed messages and instant messaging. They've been networked most or all of their lives. They have little patience for lectures, step-by-step logic, and 'tell-test' instruction. (p. 3)

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Thus, reconciling potential generational discrepancies between digital-native students and their digital-immigrant teachers becomes important if productive teaching and learning are to occur. Moreover, among a digital-native student population, gauging students' levels of technological literacy suitable for college-level learning constitutes a growing challenge for educators of all generations.

Within my own teaching discipline, the American Psychological Association (APA) *Guidelines for the Undergraduate Psychology Major* (APA, 2007) cites computer literacy as an umbrella learning goal, covered in undergraduate psychology curricula, that connects to learning undertaken within liberal arts education. Suggested learning outcomes subsumed under this goal include searching and accurately summarizing the general scientific literature of psychology, using appropriate software to produce comprehensible reports (written and oral), and using both information and technology ethically and responsibly (e.g., avoiding plagiarism). Despite the obvious benefits that computer literacy holds in an increasingly computerized world, how well does stand-alone technological literacy translate into educationally defensible information literacy? If technological and information literacy are fundamentally equivalent, then technological literacy represents a viable means to the end of a well-rounded liberal arts education as discussed in the APA *Guidelines*. If not, then technological literacy serves as an end in itself, one that possibly circumvents the essence of information literacy as an intellectual and practical skill on par with critical thinking, problem solving, and written and oral communication. For example, McGovern argued that some of today's stand-alone technologically literate undergraduates rely on a "cut-and-paste" approach to assembling information through navigating technology as opposed to using computers as cognitive aids in synthesizing and evaluating knowledge (as cited in Munsey 2008, p. 55). The differences between these two approaches to technology's use can be seen in instances where seemingly technologically savvy students—who appear equally or more conversant in technology than their professors and spend considerable time multi-tasking through checking e-mails, instant and text messaging, micro-blogging (Tweeting), and interacting with Facebook—fail to use technology correctly to complete course assignments (e.g., effectively designing and implementing database search strategies) that challenge them to use technology as more than a passive conveyor of information. Seymour Papert's groundbreaking theoretical work with computers as instruments of learning (Papert, 1980; Papert & Solomon, 1971) sheds light on this issue of mounting importance to college educators, as does Gordon Pask's (1975, 1976) abstract view of human-computer interaction as a platform for "conversation"—a dynamic process from which knowledge-sharing and learning flow. I will explore these undergirding theoretical positions in the following section.

III.

Underlying Theoretical Frameworks

An accomplished protégé of Jean Piaget who was invited to study with him in the 1960s (Johnstone, 2003), Papert soon came to realize that computers held the potential to change the nature of education. As part of this realization, Papert also foresaw change in the meaning of literacy. To highlight this notion, Papert introduced the term *letteracy* to refer to knowledge about the written word that connotes literacy solely in terms of functionally understanding print medium (Papert, 1994). This limiting view of literacy often surfaces when someone discusses computer literacy. In other words, knowing the basic operations of computers qualifies you as computer literate. However, these same defining parameters do not necessarily apply to computer literacy in the broader sense of a well-informed, intellectually curious person. Slanted in the direction of college classroom experiences, the fascination that some undergraduates possess with stand-alone technology, such as glitzy cell-phone applications that may be geared toward classroom use, may actually get in the way of other forms of technology-enhanced instruction in which students are encouraged to construct new ways to think and solve problems. Another impediment to students constructing knowledge through technology-assisted instruction may occur when educators feel uncomfortable with technology to the extent that this discomfort blocks the teaching process. Ultimately, it is vital that teachers and their students strike a harmonious balance regarding the most effective uses of technology as a means of achieving higher-level learning through appropriately engaging teaching techniques. The challenge for teachers is to select and use technology (e.g., PowerPoint presentations) as an adjunct to stimulating meaningful learning while not turning off students to the degree where that learning becomes pointless drudgery, yet at the same time conditioning students over time to accept technology-assisted learning applications that expand the intellect but may fall below the boundaries of unadulterated entertainment.

The Association of American Colleges and Universities (AAC&U), the national organization representing colleges and universities, defines a liberal education as one that "empowers individuals with broad knowledge and transferable skills" (AAC&U, 2008, para. 1). In the framework of an undergraduate liberal education, the contrast between limiting and broad definitions of computer literacy even more clearly distinguishes stand-alone technological literacy from information literacy (Mayo, 2010b). The undergraduate psychology major can be used to illustrate this point. Reflected in the learning goals and outcomes of the APA *Guidelines* (APA, 2007), the undergraduate psychology major has embraced the value of a liberal education through an encompassing, generalizable set of knowledge and skills taught in undergraduate psychology curricula, including computer literacy. Technology-centered pedagogy that focuses on student engagement and reflective thinking produces learners with the skill set required to creatively problem solve and actively seek and discover knowledge. Papert built upon Piaget's constructivist learning theory in trailblazing how technology can afford these new ways to learn (Johnstone, 2003; Papert, 1999). To Piaget (1973), *constructivism* implies that learners construct and reconstruct knowledge through active cognitive processes integrating personal experience, discovery, and rediscovery. Piaget's position challenges the static view of learning that portrays learners as passive recipients of knowledge in a manner that allows information to be "poured" into their heads. Papert (1987) coined the term *constructionism* not only taking Piaget's traditional constructivist view into account, but also blending it with a "learning-by-making" (Papert, 1991, p.1) perspective that emphasizes the efficacy of experiential learning when constructing meaningful artifacts such as personalized applications of computer programs. With the continual development and refinement of "constructing" computer software, constructionism has found a comfortable home in the modern information age.

How can college educators apply Papert's learning principles to facilitate information literacy among a technology-savvy generation of digital natives, especially if the educators themselves are not digital natives? One particularly useful way is to encourage students to construct meaningful knowledge through learning assignments that push them to actively discover connections between ideas. For example, graphic organizers—including concept maps, mind maps, and repertory grids—can be used to introduce course content to students through visually descriptive conceptual structures that elucidate links within, between, and across categories of knowledge (Mayo, 2010a). Used in conjunction with personalized computer applications, these pedagogical strategies engage students in critical thinking and metacognitive reflection as components of information literacy (Mayo, 2010b) that tap into the upper levels of Bloom's revised taxonomy of educational objectives (Krathwohl, 2002), including analysis, evaluation, and creation.

When personalized computer applications assume an interactive character, they offer the added bonus of allowing learners to engage freely in reflective dialogue for learning purposes. In accordance with Pask's (1975, 1976) *conversation theory*, new knowledge will then arise through a dialectical process in which individuals compare and contrast personally held conceptions with those of others. To Pask, meaningful knowledge construction occurs when students learn conceptual relationships through "teachback," where one person teaches another what s/he has learned. Applied to the present Internet-savvy generation of digital-native learners, opportunities exist for individuals to use online software to interact in dynamic dialogue centered on personal construct systems evidenced in graphic-organizational learning techniques. In this way, technology serves as a cognitive tool in learning, networking, collaborating, and problem solving (Nanjappa & Grant, 2003). Extrapolating from Wittgenstein's (1921/1981) philosophical premise that knowledge formation as a whole derives from independent knowledge iterations, knowledge in cyberspace can be both depicted within and made available to others through hyperlinks to knowledge representations that promote intellectual development (Ryder, 1994). In the next section, I will introduce online computer programs that allow learners to construct and share knowledge representational systems.

IV.

Computer Applications of Concept Maps, Mind Maps, and Repertory Grids

Software with embedded conceptual-change features, such as online computer programs that permit learners to create and analyze cognitive maps and data-grid matrices, help students to sequence their learning from faulty preconceptions to increasingly accurate conceptual understandings. Although such software packages can prove useful as learning tools across college disciplines, they become particularly relevant as heuristic aids in psychology and other human sciences because these disciplines afford much opportunity for metacognitive reflection into both the content and processes involved in learning.

Concept maps are top-down arranged schematic diagrams that illustrate conceptual connections (Novak, 1977, 1990). In concept mapping, concepts are represented as boxes or circles, connected with labeled arrows and short linking phrases, proceeding in a general-to-specific hierarchy. *CmapTools* (Institute for Human and Machine Cognition, 2008) is a free downloadable software toolkit that permits users to construct, share, and critique concept maps. In various ways ranging from situational in-class learning assignments to instructional paradigms woven throughout the entire fabric of a course, I have successfully used this software package in teaching introductory psychology, life-span developmental psychology, applied psychology, and psychology of adjustment (Mayo, 2010a). For each concept-mapping assignment, I either allow students to generate terms associated with the topic or provide them with a "Key Concepts Sheet" of ten to fifteen terms, depending on the level of conceptual depth and complexity inherent in the assigned topic. Figure 1 shows a concept map of Urie Bronfenbrenner's (1979) bioecological theory, generated through Cmap Tools and created as part of a class assignment by one of my former life-span development students.

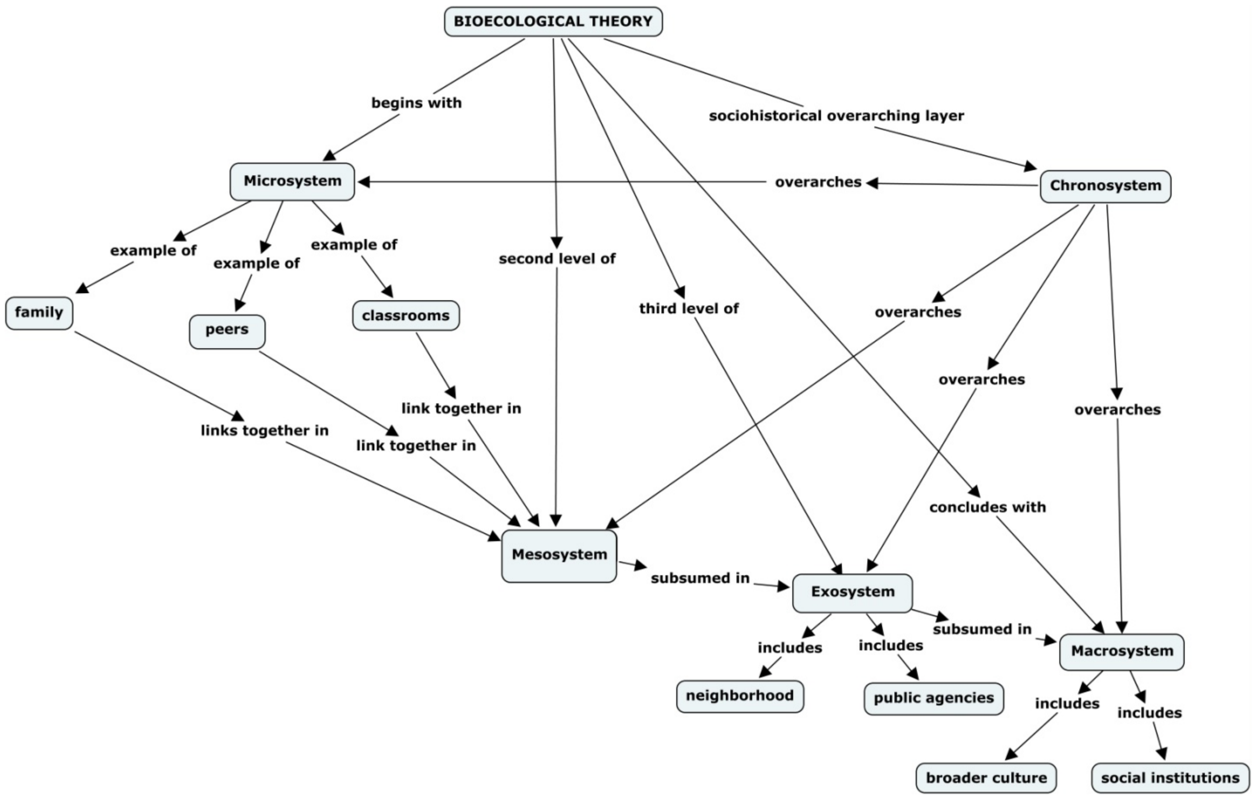


***Figure 1*. Student-Generated Concept Map of Bronfenbrenner's Bioecological Theory.**

Before being asked to create concept maps, I expose students to an in-class training module that takes approximately thirty minutes to complete in small groups, followed by fifteen to twenty minutes in which students ask questions and share their completed maps with the entire class. This practice is rooted in my own classroom observations in conjunction with data that I have systematically gathered from collaborative cross-disciplinary pilot research on concept mapping—focusing on coverage of the human nervous system in both introductory psychology and biology classes (Mayo & Salata, 2002)—which combine to indicate that classroom success with concept mapping requires preliminary training on how to construct a good concept map. Refer to Appendix A for the aforementioned concept-mapping training module (Mayo, 2010a).

Mind maps are non-linear diagrams that arrange ideas around a central theme (Buzan & Buzan, 2000). How do mind maps compare to concept maps? Mind maps radiate in multiple directions from a single concept, whereas concept maps may stem from several concepts arranged in a top-to-bottom hierarchical fashion. Therefore, mind maps take on the appearance of radial tree branches emanating from a central source, while concept maps assume a more downward-flowing network representation. The directional flexibility inherent in mind mapping makes it well-suited to organizing ideas while taking notes, studying, solving a problem, researching a topic, and brainstorming during essay writing.

To construct a mind map, start in the middle of a blank page with a central idea, then develop supporting ideas around the main topic and repeat the same procedure for subtopics, using correspondingly placed connecting lines throughout the entire process. Figure 2 portrays a student-generated mind map for selected categories of the Diagnostic and Statistical Manual of Mental Disorders (4th ed., text rev.) (American Psychiatric Association, 2000). This student, enrolled in a section of introductory psychology that I had taught previously, created this basic mind map with *Freemind* (Kumar, 2007)—downloadable, open source, mind-mapping software written in Java—while outlining notes on assigned reading in abnormal psychology. Similar to concept mapping, I have also discovered that initial training on how to properly construct a mind map assists students in using mind mapping to the fullest as a visual thinking tool.

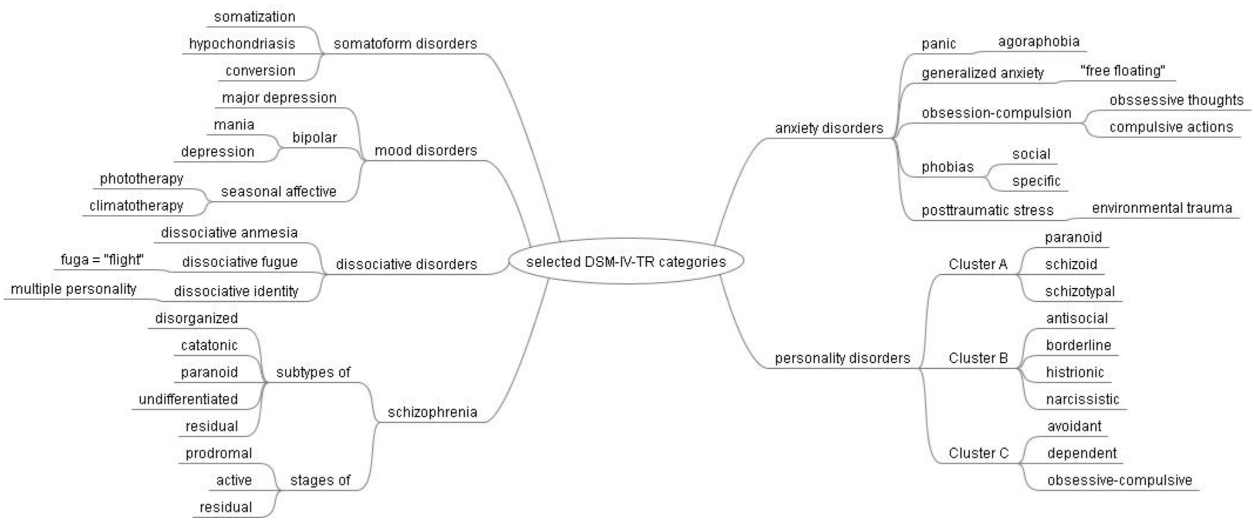


***Figure 2*. Student-Created Mind Map for Selected Categories of the Diagnostic and Statistical Manual of Mental Disorders** (4th ed., text rev.) (DSM-IV-TR).

Repertory grids are data-grid matrices that represent an individual's personal construct systems (Kelly, 1955). Similar to my successful classroom use of concept and mind mapping, I have also used the repertory grid technique (RGT) as an effective organizational and heuristic device in the context of teaching both life-span developmental psychology (Mayo, 2004b, 2008) and history and systems of psychology (Mayo, 2004a, 2008). When used as objects of whole-class discussion, repertory grids are an exceptional medium for organizing and synthesizing a diverse array of information in reviewing for major exams.

Consistent with my classroom applications of concept and mind maps, the RGT also necessitates prerequisite training on behalf of students. In fact, students may feel overwhelmed by the task of constructing repertory grids without preliminary instruction. Refer to Appendix B for a repertory grid student-training module that I have designed and used as an in-class exercise while teaching history and systems of psychology. This training module concerns the writings of Saint Augustine, who preserved the subject matter of psychology, infused with Orthodox church doctrine, from the fourth century A. D. until the scholarly contributions of Saint Thomas Aquinas roughly eight centuries later. In this instance, students also receive additional advance instruction regarding long-standing debates throughout psychology's history that underlie six bipolar *constructs* (meaning dimensions): mind-body, nature-nurture, subjectivism-objectivism, holism-elementalism, free will-determinism, and utility-purity. At the beginning of the term, I walk students through the process of how to rate Augustine's intellectual stance (and briefly justify these ratings) on a series of 1-11 continua relative to each bipolar construct. I use this early learning experience as an intellectual springboard for students to construct repertory grids on their own as class assignments throughout the remainder of the term.

As a cost-free means of eliciting, interpreting, and comparing students' knowledge frameworks, interactive computer applications of repertory grids are presently available for instructional use. One such knowledge management system is a web application known as *WebGrid* (Gaines & Shaw, 2010). *WebGrid* offers online techniques for modeling and visualizing relationships between/among constructs and *elements* (persons, objects, events, or problems of interest). Figures 3-5 are based on the work of one of my former students who completed these grids to partially fulfill an assignment in a history and systems of psychology class, comparing and contrasting the views of pioneering contributors to psychology's historical development. Figure 3 shows an 8 x 8 x 11 rating-grid display in which this student-rated eight bipolar constructs (mind-body, nature-nurture, subjectivism-objectivism, holism-elementalism, free will-determinism, utility-purity, verity-falsity, and major contribution-minor contribution) against eight elements (Wilhelm Wundt, William James, Sigmund Freud, Ivan Pavlov, John B. Watson, B. F. Skinner, Max Wertheimer, and Abraham Maslow) on a series of eleven-point Likert-type continua. Figures 4 and 5 depict analyses drawn from the dataset shown in Figure 3. Figure 4 portrays the results of a cluster analysis that affords inferences on whether two constructs are applied similarly to different elements, while also representing how different elements are rated on the same constructs. Figure 5 reveals the results of a principal components analysis that provides a visual overview of the distribution of constructs and elements in relation to one another.

	Wilhelm Wundt	William James	Sigmund Freud	Ivan Pavlov	John B. Watson	B. F. Skinner	Max Wertheimer	Abraham Maslow
mind-body	5	5	6	8	11	11	4	3
nature-nurture	8	4	2	11	11	11	1	4
subjectivism-objectivism	3	6	1	11	11	11	2	1
holism-elementalism	11	1	10	11	11	11	1	1
free will-determinism	6	3	11	11	11	11	11	1
utility-purity	11	1	2	3	5	1	8	1
verity-falsity	10	3	5	2	7	3	9	8
major-minor contribution	2	2	1	2	4	1	10	7

***Figure 3*. 8 (Bipolar Constructs) X 8 (Elements; Psychology's Pioneering Contributors) X 11 (1-11 Rating Continua) *WebGrid* Dataset Display.** Figure 3 appears in "Repertory Grid as a Heuristic Tool in Teaching Undergraduate Psychology," by J. A. Mayo, 2008, in D. S. Dunn, J. S. Halonen, & R. A. Smith (Eds.), *Teaching Critical Thinking in Psychology: A Handbook of Best Practices* (p. 132). London: Blackwell. Copyright 2010 by Blackwell. Reprinted with permission.

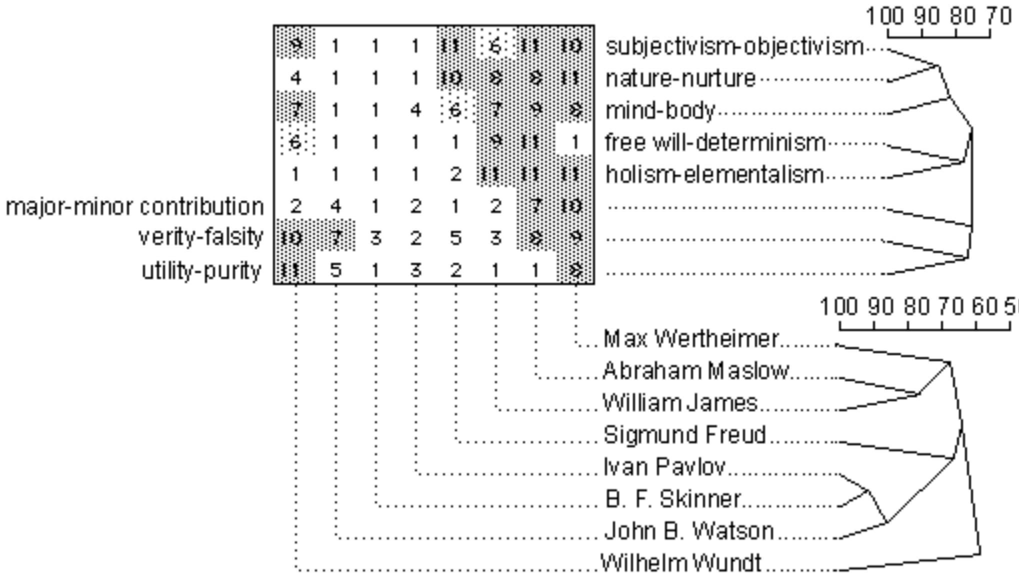


***Figure 4. WebGrid* Cluster Analysis for the Datatset Displayed in Figure 3.** Figure 4 appears in "Repertory Grid as a Heuristic Tool in Teaching Undergraduate Psychology," by J. A. Mayo, 2008, in D. S. Dunn, J. S. Halonen, & R. A. Smith (Eds.), *Teaching Critical Thinking in Psychology: A Handbook of Best Practices* (p. 133). London: Blackwell. Copyright 2010 by Blackwell. Reprinted with permission.

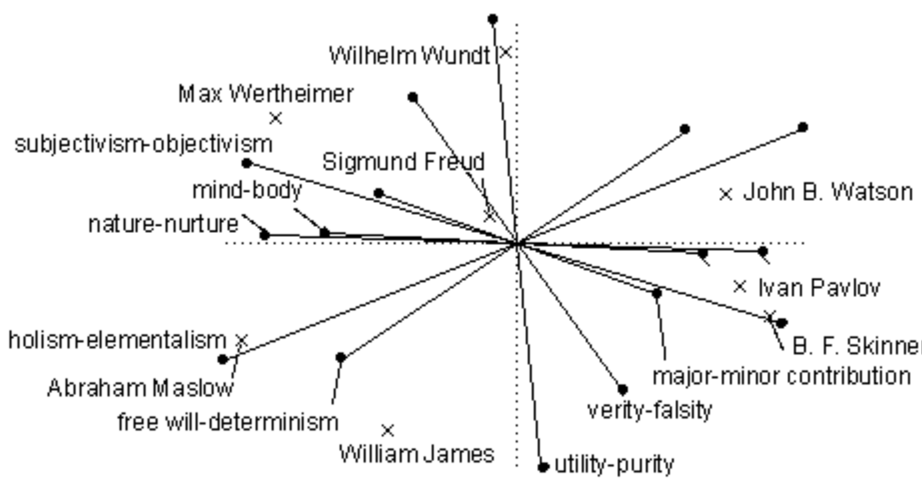


***Figure 5. WebGrid* Principal Components Analysis for the Dataset Displayed in Figure 3.** Figure 5 appears in "Repertory Grid as a Heuristic Tool in Teaching Undergraduate Psychology," by J. A. Mayo, 2008, in D. S. Dunn, J. S. Halonen, & R. A. Smith (Eds.), *Teaching Critical Thinking in Psychology: A Handbook of Best Practices* (p. 133). London: Blackwell. Copyright 2010 by Blackwell. Reprinted with permission.

V.

Concluding Remarks

Using instructional technology to encourage information literacy in pursuit of the learning goals and outcomes of an undergraduate liberal education renders that technology a means to an end, rather than an end in itself. Personalized computer applications of concept maps, mind maps, and repertory grids, which engage students in actively discovering connections between ideas, offer a technology-assisted means to accomplish metacognitive reflection as an important pedagogical end.

Appendix A: Concept-Mapping Student Training Module

Your first task is to look at both good and bad examples of concept maps on the next page before answering these questions:

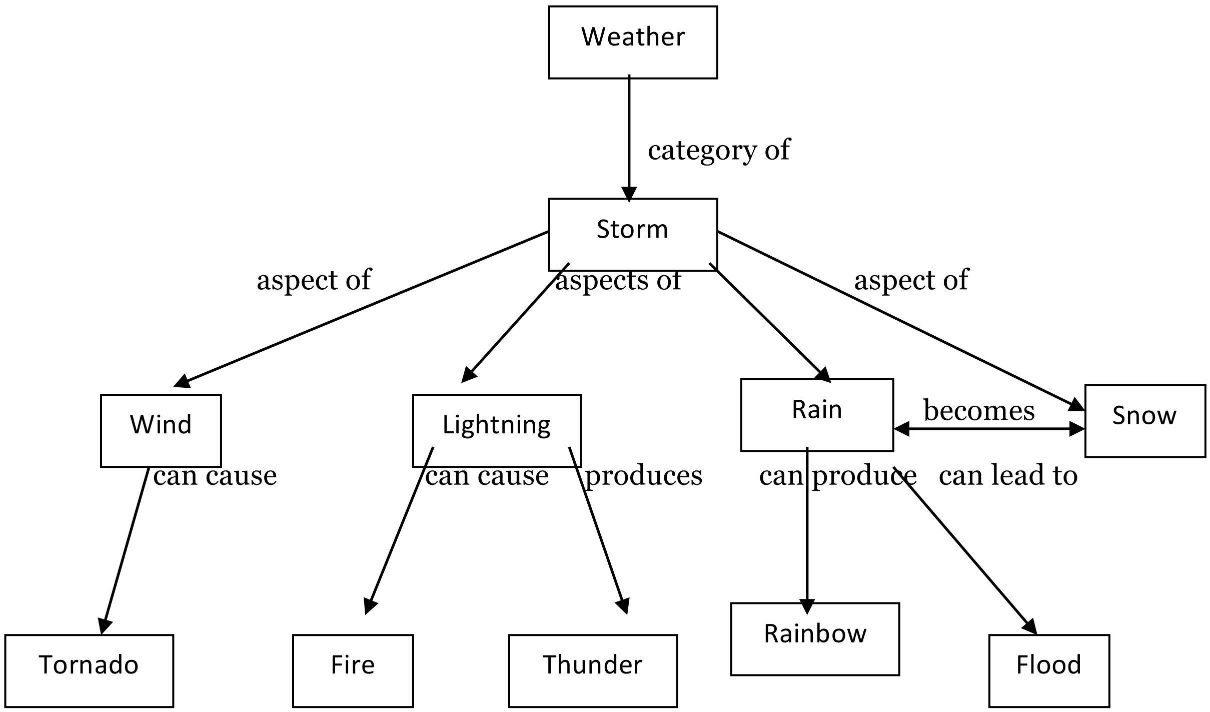
1. What is common between these two images?
2. What is different between these two images?

A concept map is a hierarchically arranged diagram that displays relationships between concepts under a category of knowledge. Here are the key steps that you should follow when creating a concept map:

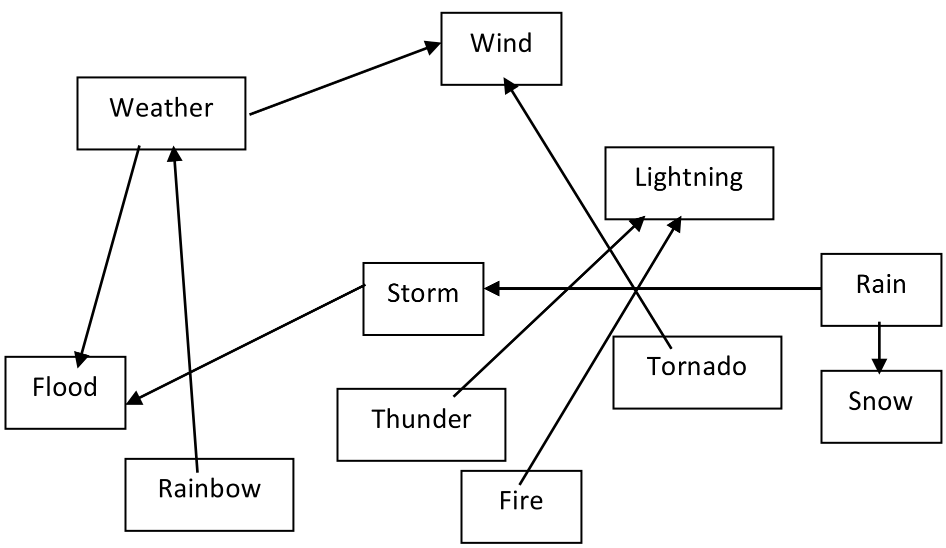
1. Create or find a list of common terms from a category of knowledge.
2. Rank those terms on a continuum from abstract to specific concepts, assigning numbers to concepts: 1 = most abstract and 2, 3, 4, etc. = increasingly less abstract.
3. Group concepts into levels of abstraction.
4. Decide if all concepts can be categorized under your most abstract item.
5. If you decide "no" under step 4, then add a concept to the list under which all concepts will fit.
6. Place the most abstract item in a central location at the top of your paper.
7. Choose the next level of abstraction and place concepts underneath the main one in a horizontal row, leaving space between them. Continue this step until your diagram is complete.
8. Connect concepts according to their relationships and write brief connecting phrases to describe each relationship. Arrows should proceed from top to bottom.
9. Place special cross-connections if they are useful. Again, include descriptive connecting phrases.

Terms: Fire, Thunder, Storm, Rainbow, Rain, Tornado, Lightning, Snow, Weather, Flood, Wind

GOOD EXAMPLE



BAD EXAMPLE



For your second task, construct a concept map with the following terms:

Written, Computer, Keyboard, Paper, Typewriter, Pencil, Eraser, Mouse, Word-processor, Notepad, “Post-it” note, Essay, Printout, Communication, Electronic, Media

Refer back as needed to the previously presented key steps of concept-map construction. Begin by brainstorming (e.g., defining terms, writing down possible relationships) and creating a first-draft concept map. Then use a separate page for a revised concept map. Lastly, write your final edited version on yet another page. Be sure to label each concept map as *First Draft*, *Revised*, and *Final Revision*, accordingly.

Appendix A appears in *Constructing Undergraduate Psychology Curricula: Promoting Authentic Learning and Assessment in the Teaching of Psychology*, by J. A. Mayo, 2010, pp. 97-98. Washington, D.C.: American Psychological Association (APA). Copyright 2010 by the APA. Adapted with permission.

Appendix B: Repertory-Grid Student Training Module

Directions: We will use the writings of Saint Augustine as an example of how to record and justify your ratings in a repertory grid. Use the 11-point scale provided to rate Augustine's contribution to the historical development of psychology on each of the following six bipolar meaning dimensions. For each meaning dimension, place an **X** on the appropriate line, somewhere between lines 1 and 11, which best matches Augustine's perspective. If you believe on a rare occasion that a meaning dimension does not apply to Augustine, print **NA** on line #6 for that dimension. In the space provided at the end of the rating scale, offer a brief justifying rationale for each rating—numbered 1, 2, 3, 4, 5, and 6 with the numerical rating in parenthesis before the written justification.

Rating Scale

		1	2	3	4	5	6	7	8	9	10	11	
1.	mind		X										body
2.	nature			X									nurture
3.	subjectivism		X										objectivism
4.	holism									X			elementalism
5.	free will		X										determinism
6.	utility			X									purity

Justifying rationale for each rating:

1. (Rating = 2). Augustine equated mind with soul, which left the body after death.

2. (Rating = 3). Augustine used the doctrine of *original sin* to justify his own wrongdoings.

3. (Rating = 2). Augustine relied heavily on introspection and private experiences, though he sometimes dealt with mental life in more naturalistic terms as borrowed from ancient Greek *pagan philosophers*.

4. (Rating = 9). Augustine broke down the structure of the mind into three elements: memory, reason, and will. However, he tried to unify these elements in explaining how a holy trinity also could be a unity.

5. (Rating = 2). Augustine thought that free will was the most important faculty of the mind, yet he used *original sin* to explain away the failure of his own will.

6. (Rating = 3). Although Augustine's psychology was intertwined with Orthodox church doctrine, he preserved the subject matter of psychology in this modified form for approximately eight centuries, which allowed subsequent scholars to interpret and critique his writings and thereby advance psychology in the centuries that followed.

References

American Psychological Association. (2007). *APA Guidelines for the undergraduate psychology major*. Washington, DC: Author. Retrieved October 9, 2011, from www.apa.org/ed/resources.html

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders (4th ed. Rev-TR)*. Washington, D.C.: Author.

Association of American Colleges and Universities and the Council for Higher Education Accreditation (2008). *New leadership for student learning and accountability: A statement of principles, commitments to action*. Washington, DC: Authors. Retrieved October 9, 2011, from http://www.chea.org/pdf/2008.01.30_New_Leadership_Statement.pdf

Bronfenbrenner, U. (1979). *The ecology of human development: Experiments by nature and design*. Cambridge, MA: Harvard University Press.

Buzan, T., & Buzan, B. (2000). *The mind map book* (millennium edition). London: BBC Worldwide.

Campoy, R. (1992, August). The role of technology in the school reform movement. *Educational Technology, 32*, 17-22.

Gaines, B. R., & Shaw, M. L. G. (2010). *WebGrid 5* [Computer program]. Alberta, Canada: Knowledge Science Institute. Available at: http://gigi.cpsc.ucalgary.ca:2000/

Institute for Human and Machine Cognition (2008). *CmapTools: Knowledge Modeling Kit* [Computer program]. Pensacola, FL: Institute for Human and Machine Cognition. Available at: http://cmap.ihmc.us/download/

Johnstone, B. (2003). *Never mind the laptops: Kids, computers, and the transformation of learning*. Bloomington, IN: iUniverse.

Kelly, G. A. (1955). *The psychology of personal constructs* (Vols. 1-2). New York: Norton.

Krathwohl, D. R. (2002). A revision of Bloom's taxonomy: An overview. *Theory into Practice, 41*, 212-218.

Kumar, S. (2007). *Freemind user guide* (version 0.8.0). [Computer program]. Toronto, Ontario: Seneca College of Applied Arts and Technology. Available at: http://freemind.sourceforge.net/FreeMind%20User%20Guide%20by%20Shailaja%20Kumar%20(manual).pdf

Leung, G. (2010). *The role of technology in contemporary education*. Retrieved October 9, 2001, from http://www.leadingedgelearning.ca/q2011/Docs/QuestJournal2010/Article11.pdf

Mayo, J. A. (2004a). A pilot investigation of the repertory grid as a heuristic tool in teaching historical foundations of psychology. *Constructivism in the Human Sciences, 9*, 31-41.

Mayo, J. A. (2004b). Repertory grid as a means to compare and contrast developmental theories. *Teaching of Psychology, 31*, 178-180.

Mayo, J. A. (2008). Repertory grid as a heuristic tool in teaching undergraduate psychology. In D. S. Dunn, J. S. Halonen, & R. A. Smith (Eds.), *Teaching critical thinking in psychology: A handbook of best practices* (127-135). London: Blackwell.

Mayo, J. A. (2010a). *Constructing undergraduate psychology curricula: Promoting authentic learning and assessment in the teaching of psychology*. Washington, D.C.: American Psychological Association.

Mayo, J. A. (2010b). Constructivist pedagogy: Advancing liberal education in undergraduate psychology. *Psychology Teacher Network, 20*(1), 1, 3-5.

Mayo, J. A., & Salata, M. (2002). [Cross-disciplinary applications of concept mapping in the undergraduate curriculum]. Unpublished raw data.

Munsey, C. (2008). Charting the future of undergraduate psychology. *Monitor on Psychology, 39*(8), 54-57.

Nanjappa, A., & Grant, M. M. (2003). Constructing on constructivism: The role of technology. *Electronic Journal for the Integration of Technology in Education, 2*, 38-56. Retrieved October 9, 2011, from http://ejite.isu.edu/Volume2No1/nanjappa.pdf

Novak, J. D. (1977). *A theory of education*. Ithaca, NY: Cornell University Press.

Novak, J. D. (1990). Concept maps and Vee diagrams: Two metacognitive tools to facilitate meaningful learning. *Instructional Science, 19*, 29-52.

Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas*. New York: Basic Books.

Papert, S. (1987). *Constructionism: A new opportunity for elementary science education*. [National Science Foundation Award Abstract No. 8751190] Retrieved October 9, 2011, from http://nsf.gov/awardsearch/showAward.do?AwardNumber=8751190

Papert, S. (1991). Situating constructionism. In I. Harel & S. Papert (Eds.), *Constructionism* (1-11). Norwood, NJ: Ablex Publishing Company.

Papert, S. (1994). The children's machine: Rethinking school in the age of computer. London: Harvester/Wheatsheaf.

Papert, S. (1999). *Child Psychologist Jean Piaget*. Retrieved October 9, 2011, from http://www.time.com/time/time100/scientist/profile/piaget.html

Papert, S., & Solomon, C. (1971). *Twenty things to do with a computer*. Cambridge: Massachusetts Institute of Technology Artificial Intelligence Laboratory. [Artificial Intelligence Memo 248] Retrieved October 9, 2011, from http://www.stager.org/articles/twentythings.pdf

Pask, G. (1975). *Conversation, cognition, and learning*. Amsterdam: Elsevier.

Pask, G. (1976). *Conversation theory: Applications in education and epistemology*. Amsterdam: Elsevier.

Piaget, J. (1973). *To understand is to invent*. New York: Grossman.

Prensky, M. (2001). Digital natives, digital immigrants: Part 1. *On the Horizon, 9*, 1-6.

Ryder, M. (1994). *Augmentation of the intellect: Network instruments, environments and strategies for learning*. Retrieved October 9, 2011, from http://carbon.ucdenver.edu/~mryder/augment.html

Strommen, E. F., & Lincoln, B. (1992). Constructivism, technology, and the future of classroom learning. *Education and Urban Society, 24*, 466-476.

Wittgenstein, L. (1981). *Tractatus logico-philosophicus* [Logical-philosophical treatise] (D. R. Pears & B. F. McGuinness, Trans.). London: Routledge. (Original work published 1921).