視覚デザインの原理と要素
－教材の視覚デザインの文献研究－
Principles and Elements of Visual Design:
A Review of the Literature on Visual Design of Instructional Materials

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ABSTRACT

　多くの図表が教材に使われるようになった現在，学習における視覚効果の分析はより重要な課題になって来た。そのような背景で，本研究は教材のビジュアルデザインの研究に関心を持つ研究者の支援を目的とし，ビジュアルデザインの概念についての文献を調査した。図表の分類については主に表面的特徴に基づく分類と，機能に基づく分類があることが判明した。ビジュアルデザインの原理には，バランス，一体感，近接性，対照性，強調，配置があり，要素には，線，輪郭，形状，明度，色，空間，テクスチャ，書体があることが判明した。しかしながら，研究者達はデザインは原理にのみ基づいて行われるものではないことも示唆している 。実際のデザインの過程を分析することは，インストラクショナルデザインの分野に新たな見解をもたらすと共に，現場で働くデザイナー達の手助けとなる可能性も秘めている。本文献研究がインストラクショナルデザインの分野におけるビジュアルデザインの研究に貢献することを願う。

　An increasing number of graphics used in instructional materials makes it important to explore the effects of visuals on learning (Anglin, Vaez & Cunningham, 2003). In this context, this paper reviews the concepts relevant to visual design studies for researchers who are interested in conducting studies in the area of visual design of instructional materials. The review identifies the relevant literature on the taxonomy of visuals,

and principles and elements of visual design. In particular, the taxonomy of visuals reveals two primary kinds: taxonomy based on surface feature and that based on functions. Scholars suggest that it is important to select visuals based on the function of visuals. The principles of visual design include balance, unity, proximity, contrast, emphasis, and alignment. The elements of visual design include line, shape, form, value, color, space, texture, and typeface. However, the literature also suggests that design takes place not only based on principles but also on designers' judgment, formed by multiple factors such as the purpose of design. Analyzing the actual visual design process could bring new knowledge to the field and would help designers to make optimal design judgments; this is together with existing studies and principles of visual design. It is hoped that this literature review will help researchers describe as well as analyze the visual design process in order to advance the knowledge of the field of instructional design.

Visual Design for Learning

"Communicating effectively is an important part of instructional design, and visual display plays a critical part in most instructional media." (Brown & Green, 2011, p. 206). Indeed, exploring the effects of visuals on learning is becoming important because of the increasing number of graphics used in instructional materials (Anglin, Vaez & Cunningham, 2003). In this context, this paper reviews concepts relevant to visual design studies (principles and elements of visual design). It is of relevance for researchers who are interested in conducting studies in the area of visual design of instructional materials. Since the terms visual design and graphic design are often used interchangeably (e.g. Clark & Lyons, 2011), this literature review also treats them interchangeably. According to Evans and Thomas (2013), "graphic design is the art of arranging pictographic and typographic elements to create effective communication" (p. 4).

Taxonomy of Visuals

There are several taxonomies of visuals to date. For example, Clark and Lyons (2004) categorize visuals into six kinds by surface features: illustration, photographic, modeled, animation, video, and virtual reality. Modeled is "three-dimensional representation" of an object, while the

virtual reality is "interactive three-dimensional world that dynamically changes as the 'user' moves through and views it" (p. 10). However, the authors also contend that selection of visuals should be based on their functions rather than on their surface features, in order to create effective visual design for learning. Indeed, Anglin, Vaez and Cunningham (2003) criticize taxonomies that classify visuals based on forms not on functions.

Clark and Lyons (2011) identify several functions of visuals: decorative, representational, mnemonic, organizational, relational, transformational, and interpretive. Mayer (2009) argues that designers should refrain from using decorative and representational graphics because they do not significantly contribute to learning. However, Norman (2002) states that designers have to be careful not only about cognitive but also emotional aspects of designs due to the fact that the human cognition and emotion are strongly related to each other. Greenspan and Shanker (2004) went so far to state that intelligence is a part of the process of emotion. People naturally have feelings about learning contents and these feelings determine how they organize the contents in their cognition or schema.

Making decisions on the selection of visuals is indeed a complicated task. However, in order to select appropriate visuals, it is important to consider the learning goals and individual differences (Clark

& Lyons, 2004). Likewise, Brown and Green (2011) discourage from designing visuals solely based on designer's personal preference. In order to achieve successful visual design, Evans and Thomas (2013) recommends designers to learn principles and elements of visual design. Learning and understanding visual principles and elements should also be important for researchers who are investigating visual design of instructional materials. Thus, the remainder of this paper will address the principles and elements of visual design.

Principles of Visual Design

Much of the literature suggests how to design visuals (Boling, Schwier, & Misanchuk, 2000; Brown & Green, 2011; Fleming & Levie, 1993; Gatto, Porter, & Selleck, 2011; Keller & Burkman, 1993; Lee & Boling, 1999; Lidwell, Holden & Butler, 2003; Lohr, 2008; Mayer, 2009; Ware, 2008). One of the most famous books used as a textbook for graphic designers is 'Universal Principles of Design' written by Lidwell, Holden and Butler (2003). Many principles addressed in the books are compatible with findings from psychology and instructional design. For example, the concepts "schema" and "advance organizer" discussed in this book are also addressed in textbooks of instructional design such as Principles of Instructional Design written by Gagne, Wager, Golas and Keller (2005). While there are several visual design principles described in the visual design literature, the following principles seem to frequently appear in multiple sources.

Balance

Balance is the concept describing the distribution of visual elements (Lohr, 2008). The decision regarding balance is very basic and unavoidable when one makes visual design decisions (Gatto, Porter, & Selleck, 2011). Evans and Thomas (2013) identify four types of balance: symmetrical, asymmetrical, radial, and crystallographic. "Crystallographic balance is the even distribution of like elements over the surface of a design." (p. 12). Gatto, Porter, and Selleck (2011) also identify four types of balance but instead of crystallographic, they consider approximate symmetry balance as the fourth category. Approximate symmetry balance is used in order to avoid monotonous symmetry balance and add visual interest. While asymmetrical balance is difficult to achieve compared with symmetrical balance, it adds more energy and interest. Radical balance is also called rotation symmetry balance (Lidwell, Holden & Butler, 2003), and it usually conveys more energy and more sense of movement than symmetrical balance (Gatto, Porter, & Selleck, 2011) or reflection symmetry (Lidwell, Holden & Butler, 2003).

Unity

While using various kinds of elements make visual design interesting, their excessive use can mess up visual design and thus, controlling variety or achieving unity is important (Evans & Thomas, 2013). Gatto, Porter, and Selleck (2011) address several ways to achieve unity. The first way is to make a certain element dominant while making everything else as subordinate. In other words, make a scale of one element larger than others (Evans & Thomas, 2013). Another way to make unity is to repeat elements (Gatto, Porter, and Selleck, 2011). Brown and Green (2011) also recommend repetition as a way to achieve unity. However, Gatto, Porter, and Selleck (2011) discourage from using too much repetition as it can make the visual design monotonous. Additionally, using similar colors can help achieve unity and harmony of visual design. Finally, using similar texture is an effective way to convey the sense of unity.

Proximity

Proximity is the matter of the position and space of visual elements (Evans & Thomas, 2013). Arranging related elements together help better organization and improve consumption of the information (Lohr, 2008; Brown & Green, 2011), as people perceive elements close to each other as related (Lidwell, Holden & Butler, 2003; Lohr, 2008). The principle of proximity is also famous as a principle of Gestalt (Wertheimer, 1923).

Contrast

"Whereas variety describes small differences within a design, contrast describes larger differences in the elements of a design" (Gatto, Porter, & Selleck, 2011, p. 168). Contrasting a certain element from others makes it easier to find (Ware, 2008). Contrast also contributes to the creation of mood (Gatto, Porter, & Selleck, 2011). There are multiple ways to achieve contrast. One way to make contrast is to use substantially different colors (Lidwell, Holden & Butler, 2003; Ware, 2008; Brown & Green, 2011; Gatto, Porter, & Selleck, 2011). Another way to achieve contrast is to use objects of different sizes (Ware, 2008; Brown & Green, 2011; Gatto, Porter, & Selleck, 2011). Using different shapes (Ware, 2008; Gatto, Porter, & Selleck, 2011) as well as different typefaces such as bold and italic (Lidwell, Holden & Butler, 2003; Brown & Green, 2011) can also create contrast. Texture and lines are other opportunities to create contrast (Gatto, Porter, & Selleck, 2011).

Emphasis

A concept related the construct of contrast is emphasis. Emphasis makes certain objects stand out and thus attracts more attention (Evans & Thomas, 2013). In addition to using the contrast techniques addressed above, there are several ways to make emphasis. For example, Gatto, Porter, and Selleck (2011) discuss two techniques to create emphasis. The first strategy that designers could use is to place certain elements together so that, as a group, the elements stand out from others. The second strategy, on the contrary, is isolating a particular element in order to make the element stands out from others. Additionally, arranging things in hierarchical order makes certain elements emphasized and dominant than other elements (Lohr, 2008; Evans & Thomas, 2013). Another technique for emphasis is to make shapes or arrangement distorted. However, people usually do not feel comfortable with distorted elements, and thus, this strategy is not recommended (Gatto, Porter, & Selleck, 2011).

Alignment

Placing elements along a common imaginary line is called alignment (Lidwell, Holden & Butler, 2003). There are three types of alignment: vertical, horizontal and diagonal, and in cases of vertical alignment, elements located on the top are usually perceived as more important (Lohr, 2008). Different ways of alignment make different effects (Gatto, Porter, & Selleck, 2011), and designers should be careful about alignments when they are adding and placing elements (Brown & Green, 2011).

Elements of Visual Design

The elements of visual designs are ingredients that designers can use (Gatto, Porter, & Selleck, 2011). Evans and Thomas (2013) identify line, texture, shape, space, and type as tangible elements, and size, color, value, and volume as conditional elements. The elements identified by Gatto, Porter and Selleck (2011) are line, color, shape, form, value, space, and texture. Such elements will be defined and explained in the following section.

Line

Gatto, Porter, and Selleck (2011) identify six kinds of lines: structural line, outline, contour line, gesture line or movement line, sketch line, and implied line. Especially, outline is defined as edge lines while contour lines are used to describe shapes of objects. Sketch lines describe even more details than other types of lines. Implied lines are imaginary lines can be created by rows of objects. Also, there are vertical, horizontal, diagonal, and curved lines. Vertical lines tend to convey feelings of height, stability, and dignity, while horizontal lines tend to create calm, tranquil, and balanced atmosphere. Additionally, diagonal lines make the design more dynamic and dramatic while curved lines convey more feeling or more relaxing movement. It might be obvious but interesting to note that the human mind can judge accurately whether a line is vertical or horizontal while it is harder to judge if the line is at forty-five degrees or not (Ware, 2008).

Shape

The shape is two-dimensional object made by lines and it broadly can be categorized into two types, geometric and organic (Gatto, Porter, & Selleck, 2011). Geometric shapes are squares or circles while organic shapes are irregular shapes. They also address concepts of positive and negative shapes. Positive shapes are actual shapes and negative shapes are spaces between positive shapes. "A successful design is one that carefully balances both" (p. 40).

Form

The form is a three-dimensional object which not only has width and height but also has depth (Gatto, Porter, & Selleck, 2011). The quality of a shape is also decided by its surface and weight.

Value

The value is "the intensity of white in a color; also known as brightness and luminance" (Lohr, 2008, p. 262). Value cannot do multiple things such as creating mood as well as to describe the depth of objects (Lohr, 2008; Gatto, Porter, & Selleck, 2011). Colors with lighter value are called high-keyed or pastel colors while dark value colors are called low-keyed (Gatto, Porter, & Selleck, 2011).

Color

Color is a very important element of visual design that decides the mood of a design. For example, red conveys feeling such as passion, orange can been seen as energetic, yellow can show brightness, green feels freshness, and so on (Lohr, 2008). However, it should be noted that different cultures interpret meanings of colors differently (Ware, 2008).

Space

Space is a place where objects, both two- and three-dimensional objects, exist (Evans & Thomas, 2013). In particular, the method of depicting three-dimensional space on a two-dimensional surface is called perspective" (Gatto, Porter, & Selleck, 2011, p. 106). A space where there are no objects is called either white space or negative space and effective use of such space is important for making attractive and effective visual design (Lohr, 2008; Brown & Green, 2011).

Texture

The texture is a quality of objects' surface, and it could be, for example, rough or patterned (Lohr, 2008; Gatto, Porter, & Selleck, 2011).

Typeface

The typeface is "the formal definition of alphabetical and numerical characters that are unified by consistent visual properties" (Lohr,

2008). There are three kinds of typeface: serif, sans serif, and decorative, and sans serif typefaces are considered to be more legible while serif typefaces are more readable (Lohr, 2008; Brown & Green, 2011). "Legibility is defined as how easy it is to read short burst of text, such as headings, bullets, and signings" while "readability is defined as how easy it is to read a lot of text, or long passage of text" (Lohr, 2008, p. 227). Font size is an important factor which decides readability (Poulton, 1967). Another study by Poulton and his colleague compared reading of justified and unjustified right-hand margins (Gregory & Poulton, 1970). In the study (n = 72), they found that the novice readers performed better reading comprehension from unjustified right-hand margins. For a detailed discussion of strategies to construct legible typefaces, please refer to Gaultney (2001).

Conclusion

Several principles can guide designers to make visual design decisions. However, these principles provide a brief guideline and do not answer specific design needs. Indeed, "design is not a collection of formulas that, if followed and applied, ensure effective results" (Evans & Thomas, 2013, p. 4). Nelson and Stolterman (2003) also contend that merely scientific knowledge is not enough for designing. Also, the fact that people do not always interpret the meaning of images as the designers intended (Boling, Eccarius, Smith, & Frick, 2004) makes things even more complicated. In order to improve one's design judgment and sense, designers are suggested to learn from what others do (Brown & Green, 2011; Gatto, Porter, & Selleck, 2011). Observing and analyzing the actual visual design process could bring new knowledge to the field and would help designers make optimal design judgment along with the existing studies and principles of visual design. It is hoped that this

review of the principles and elements of visual design will help researchers describe and analyze the visual design process in order to advance knowledge of the field of instructional design.

Acknowledgement

References

Anglin, G. J., Vaez, V., & Cunningham, K. L. (2003). Visual representations and learning: The role of static and animated graphics. In D. H. Jonassen & M. P. Driscoll (Eds.), *Handbook of research for educational communications and technology: A project of the Association for Educational Communications and Technology* (2nd ed.). London, UK: Routledge.

Black, A., & Stanbridge, K. L. (2012). Documents as "critical Incidents" in organization to consumer communication. *Visible Language, 46*(3), 246-281. Retrieved from http://visiblelanguagejournal.com

Blackwell, A. F., & Engelhardt, Y. (1998). A taxonomy of diagram taxonomies. *Proceedings of Thinking with Diagrams 98: Is There a Science of Diagrams?* Retrieved from https://www.cl.cam.ac.uk/~afb21/publications/TwD98.html

Boling, E. (2010). The need for design cases: Disseminating design knowledge. *International Journal of Designs for Learning, 1*(1), 1-8. Retrieved from http://scholarworks.iu.edu/journals/index.php/ijdl/

Boling, E., Schwier, R., & Misanchuk, E. (2000, May 31). *Visual design for instructional multimedia.* Retrieved February 10, 2014, from http://vdim.ca/Start.HTM

Boling, E., Eccarius, M., Smith, K., & Frick, T. (2004). Instructional illustrations: Intended meanings and learner interpretations. *Journal of Visual Literacy, 24*(2), 185-204.Brown, I. (1992). A cross-cultural comparison of children's drawing development. Visual Arts Research, 18(1(35)), 15-20. doi:10.2307/20715764

Brown, A., & Green, T. D. (2011). *The essentials of instructional design: Connecting fundamental principles with process and practice* (2nd ed.). Boston, MA: Prentice Hall.

Bruner, J. (1990). *Acts of meaning*. Cambridge, MA: Harvard University Press.

Carter, L. F. (1947). An experiment on the design of tables and graphs used for presenting numerical data. J*ournal of Applied Psychology, 31*(6), 640. doi:10.1037/h0054246

Clark, R. C., & Lyons, C. C. (2004). *Graphics for learning: Proven guidelines for planning, designing, and evaluating visuals in training materials*. San Francisco, CA: Pfeiffer.

Clark, R. C., & Lyons, C. C. (2011). *Graphics for learning: Proven guidelines for planning, designing, and evaluating visuals in training materials* (2nd ed.). San Francisco, CA: Pfeiffer.

Culbertson, H. M., & Powers, R. D. (1959). A study of graph comprehension difficulties. *Educational Technology Research and Development*, 7(3), 97-110. doi:10.1007/BF02767016

Dwyer, F. M. (1971). Color as an instructional variable. *AV Communication Review, 19*(4), 399-416. doi:10.1007/BF02768365

Easterby, R. S. (1970). The perception of symbols for machine displays. *Ergonomics, 13*(1), 149-158. doi:10.1080/00140137008931127

Evans, P., & Thomas, M. (2013). *Exploring the elements of design* (3rd ed.). Delmar, NY: Cengage Learning.

Fleming, M. (1967). Classification and analysis of instructional illustrations. *Educational Technology Research and Development*, 15(3), 246-258. doi:10.1007/BF02768609

Fleming, M. L., & Levie, W. H. (1993). *Instructional message design: Principles from the behavioral and cognitive sciences* (2nd ed.). Englewood Cliffs, NJ: Educational Technology Publications.

Gagne, R. M., Wager, W. W., Golas, K. C., & Keller, J. M. (2005). *Principles of instructional design* (5th ed.). Belmont, CA: Wadsworth, Cengage Learning.

Gatto, J. A., Porter, A. W., & Selleck, J. (2011). *Exploring visual design: The elements and principles* (4th ed.). Worcester, MA: Davis Publications.

Gaultney, V. (1972). Balancing typeface legibility and economy. *Psychology, 56*, 156-61. Retrieved from http://www.science.uwa.edu.au/

Greenspan, S. I., & Shanker, S. (2004). *The first idea how symbols, language, and intelligence evolved from our early primate ancestors to modern humans*. Cambridge, MA: Da Capo Press.

Gregory, M., & Poulton, E. C. (1970). Even versus uneven right-hand margins and the rate of comprehension in reading. *Ergonomics, 13*(4), 427-434. doi:10.1080/00140137008931157

Hai-Jew, S. (2010). *Digital imagery and informational graphics in E-learning: maximizing visual technologies*. Hershey, PA: Information Science Reference.

Hartley, J., Fraser, S., & Burnhill, P. (1974). A selected bibliography of typographical research relevant to the production of instructional materials. *AV Communication Review, 22*(2), 181-190. doi:10.2307/30217771

Hassenzahl, M. (2004). The interplay of beauty, goodness, and usability in interactive products. *Human-Computer Interaction, 19*(4), 319-349. doi:10.1207/s15327051hci1904_2

Hassenzahl, M., & Monk, A. (2010). The inference of perceived usability from beauty. *Human-Computer Interaction, 25*(3), 235-260. doi:10.1080/07370024.2010.500139

Hedberg, J. G., & Brown, I. (2002). Understanding cross-cultural meaning through visual media. *Educational Media International, 39*(1), 23-30. doi:10.1080/09523980210131123

Holliday, W. G. (1973). Critical analysis of pictorial research related to science education. *Science Education, 57*(2), 201-214. doi:10.1002/sce.3730570210

Kalyuga, S. (2005). Prior knowledge principle in multimedia learning. In R. E. Mayer (Ed.), *The cambridge handbook of multimedia learning* (1st ed., pp. 325-337). Cambridge, UK: Cambridge University Press.

Karl, H. (1994). The image is not the thing. In R. F. Fox (Ed.), *Images in language, media, and mind*. Urbana, IL: National Council of Teachers of English.

Keller, J. M., & Burkman, E. (1993). Motivation principles. In M. L. Fleming & W. H. Levie (Eds.), *Instructional message design: Principles from the behavioral and cognitive sciences* (2nd ed., pp. 3-53). Englewood Cliffs, NJ: Educational Technology Publications.

Konz, S. A., & Dickey, G. L. (1969). Manufacturing assembly instructions; A summary. *Ergonomics, 12*(3), 370-382. doi:10.1080/00140136908931061

Konz, S. A., Chawla, S., Sathaye, S., & Shah, P. (1972). Attractiveness and legibility of various colours when printed on cardboard. *Ergonomics, 15*(2), 189-194. doi:10.1080/00140137208924423

Lee, S. H., & Boling, E. (1999). Screen design guidelines for motivation in interactive multimedia instruction: A survey and framework for designers. *Educational Technology, 39*(3), 19-26. doi:10.1.1.132.6061

Lewis, R. A. (1972). Legibility of capital and lowercase computer printout. *Journal of Applied Psychology, 56*(3), 280. doi:10.1037/h0033042

Lidwell, W., Holden, K., & Butler, J. (2003). *Universal principles of design*. Gloucester, MA: Rockport.

Lohr, L. L. (2008). *Creating graphics for learning and performance: Lessons in visual literacy* (2nd ed.). Upper Saddle River, NJ: Pearson.

Mayer, R. E. (2005). Principles for reducing extraneous

process in multimedia learning: Coherence, signals, redundancy, spatial contiguity, and temporal contiguity principles. In R. E. Mayer (Ed.), *The cambridge handbook of multimedia learning* (1st ed., pp. 325-337). Cambridge, UK: Cambridge University Press.

Mayer, R. E. (2009). *Multimedia Learning* (2nd ed.). Cambridge, UK: Cambridge University Press.

Mayer, R. E., & Moreno, R. (2010). Techniques that reduce extraneous cognitive load and manage intrinsic cognitive load during multimedia learning. In J. L. Plass, R. Moreno, & R. Br?nken (Eds.), *Cognitive load theory* (1st ed., pp. 131-152). Cambridge, UK: Cambridge University Press.

Nakarada-Kordich, I., & Lobb, B. (2005). Effect of Perceived attractiveness of web interface design on visual search of web sites. *6th ACM SIGCHI New Zealand chapter's international conference on Computer-human interaction, Auckland* (pp. 25-27). doi: 10.1145/1073943.1073949

Nelson, H. G., & Stolterman, E. (2003). *The design way: Intentional change in an unpredictable world: Foundations and fundamentals of design competence*. Englewood Cliffs, NJ: Educational Technology Publications.

Nelson, H. G., & Stolterman, E. (2012). *The design way: Intentional change in an unpredictable world* (2nd ed.). Cambridge, MA: The MIT Press.

Norman, D. A. (1988). *The design of everyday things*. New York, NY: Currency Doubleday.

Norman, D. A. (2002). *Emotion & design: attractive things work better. Interactions, 9*(4), 36-42. doi:10.1145/543434.543435

Norman, D. (2004). Introduction to this special section on beauty, goodness, and usability. *Human-Computer Interaction, 19*(4), 311-318. doi:10.1207/s15327051hci1904_1

Paas, F., Renkl, A., & Sweller, J. (2003). Cognitive load theory and instructional design: Recent developments. In F. Paas, Arenkl, & J. Sweller (Eds.), *Cognitive load theory: A special issue of educational psychologist* (pp. 1-4). London, UK: Routledge.

Pettersson, R. (1989). *Visuals for information: Research and practice*. Englewood Cliffs, NJ: Educational Technology Publications.

Poulton, E. C. (1967). Skimming (scanning) news items printed in 8-point and 9-point letters. *Ergonomics, 10*(6), 713-716. doi:10.1080/00140136708930925

Rieber, L. P. (1994). *Computers, graphics & learning*. Madison, WI: Brown & Benchmark.

Schenkman, B. N., Jonsson, F. U. (2000). Aesthetics and preferences of web pages. *Behavioral Information Technology*, 19, 367-377. Retrieved from http://www.idemployee.id.tue.nl/

g.w.m.rauterberg/Special-Issues/2006-BIT-25_years/

Short, T. L. (2007). *Peirce's theory of signs*. Cambridge, NY: Cambridge University Press.

Tractinsky, N. (2004). Toward the study of aesthetics in information technology. *25th Annual International Conference on Information Systems, Washington, DC* (pp. 771-780). Retrieved from http://www.ise.bgu.ac.il/faculty/noam/papers/04_nt_icis.pdf

Tversky, B., Zacks, J., Lee, P., & Heiser, J. (2000). Lines, blobs, crosses and arrows: Diagrammatic communication with schematic figures. In M. Anderson, P. Cheng, & V. Haarslev (Eds.), *Theory and application of diagrams* (Vol. 1889, pp. 221-230). Berlin, HD: Springer Berlin Heidelberg.

Udsen, L. E., & Jørgensen, A. H. (2005). The aesthetic turn: unraveling recent aesthetic approaches to human-computer interaction. *Digital Creativity, 16*(4), 205-216. doi: 10.1080/14626260500476564

Ware, C. (2008). *Visual thinking for design*. Burlington, MA: Morgan Kaufmann.

Washburne, J. N. (1927). An experimental study of various graphic, tabular, and textual methods of presenting quantitative material. *Journal of Educational Psychology, 18*(6), 361. doi:10.1037/h0074758

Wertheimer, M. (1923). Untersuchungen zur Lehre von der Gestalt II. Psycologische Forschung, 4, 301-350.

Williams, R., & Tollett, J. (2001). *Robin Williams design workshop*. Berkeley, CA: Peachpit Press.

Winn, W. D. (1990). A theoretical framework for research on learning from graphics. *International Journal of Educational Research, 14*(6), 553-564. doi:10.1016/0883-0355(90)90025-4

Winn, W. D. (1993). Perception principles. In M. Fleming & W. H. Levie (Eds.), *Instructional message design: Principles from the behavioral and cognitive sciences* (2nd ed.). (pp. 55-126). Englewood Cliffs, NJ: Educational Technology Publications.