Using Concept Mapping in Introductory Statistics

Alisa Izumi, Ed. D.
Western Governors University

Tell me, I forget.
Show me, I remember.
Involve me, I understand.
Chinese proverb

This proverb illustrates well the importance of getting learners mentally involved in learning activities, generating connections between what they already know and what they are being asked to learn, and constructing meaning from their experiences. When students become active participants in the knowledge construction process, the focus of learning shifts from covering the curriculum to working with ideas (Scardamalia, 2002). Moreover, using manipulative tools "to think with" facilitates working with ideas and learning from that process.

For example technology tools provide "the means through which individuals engage and manipulate both resources and their own ideas" (Hannafin, Land, & Oliver, 1999, p. 128). Some kinds of technology tools can extend memory and make thinking visible. Good examples include brainstorming and concept mapping software such as *Inspiration9®*. Others programs or simple paper and pencil models help to represent knowledge and facilitate communication. These tools enable learners to experiment with modeling complex ideas.

How do with model complex ideas? Understanding a new concept involves a process of integrating new information with current models of the world. The self creates a new and different world through cognitive construction—the act of creating and refining usable models. With this perspective on teaching and learning, the instructor plays a key role by providing experiences and helping the students to build complex mental models compatible with textbook explanations and their applications to daily life. These activities may take the form of a dialogue or conversation through which the instructor and the students suggest, construct and exchange ideas to produce mental models in basic statistics. Unfortunately, many students have difficulty building and communicating mental models of basic statistics. It may be that some of this difficulty in developing mental models is due to students' inability to integrate text information with everyday usage. While statisticians hold complex statistical models, beginning students' knowledge is often rote and not readily transferable.

One method for attaching meaning to statistics terms is through a concept map. Concept maps are a graphic representation of students' knowledge. Having students create concept maps can provide us insights into how students organize and represent knowledge. This can be a useful strategy for assessing both the knowledge students entering a program or course and their developing knowledge of course material. Concept maps include *concepts*, usually enclosed in circles or boxes, and *relationships* between concepts, indicated by a connecting line. Words on the line are *linking words* and specify the relationship between concepts. See an example (pdf)

To produce this map, teachers ask students to create visual displays using *Inspiration 9®* http://www.inspiration.com/ which is a computerized tool that inspires students to develop and organize their ideas. Students easily create and update concept maps to help focus on their ideas. Visual learning techniques such as concept maps help students to process and retain new information by making connections between new and existing knowledge.

Through the process of creating and sharing concept maps, students provide very rich descriptions of current understanding. Teachers can thus better engage students in conversation and progress the learning through a Co-Construction process. In the Co-Construction process, after students draw their initial concept maps, the instructor provides the students with guidance crucial to the building of improved models. The guidance takes the form of a dialogue in which the instructor probes the students' ideas on an individual basis. Then, instead of presenting the students with the statistical model, as likely in traditional teaching, the instructor confronts the students with successive counterarguments and constraints that stimulate the students to review and modify their evolving ideas.

Are student relational concept maps produced on a computer a viable method to engage students and if so, what patterns might we see? With concept mapping programs like *Inspiration 9®*, teachers can gather student data on statistical understanding. Note computer programs are not always readily available. In this case, other options include sticky "post it" arranged on a poster board or even table top. The advantage of a software program is the ease of saving and filing student concept maps for easy viewing and integrative discussions. Each class meeting, I asked students to reflect and share their understanding of statistical tasks in which they produced student surveys, collected and then analyzed data. We based class discussions on what students needed in order to complete these tasks. When students finished tasks in the beginning and program end, student pairs discussed and drew concept maps. From the resulting concept maps produced at the end of the program, most students began with some simple conceptions that later became more interlinked and complex.

Overview of the Class Content

As a SummerMath instructor at Mount Holyoke College, I evaluated student gains in order to direct ongoing instruction in central measures—a fundamental of statistical reasoning. I was interested in how students developed models and how they employed these models to explain data generated from student surveys on teenage behaviors.

Participants

At Mount Holyoke College's Summermath, a 2-week workshop class containing a diverse mix of young women ages 14-17, met daily for 1.5 hours to provide a forum discussing data collection, central measures and variability. The researcher was the instructor. The class of 14 female students had mixed distribution of ethnicities, grade level, and abilities. The class size self-divided into high and lower level students. Both groups contained 50% black-white racial mixtures. While there was some informality, the class content and general outline was directed by the instructor. Students were encouraged to talk, discuss, and argue in both their small group discussions and in the whole class interaction. Students were verbally encouraged to come with their prior conceptions, pieces of knowledge, beliefs, and misconceptions.

Students began and ended with conceptual maps linking their self-generated statistical topics. They investigated and discussed common themes of data collection, organization, presentation, and analysis through creating and collecting Summermath student surveys. Using this hands-on approach, many of the real-life problems of randomness, sample selection, survey bias appeared. We discussed these issues along with measurement choices that can highlight certain opinions. We also discussed causal relationships through strong correlation, plausibility, replication, direct variation, and computerized cross tab analyses.

Data Collection
The class described in this study took place in at Mount Holyoke College's computer laboratory. Using an Inspiration 6® file, students provided a spatial display of their knowledge structures including the concepts, connections among concepts, and the relationships underlying the connections. Students used Inspiration 6® to provide a spatial display of their knowledge structures including the concepts, connections among concepts, and the relationships underlying the connections. The student pair moved the concepts in the boxes around the screen to depict how they were associated. The pair then connected the concepts by lines to show the linkages the student perceived. Finally, they entered words on the lines to describe the nature of the linkages or relationships.

Students began and ended with conceptual maps linking their self-generated statistical topics. They investigated and discussed common themes of data collection, organization, presentation, and analysis through creating and collecting student surveys. Using this hands-on approach, many of the real-life problems of randomness, sample selection, survey bias appeared. We discussed these issues along with measurement choices that can highlight certain opinions. We also discussed causal relationships through strong correlation, plausibility, replication, direct variation, and computerized cross tab analyses.

Student examples below provide a spatial display of their knowledge structures including the concepts, connections among concepts, and the relationships underlying the connections.

Example
Figure 1
Low Ability (pre)

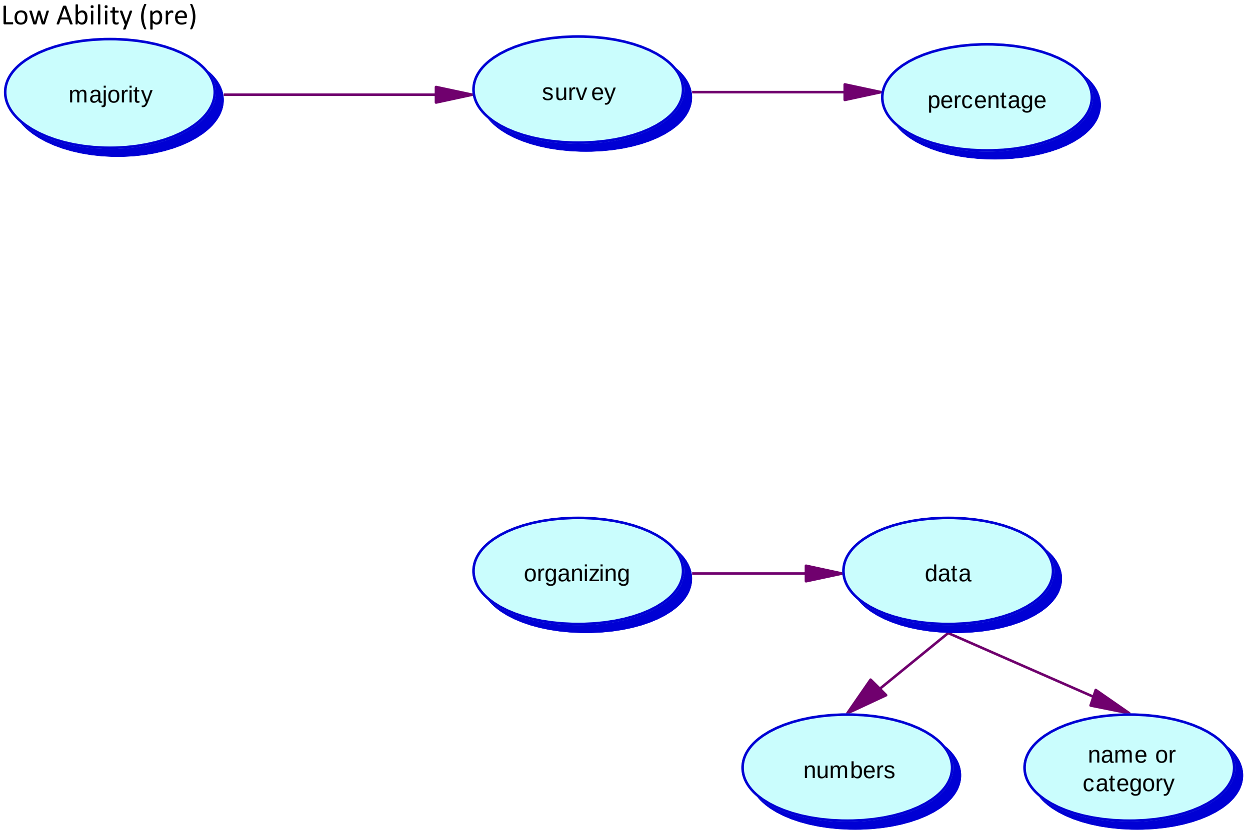


Figure 2

Low Ability (post)

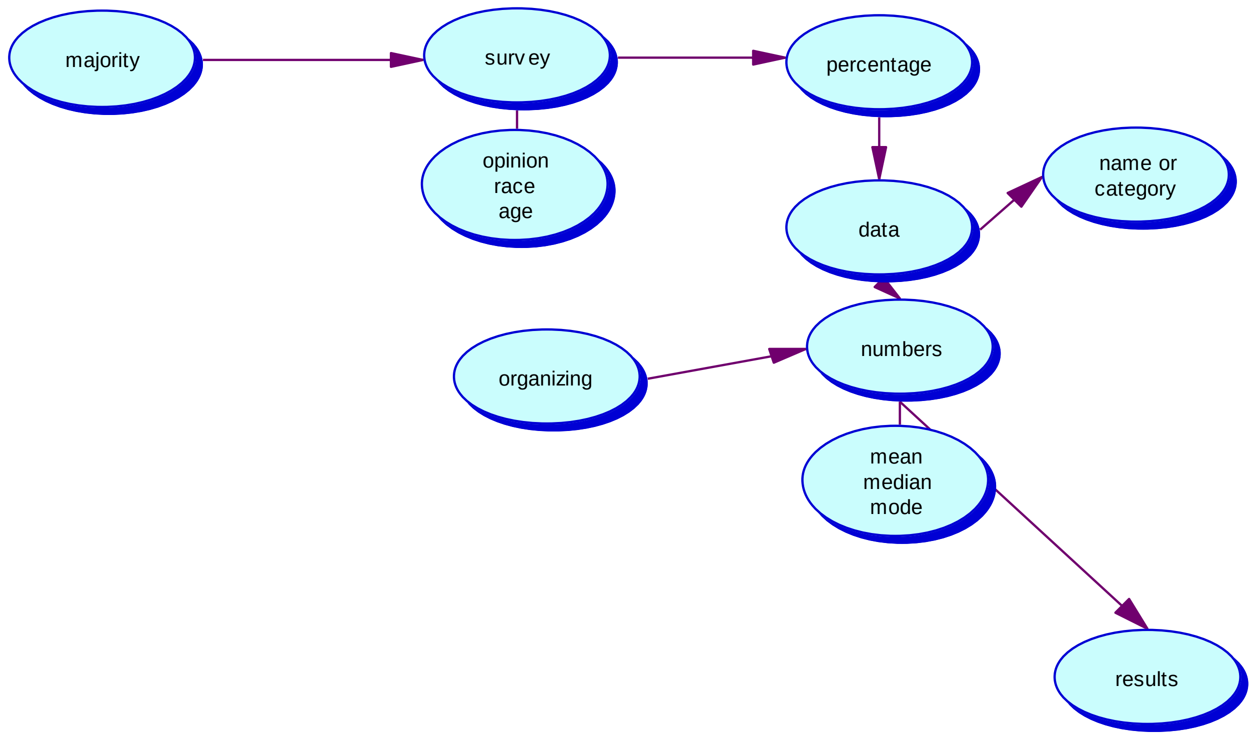


Figure 3
High ability (pre)

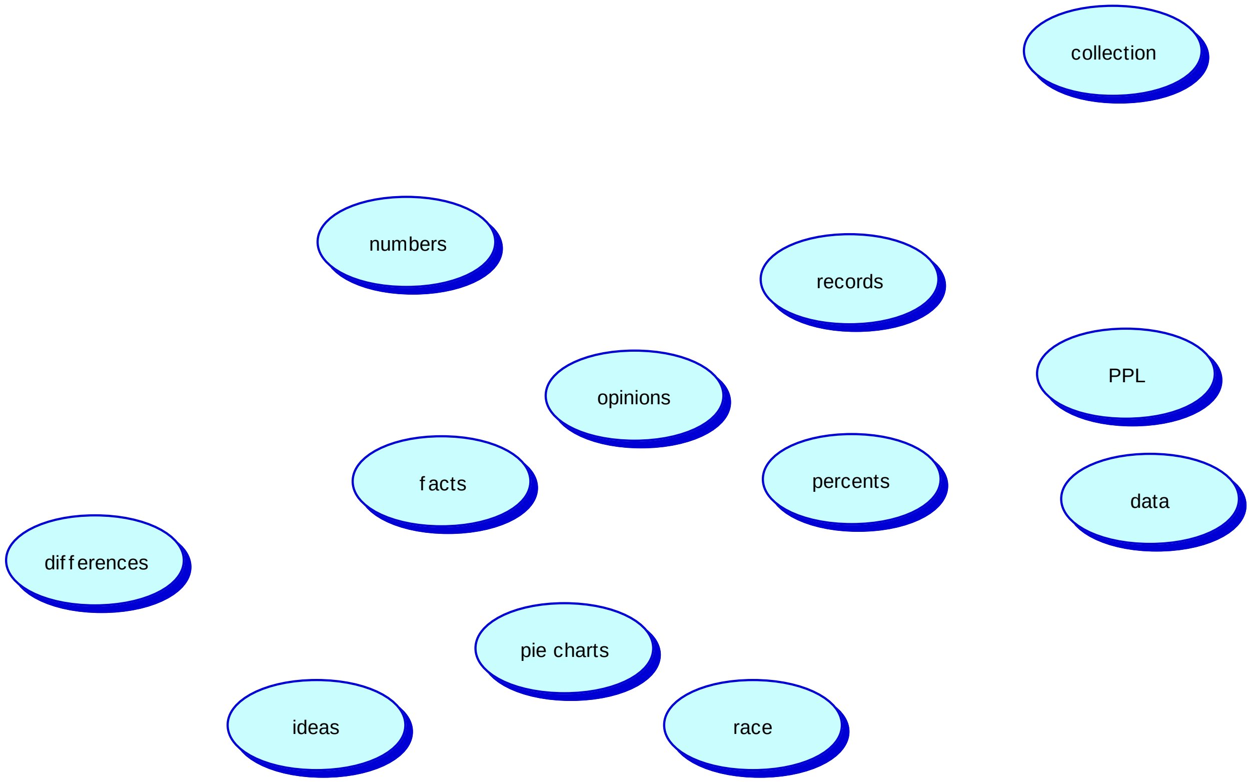
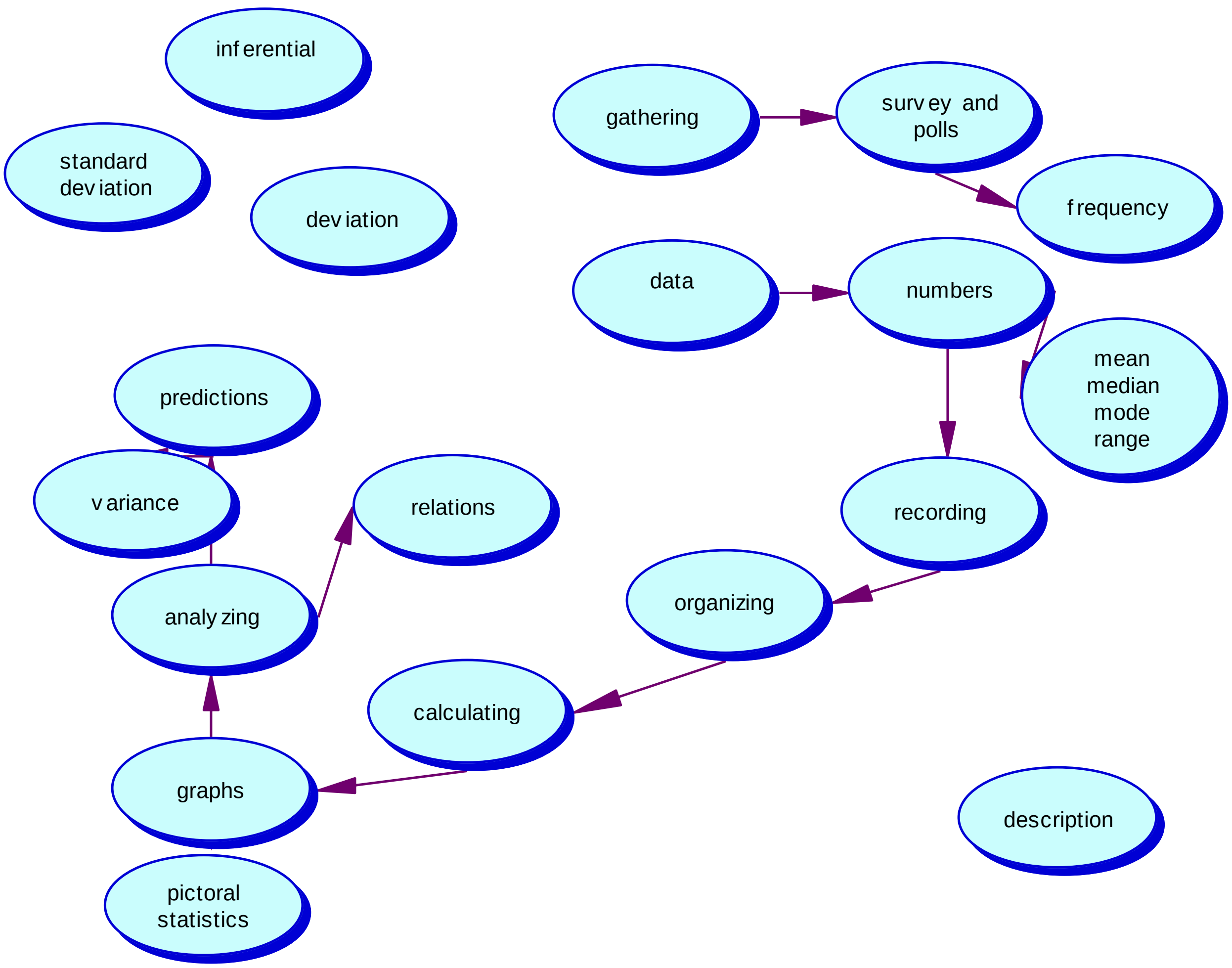


Figure 4

High ability (post)



Through the process of producing these maps, students develop self-regulatory processes that improve cognitive skills. These cognitive skills are manifested by number of concept linkages, by the allocation of attention as shown through the student details, and by sensitivity to informational feedback with teacher.

In the preceding figures, student concept maps are described in the following Table 1.

Table 1

Concept Maps listed by teacher	Pre-workshop	Post-workshop
Low abilities (figs. 1&2)	3 linear concepts which show limited knowledge by the few concepts represented	4 concepts arranged with the beginning hierarchical under-standing
High ability (figs. 3&4)	12 concepts with appropriate terminology. Not linked but spaced in appropriate regions	19 concepts with increased understanding of terms like inference and distinguishing more advanced statistical topics

REFERENCES

Bajzek, D., Brooks, J., Jerome, W., Lovett, M., Rinderle, J., Rule, G. & Thille, C. (2008). *Assessment and Instruction: Two Sides of the Same Coin*. In G. Richards (Ed.), Proceedings of World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2008 (pp. 560-565). Chesapeake, VA: AACE.

Chi, M. T. H., Glaser, R., and Rees, E. (1982). Expertise in problem solving. In R. J. Sternberg, ed. *Advances in the Psychology of Human Intelligence*. Hillsdale, NJ: Erlbaum.

Cuevas, H.M., Fiore, S.M. & Oser, R.L. (2002). Scaffolding cognitive and metacognitive processes in low verbal ability learners: use of diagrams in computer-based training environments. *Instructional Science*. 30: 433-464.

Davenport, J., Yaron, D., Klahr, D., & Koedinger, K. (2008). *When do diagrams enhance learning? A framework for designing relevant representations*. International Conference of the Learning Sciences, 2008.

Hannafin, M. J., Land, S., & Oliver, K. M. (1999). Open learning environments: Foundations, methods, and models. In C. Reigeluth (ed.), Instructional-Design Theories and Mocels: Volume II (pp. 115-140). Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

Hmelo-Silver, C.E. (2003). Analyzing collaborative knowledge construction: multiple methods for integrated understanding. *Computers and Education*. 41 (4), 397-420.

Resnick, L. B., Salmon, M., Zeitz, C. M., Wathen, S. H., & Holowchak, M. (1993). Reasoning in conversation. *Cognition and Instruction, 11*(3 & 4), 347-364.

Rye, J. A. (2002). Scoring concept maps: an expert map-based scheme weighted for relationships. *School Science and Mathematics* v. 102 no1 (Jan. 2002) p. 33-44.

Scardamalia, M. (2002). Collective Cognitive Responsibility for Advancement of Knowledge. In B. Smith (ed.). Liberal Education in a Knowledge Society. Chicago: Open Courst. Pp. 67-98 Retrieved from http.//ikit.org/fulltext/2002CollectiveCog.pdf