# METHODS & TECHNIQUES

## Concept Maps As an Assessment Tool in Psychology Courses

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*A concept map is a graphic, hierarchically arranged knowledge representation that reflects the content of an individual's semantic long-term memory. In this article we describe the basic mapping technique, a number of variations on the technique, how faculty members can use concept maps as an adjunct to traditional assessment techniques in psychology courses, and as a means of evaluating students' maps both quantitatively and qualitatively. Based on the results of a comparison between students' concepts maps completed at the beginning and the end of semester, we conclude that the technique is effective at evaluating students' knowledge.*

Most psychology instructors use traditional assessment techniques such as multiple-choice items, essays, and fill-in-the-blank style questions to evaluate students' learning. However, educational reforms have suggested that educators consider alternative assessment techniques as an adjunct to traditional evaluative methods (Ruiz-Primo & Shavelson, 1996). Concept mapping is one alternative technique that is particularly promising (McClure, Sonak, & Suen, 1999; Novak, 1998). Both concept maps and traditional assessment techniques measure the content of semantic long-term memory (cf. Young, 1996), and both forms of assessment can be completed in relatively comparable time frames. However, although it is often possible to perform well on objective examinations by simply memorizing facts, students need a deeper understanding of course material to construct a comprehensive, well-integrated, and veridical map. Thus, to create the map, students must know the basic material required to complete exams that use objective items and be capable of integrating that information into a coherent structure.

A concept map is a hierarchically arranged, graphic representation of the relationships among concepts (Novak, 1990, 1998) that exist within an individual's long-term memory (Bower, Clark, Lesgold, & Winzenz, 1969). When constructing a map, students place concepts (i.e., nodes) in near or far proximity to a central concept (typically enclosed in a box placed near the top of a sheet of paper). Labeled links connect the nodes and indicate the nature of the relations between pairs of elements. The combination of two nodes connected by a link creates a proposition, which is the smallest linguistic unit that carries meaning (Anderson, 2000).

Figure 1 depicts the concept map of a student enrolled in an introductory psychology course at a large Midwestern university. This map, which the student completed during the first week of the semester, reveals a somewhat sketchy understanding of general psychology. Indeed, the majority of propositions are not representative of material normally presented in a high school or college-level psychology course. Rather, they appear to represent content based on the student's personal life experiences. In fact, most instructors would judge many of the propositions as inaccurate. For instance, the proposition "psychology is mental illness," found at the top of Figure 1, suggests that psychology focuses only on psychological disorders.

In addition to nodes and labeled links, concept maps contain labeled dashed lines called *cross links*. Cross links connect independent branches of nodes (e.g., in Figure 1 the proposition "eating disorders are caused by depression" is established with the use of a cross link). The interconnective nature of cross links serves an important integrative function when constructing a map. For example, the presence or absence of cross links gives the instructor insights into the dynamic structure of students' knowledge. Further inspection of Figure 1 reveals a common characteristic of concept maps, which is that general propositions are within close proximity of the central concept (near the top of the page), whereas propositions that are more specific are farther away from the central concept (near the bottom or edges of the page). Therefore, individuals with general knowledge about the central concept, but who lack specific information, typically draw maps that are wide but not deep. In contrast, individuals with breadth and depth of knowledge typically draw maps that are both wide and deep.

Teachers in several academic disciplines have supported the educational appropriateness of using concept maps as an assessment technique. For example, Markham, Mintzes, and Jones (1994) and Wallace and Mintzes (1990) demonstrated that concept maps are a valid means of evaluating students' knowledge in the area of biology, whereas Cullen (1990) argued on behalf of their effectiveness when used in college chemistry courses. In this article we describe how instructors can use concept maps to evaluate student learning in psychology courses.

### Pragmatics of Using Concept Maps

Depending on the assessment objectives, an instructor can choose any of several different approaches when using con-

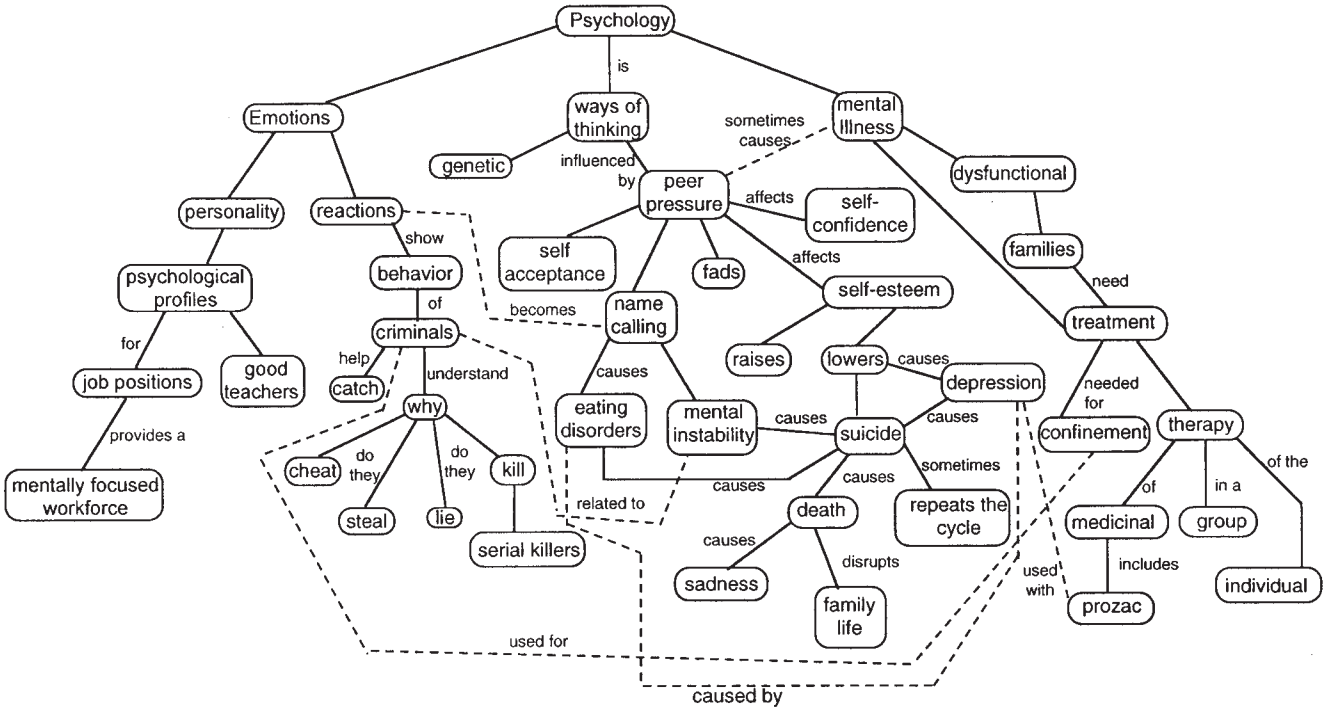


Figure 1. Concept map on the topic of "psychology" created by an introductory psychology student during the first week of the semester.

cept maps to evaluate student knowledge (for a review, see Ruiz-Primo & Shavelson, 1996). For example, instructors may require students to (a) justify elements of a concept map developed by the instructor, (b) incorporate a list of prespecified terms into a map they draw on their own, (c) flesh out a map that the instructor has started, or (d) create a map from scratch on their own. In each of these cases, the topic of the map—determined by the central concept—can be as broad or narrow as the instructor desires. The evaluative objective may make it appropriate to have individuals create a broadly focused map (using a central concept; e.g., "psychology") or one that is more constrained (using a central concept; e.g., "working memory capacity").

Regardless of the evaluative objective of the exercise, it is important to clearly communicate expectations regarding the content of the finished work product and the standards used to score the map. Similar to many cognitive skills, the ability to map effectively improves with practice, particularly in the early learning stages (Novak & Gowin, 1984). Therefore, it is best to give students the opportunity to complete two or three concept-map assignments early in the semester, before using the technique for evaluative purposes.

One benefit of using concept maps as an adjunct to traditional testing techniques is that the maps lend themselves to both quantitative and qualitative analysis (Ruiz-Primo & Shavelson, 1996). Quantitative markers include counts of the number of (a) valid nodes, (b) valid propositions, (c) valid cross links, (d) branches represented, (e) hierarchical levels represented, and (f) a ratio of upper-level propositions to lower-level propositions (i.e., an index of knowledge specificity). Qualitative scoring methods include (a) comparison of student maps to a criterion map created by the instructor, (b) evaluation of how effectively students incorporate a predetermined list of concepts into a map, (c) evaluation of propositions in terms of whether they represent "deep" or "surface" structure (as defined by the instructor), (d) evaluation of the structural integrity of students' maps (i.e., is the map coherent and well integrated?), and (e) evaluation of how well students can articulate (orally or in writing) the rationale behind their map or a map provided by the instructor.

Concept mapping typically involves students creating a map during the course of a 50- to 75-min class session, using a sheet of notebook paper (used to list important terms), an 11 × 17 (or larger) blank sheet of paper (used to construct the map), and a pencil with a good eraser. In addition to a basic set of instructions (see the Appendix), students who have never mapped before can benefit from first seeing a sample map. This sample map should be simple, clear, and on a familiar topic such as home repair or clothing.

## Evaluation

We evaluated the usefulness of concept maps as an assessment technique by having 17 college-level introductory psychology students complete maps at the beginning (pretest) and end (posttest) of the semester. All but 2 of the students were freshman, most of whom had not declared a major. Most of the participants (two thirds) were women. One member of this group created the map shown in Figure 1. That same individual also drew the posttest map shown in Figure 2. A comparison of the two maps reveals appreciably more nodes in the posttest map, a pretest–posttest increase in the number of psychological terms used, and an increase in the proportion of valid psychological concepts (e.g., "short-term memory lasts for 15 to 30 seconds," see Figure 2).

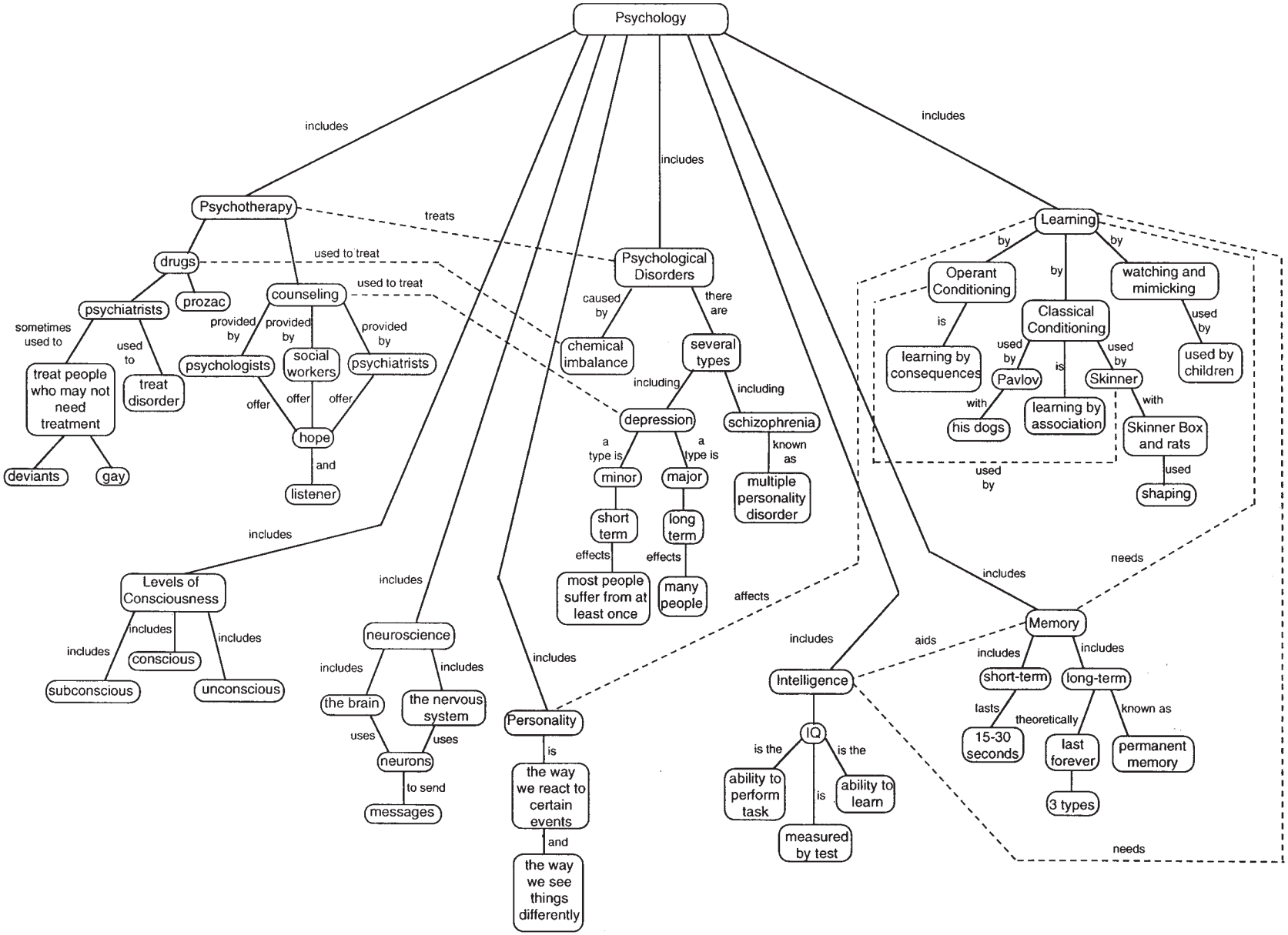


Figure 2. Concept map on the topic of “psychology” created near the end of the semester. This map was drawn by the same student who constructed the map shown in Figure 1.

**Table 1. Pretest–Posttest Scores for Five Different Quantitative Markers**

| | Pretest | | Posttest | | | |
|---|---|---|---|---|---|---|
| Variable | *M* | SD | M | SD | *t* | *p* |
| Total concepts | 34.6 | 23.0 | 56.2 | 14.5 | 7.14 | < .01 |
| Total cross links | 5.9 | 4.7 | 7.5 | 5.4 | 1.03 | *ns* |
| Number of levels | 5.6 | 1.6 | 5.7 | 1.8 | 0.14 | *ns* |
| Concepts at Level 1 | 4.3 | 1.6 | 5.6 | 1.9 | 2.28 | < .05 |
| Concepts at Level 2 | 10.6 | 6.5 | 14.1 | 4.1 | 1.72 | < .05 |

**Table 2. Percentage of Students Who Mentioned Key Concepts at Pretest and Posttest**

| Key Term | Pretest | Posttest | % Increase | *z* Score |
|---|---|---|---|---|
| Memory | 11.8 | 88.3 | 76.5 | 3.61** |
| Learning | 17.7 | 82.4 | 64.7 | 3.05** |
| Therapy | 58.8 | 94.1 | 35.3 | 2.45** |
| Disorder | 88.2 | 100.0 | 11.8 | 1.41 |
| Operant conditioning | 0.0 | 58.8 | 58.8 | 3.16** |
| Classical conditioning | 5.9 | 70.6 | 64.7 | 3.32** |
| Brain | 41.2 | 76.5 | 35.3 | 1.90* |

*$p < .05$. **$p < .01$.

We conducted quantitative and qualitative analyses of the 34 maps (i.e., 17 pretest and 17 posttest) to assess changes in students' knowledge of the field over the course of a semester. Quantitative markers included pretest–posttest counts of (a) the number of concepts represented, (b) the number of hierarchical levels represented, (c) the number of concepts contained in each of hierarchical Levels 1 and 2, and (d) the number of cross links specified. We calculated one-tailed correlated groups *t* tests to identify which of these markers indicated change. The analyses revealed a statistically significant increase, $p < .01$, in the number of concepts students generated (see Table 1). We also found an increase in the number of concepts at both the first and second hierarchical levels; both tests, $p < .05$. There were no statistically significant differences in the number of cross links used or the total number of hierarchical levels represented.

Qualitative analysis of the group's maps consisted of determining whether there was a pretest–posttest increase in the percentage of occurrence for the following seven key concepts: memory, learning, therapy, disorder, operant conditioning, classical conditioning, and the brain. We utilized seven tests of dependent proportions to establish whether there were statistically significant pretest–posttest increases in these concepts. The data shown in Table 2 reveal significant increases in the percentage of occurrence among six of the seven concepts.

## Discussion

The pretest–posttest evaluation of this technique provides empirical support for the notion that concept maps are a valid means of assessing change in introductory psychology students' course-related knowledge. Although there were clear pretest–posttest differences in the number of concepts represented in the content of the maps, there were no significant differences in the number of hierarchical levels or cross links. We believe that these null findings were due to the generality of central concept (i.e., psychology). A more focused central concept (e.g., working memory) may have revealed significant pretest–posttest differences within these two variables. Our experience with the technique suggests that it can be effective at evaluating knowledge in a variety of different courses, with students at virtually any level of training, from large introductory psychology classes to small advanced graduate seminars.

One of the key strengths of concept maps is their flexibility. They can be used to assess an individual's or a group's knowledge of a topic. They can be used as an in-class project or given to students as a take-home assignment. The scope of the maps can be broad or narrow, depending on the nature of the central concept selected. When necessary, students can complete the maps relatively quickly, with little in the way of instruction. Moreover, creating concept maps requires students to actively explore their understanding of the relationships among concepts. Educational and cognitive theorists have posited that this active exploration process leads to the refinement and synthesis of one's knowledge structures (for a discussion of this point, see Heinze-Fry & Novak, 1990); thus, the mapping process is a learning experience in and of itself.

In this article, we explored the use of concept maps as a means of assessment; however, it is worth noting that the technique and its variants are appropriate for a range of instructional applications. Students can use concept maps to create study guides or to outline a research paper. When given to students as a handout before a lecture, a well-specified map provides an organizational framework that can enhance comprehension. Students can create concept maps of their weekly readings or develop a map on a special research topic. Regardless of how concept maps are used—as a study aid, class assignment, or formal means of assessment—students find the technique a creative and intuitively appealing way of demonstrating their course-related knowledge. One student summed up the value of the technique when she stated that with concept maps "my true knowledge was mea-

sured, an adequate reflection of my psychological education. [She went on to say] concept maps made me utilize my long-term memory and organize [my] thoughts … which will help me remember these items in the future."

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## Appendix
## Concept-Map Instructions[1]

1. Write a list of 15 to 20 words related to the concept *psychology* on the piece of notebook paper.
2. Select two or three of the most general concepts from your list.
3. Write the word "psychology" at the top of the larger sheet of paper and circle it.
4. Place the concepts from Step 3 under the central concept and circle them.
5. Draw lines linking each of the new concepts to the central concept, and label each of these links.
6. Continue placing related concepts from your list under the appropriate concepts and connect these with labeled links as well. The concepts you use do not necessarily have to come from your list. You should use any concepts you can think of that you believe are important to accurately represent your knowledge.
7. Once you feel that you have drawn in all the important nodes and links, look for cross links and draw these in with dashed lines. Cross links are special links that allow you to show the interrelations between different branches of concepts contained in your map.

[1]Using the term *psychology* as the central concept.

## Note


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