# CONCEPT MAPS AS A DYNAMIC TOOL FOR TEACHING SCIENTIFIC THINKING


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## Abstract

PURPOSE

Medical education and scientific thinking often involve understanding interrelated and multidimensional topics. We have employed the concept map as an active learning method for teaching a diversity of complex science concepts in an undergraduate scientific thinking course. Here we describe our implementation of concept maps and how it can be used as tool for instruction, assessment and team building.

METHODS

A concept map is a diagram used to organize ideas and depict their relationships, typically constructed of information presented in boxes with labeled lines drawn between them to indicate connections. In our implementation as a teaching tool, students write key concepts from assigned reading onto sticky notes and work in small groups using these notes and dry-erase markers to create a concept map on a white board. The modular nature of this approach enables students to dynamically edit and rearrange concepts both during the initial construction and throughout a class period to incorporate new ideas. Students have created concept maps on topics including the scientific method, the diagnostic process for physicians and a variety of scientific research articles.

RESULTS

Concept maps created on the same topic by different groups are rarely identical, thus exposing the entire class to a diversity of understanding. When students have disagreements on ideas, the collaborative and flexible nature of these concept maps enable a constructive resolution and the addition of alternative thoughts and ideas. Additionally, over the course of the semester the sophistication of the concept maps evolves thus serving as qualitative assessment of student scientific thinking throughout the course.

CONCLUSION

Concept mapping enables students to collaboratively work towards understanding complex scientific ideas and to think critically about the relationships between them. Visualization of how students organize and structure knowledge facilitates the assessment of student growth and the diversity of understanding within a class.


## Figure 1. How to Construct a Concept Map

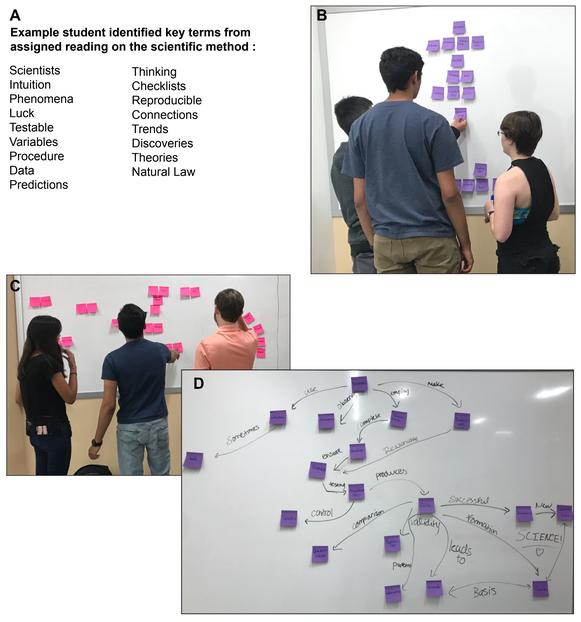


**Figure 1.** Concept mapping consists of the following stages: Brainstorming, Organization, Layout, Linking, Revising and Finalizing. **A)** In our course, students perform the brainstorming phase by writing down a list of key terms representing concepts from assigned reading, typically given as preparatory work. Depicted here are an example of a list of words a student chose from readings on the scientific method. **B)** In the organizing phase students transfer words from their lists onto sticky notes and working as individuals or in teams begin to organize the words based on their relationships, grouping similar words together. **C)** In the layout phase students arrange the words to reflect the relationships they have identified between them. **D)** In the linking phase students draw out the connections between words, adding labels to describe the nature of the relationship. This is followed by the revising and finalizing stages where students adapt the connections and layout based on discussion until a group consensus is reached. Depicted here is the final concept map created based on the key terms list in A.

## Figure 2. Concept Maps reflect the diversity of thinking on the same subject within a class period

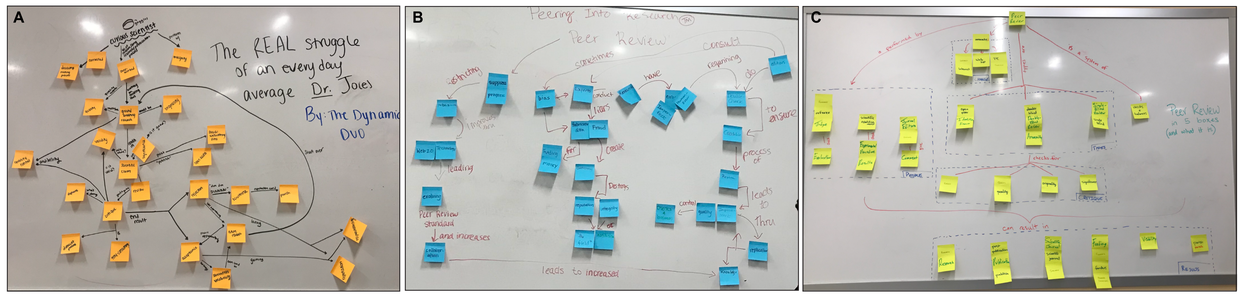


**Figure 2.** Concept maps by different student groups will often emphasize different aspects of a subject. After creating their concept maps, we have students present their work to each other, enabling the entire class to appreciate the diversity in thinking on a given subject. This approach also enables the instructor to assess how students are conceptualizing a given subject. Each concept map in **A-C** is the work of a different group of students based on the topic of scientific peer review. In the class discussion following the creation of these concept maps students noted how concept map **A** emphasized the people involved in peer review while concept map **B** was more focused on the process. Concept map **C** contains elements of both people and process

## Figure 3. Working with other students to build concept maps can promote teamwork

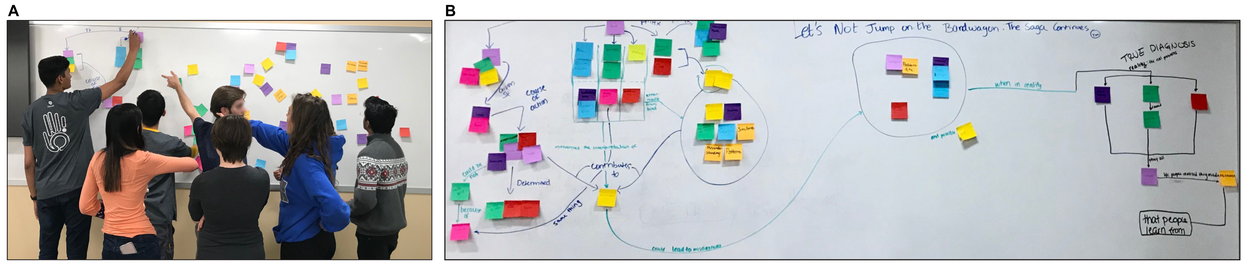


**Figure 3.** Working in a group to create a concept map allows students to share ideas with each other and develop teamwork skills. If a disagreement arises, the concept map can be adjusted to reflect a divergence in opinions. Alternatively, discussion may lead to a compromise or consensus. This approach also enables the instructor to asses group dynamics and provide guidance when necessary. By assigning students to different groups over the course of a semester for concept map work, they are exposed to different opinions and perspectives. These excercises can cultivate teamwork and comminication within a class, laying the foundation for group work outside of class as well. **A)** Students work together to combine separate concept maps on individual cases from an article on "How doctors think" into an overarching concept map. **B)** Final concept map from this class period. Sticky note color indicates the original group the concept came from.

## Figure 4. Concept maps can reflect changes in thinking over a class period

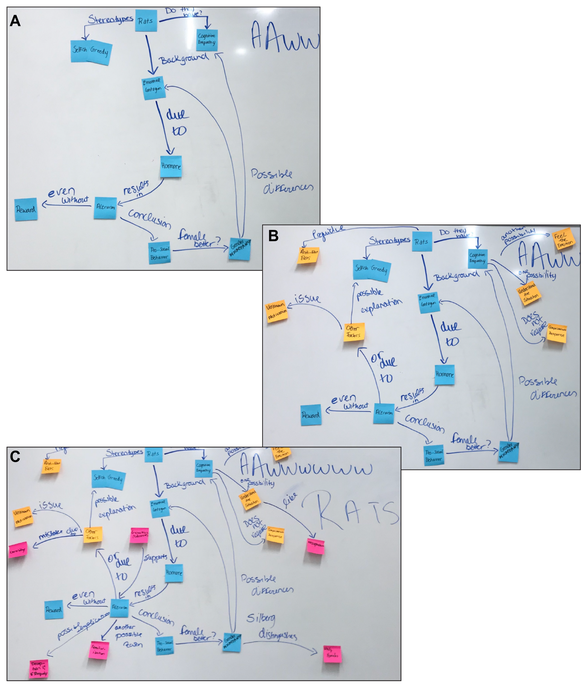


**Figure 4.** The dynamic nature of the concept map in the sticky note/whiteboard format enables students to edit and add to their concept maps in response to new information and discussion. In this manner, concept maps can be used to asses evolution in student thinking during a course period. The concept maps in **A-C** depict three subsequent concept maps by the same group. **A)** An initial concept map based on a scientific article investigating whether rats have empathy with blue sticky notes. **B)** Addition of new concepts and map revision with yellow sticky notes after class discussion of the article and the student concept maps. **C)** Final concept map after reading and discussing a critique of the first article. Pink sticky notes are the newly added concepts.

## Figure 5. Concepts maps can relect evolution in thinking over the duration of the semester

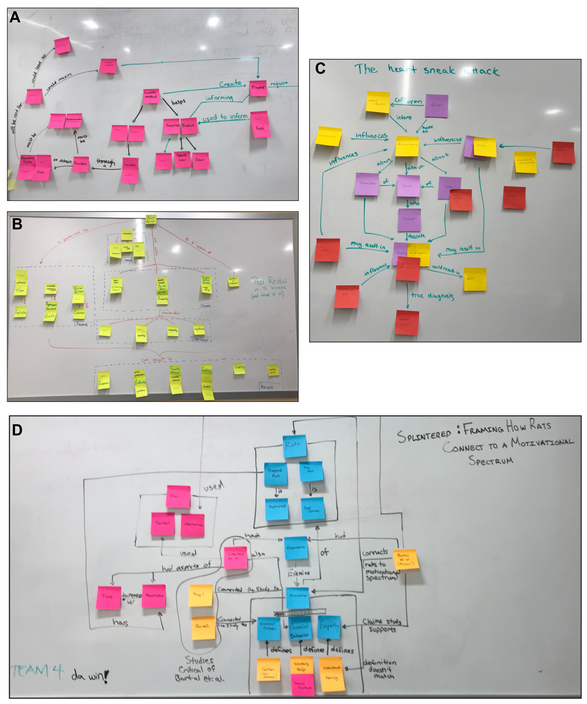


**Figure 5.** A student's approach to concept mapping often becomes more sophisticated as they continue working with the technique. Additionally as students thoughts evolve over many class periods, concept maps can be used as a qualitative method of tracking this growth. Initial concept maps often look similar to flow charts with a unidirectional narrative and little complexity. By the end of the course students are often comfortable drawing connections from many different concepts and areas, creating a full network of relationships. Depicted in **A-D** are example concept maps made by the same student over the course of the semester. **A** is the first map and **D** is the last.

## Figure 6. Students find concept maps to be a useful individual and team learning tool that promotes exposure to diverse thought

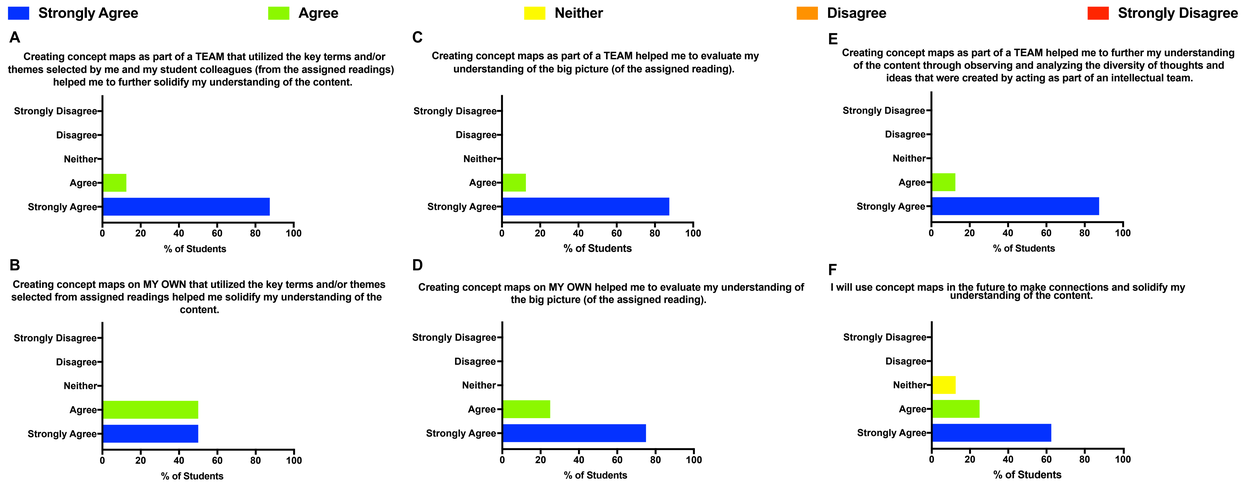


**Figure 6.** Figure 6. End of course survey of student perception of concept maps in a class of 8 students. Only one student had previous experience working with concept maps. The titles of **A-F** indicate the questions posed to the students with a summary of the responses below. Overall students had a favorable impression of concept maps as both an individual and group learning tool. The responses to questions regarding team work using concept maps were especially positive. Of note nearly all students indicated they would use concept maps in the future.

## Conclusions

Concept mapping enables students to collaboratively work towards understanding complex scientific ideas and think critically about the relationships between them.

Visualization of how students organize and structure knowledge facilitates the assessment of student growth and the diversity of understanding within a class.

Creating concept maps as part of a team furthered understanding through exposure to a diversity of thoughts and ideas

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