

Concept Mapping in Astro 101

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Concept Mapping

Students are often overwhelmed by the number of concepts, facts and relationships that rarely fit together in a linear or sequential order. Retrieving and applying the concepts becomes difficult because their memory decays, the concepts interfere with each other and there are no cues for recalling the right concepts at the right time. A concept map organizes the content, revealing relationships and patterns and making the content easier to recall.

At the University of British Columbia, we facilitate this concept mapping activity¹ in 50-minute tutorial sessions with 30–40 students. After an introduction and a warm-up exercise, groups of students create a concept map about stars. At the end of the activity, they share their maps with each other.

Key idea in the design of this activity:

Students are asked to do two things: learn how to create a concept and think about stars. We shouldn't ask them to do both at the same time.

Materials and Set-up

10 minutes

Concept maps are usually more effective when created in groups because there will likely be more concepts with additional links. We'll encourage students to work in groups of 3–5. (In groups of 2, there is often one leader and one follower. In groups larger than 5, it is difficult to crowd around the activity when working at desks and too easy for the 6th, 7th,... member to be left floating out on the edge of the group.) Each group needs

- 1 overhead transparency
- 2 or more overhead pens
- scrap paper (old 11 × 15 inch dot-matrix paper, for example)
- 1 sheet of flipchart paper (24 × 36 inches)
- 2 or more coloured flipchart markers

Put out the materials at “stations” ahead of time: transparency, overhead pens, scrap paper, flipchart markers. We don't want the students to dive into the big concept map before they know what they're doing so don't put out the flipchart paper. Passing it out later, group by group, is a great opportunity to interact with each group.

Other materials:

Sample concept map During the Introduction, you'll make a simple concept map in front of the class, so you should make one up ahead of time. For example, a 4–5 item concept map about coffee or tea (or whatever you drink to keep you awake) would be good. It should be about *something everyone in the room is already quite familiar with*. We want them learning about the structure of concept maps, not about the content of the map, itself.

¹This work is supported by the Carl Wieman Science Education Initiative (www.cwsei.ubc.ca).

Master list of concepts about stars There are benefits to the students generating their own list of items to include in the concept map, like students revealing misconceptions by including and/or linking concepts you did not expect. There is a cost, too, though: time. We'll compromise here. During the activity, you'll be watching how each group progresses and you may need to feed in any critical concepts they've left out. More about that below.

Part 1: Introduction to concept maps with an example
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5 minutes

Students will not generally engage in an activity if they can't see why it's useful to them. Concept maps need extra motivation because they are usually different than anything the students have done before or been tested on. The main selling point of this activity is that it will help them prepare for the upcoming exam. We'll motivate them to participate by explaining how this activity will help them:

It's easy to get overwhelmed by the number of concepts, facts and relationships about stars. Remembering it all during an exam is hard because

- our memory decays
- the concepts interfere with each other
- there are no cues for recalling the right concepts at the right time.

Today, you're going to draw a concept map about stars that will help you organize the concepts and link together the ones that are related. This should help you recall the material when you write the exam.

Share an example with the students: use a whiteboard or overhead to create the concept map you made up ahead of time. Do it out loud so they can hear what's going on in your head, how you decide what to include, where to put the nodes, how to link them together. Model the use of different sized bubbles or different kinds of lines and arrows to indicate which concepts and relationships are more important.

Part 2: Concept map practice

10 minutes

Before creating their concept map about stars, the students need some practice. We give them a topic they're already familiar with so they can *concentrate on the process instead of the content*: the Vancouver 2010 Olympics.

Before you draw a concept map about stars, we're going to give you a topic you're already familiar with so you can think about the process instead of the content: the Vancouver 2010 Olympics. Please take **5 minutes** to

1. Make a list of the **5 things** they remember most about the Olympics. Which 1 or 2 are most important?
2. Put them **on the overhead transparency** and join them together with lines and arrows and labels telling the actions or relationships that connect them. Highlight the important ones.

When you're done, we'll compare a couple of your maps.

We're asking them to use the overhead transparency because after 5 minutes, we'll take a few minutes to look at a couple of their maps. As you wander around the room while they're making this map, look for candidates to share with the class.

When 5 minutes are up, put a good map on overhead. “Read” the map aloud, tracing the relationships, particularly if there’s one you, yourself, experienced

hockey → drink lots of → beer. Yeah, I remember that one!

What you’re doing is showing the students how to read a concept map, informally assessing it (more about formal assessment below) and giving them positive feedback. If they’re unfamiliar with concept maps, they’re certainly unfamiliar with what make a good or bad one. Perhaps “accidently” get stuck on a relationship and ask the group that made the map to explain what they meant. You can also ask the class for comments:

Did anyone else have these things? What different ones did you include?

Do you have some of the same things but with different relationships?

With this practice planning, creating and assessing concept maps, they’re ready to proceed.

Part 3: Concept map about stars

25 minutes (until 10 min remaining)

In order to produce something in the time allowed, we need to give the students clear instructions of what to do, how to do it, and what to expect. We don’t want them to waste any of their precious cognitive load on trivial matters like, “What do I do now?” or “How long do we have?”

Over the next 25 minutes, you are going to make a concept map about **stars**.

- Pretend you’re doing it for other students in the class with the same vocabulary and knowledge as you (that is, it’s not for your professor and it’s not for your little brother.)
- Spend the first 10 minutes planning (use the scrap paper). Start by listing **5 important things about stars**. Make a rough sketch of the layout. Add new items and links as you think of them.
- When you’re happy with the layout, switch to the flipchart paper.

For the next 10 minutes, wander from group to group, checking on their progress. Remind them this is a rough draft and not to over-plan. Compare their concepts to the “master list”. If there are some important concepts missing, suggest they add it:

I notice you don’t have anything about how stars produce energy [Note: avoid saying, “I don’t see fusion on your map.”] That’s pretty important, isn’t it?

When the group seems happy with their draft and anxious to get onto the real thing, hand over a sheet of flipchart paper. Take the opportunity to remind them about emphasizing important concepts:

Before you start on the big paper, take 1 minute to look at your draft and identify the 2 or 3 most important concepts. Try to highlight those so when someone looks at your map, they’ll easily see what’s important about stars.

Once the groups are working, wander from group to group, checking on their progress. Query them on unexpected or incorrect links, make suggestions if there are important missing concepts and links, encourage them to be creative. Ask them to put their names on the paper – it makes them responsible for the content and you'll need their names when you assign marks.

Part 4: Sharing their maps

10 min

The students should look at each other's concept maps: it will reinforce familiar links or alert them to different ways of thinking. It's likely you'll have to force them to stop so you should reassure them that it's okay if they're not done ("Concept maps are hardly ever finished...") That's different than most exercises where not finished means lost marks.

It's useful for people to explain their maps to each other, too, so invite *half* of each group wander for 5 minutes while the other half stays to explain, and then switch. Take the opportunity to eavesdrop on their conversations. It might reveal misconceptions you can leverage later.

At the very end of the tutorial, get the students to hand in the big concept maps so we can grade them.

Cleanup

Collect the overhead pens and coloured markers in separate containers. Check that there is enough scrap paper, overheads and flipchart paper for the next session.



A group of 4 students working on their concept map. They're working from both sides of the lab tables so that everyone can reach the map. It's a good idea to give each group 2 or more coloured markers to avoid "I'm in charge because I have the marker."



A completed concept map. Notice the link between white dwarfs, standard candles, luminosity and distance. It highlights the power of concept maps to reveal relationships between concepts likely presented at different times during the course.

Assessment

Here are several approaches to assessment that trade marking time against “resolution” and feedback.

Participation A simple participated or not, pass/fail grade that rewards students who invested 50 minutes of their time.

Qualitative Rating Rate each concept map on a scale of 1–5 or 1–10 based on how well the map represents the concepts and relationships.

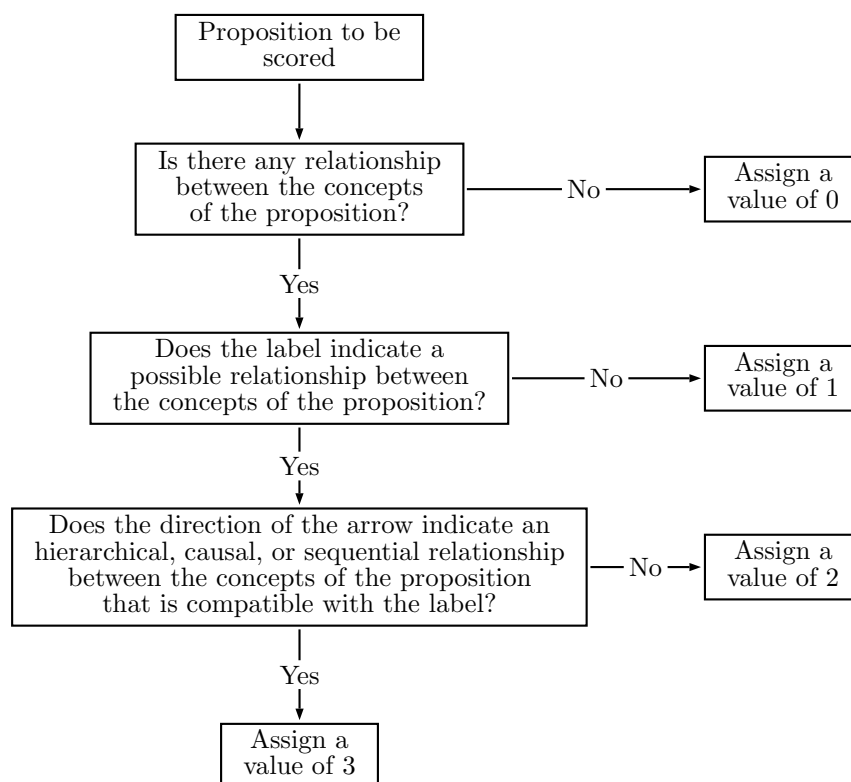
Number of Nodes, Links Count the number of nodes and *labeled* links (a defining characteristic of concept maps is that they describe not just *what* is related but also *how* so links should be labeled.) The higher the count, the greater the score.

Qualitative Rubric This University of Minnesota² rubric assesses four criteria of the concept map: structure, relationships, exploratory and communication:

Criteria	Excellent	Good	Adequate	Marginal	no credit, unacceptable
structure	non-linear structure that provides a very complete picture of your ideas	non-linear structure that provides a complete picture of your ideas	non-linear structure that provides a picture of your ideas	non-linear structure that shows some relationships between ideas	inappropriate structure
relationships	relative importance of ideas is indicated and both simple and complex relationships are very effectively mapped	relative importance of ideas is indicated and relationships are very effectively mapped	relative importance of ideas is indicated and relationships are mapped	importance is evident but not very distinctive; relationships are somewhat clear but lacking	no differentiation between ideas; no evidence of meaningful relationships
exploratory	map shows complex thinking about the meaningful relationships between ideas, themes and the framework	map shows effective thinking about the meaningful relationships between ideas, themes and the framework	map shows definite thinking about the relationships between ideas, themes, and the framework	map shows some thinking about relationships between ideas, themes, and the framework	thinking process is not clear
communication	information is presented clearly and allows for a high level of understanding	information is presented clearly and allows for a good level of understanding	information is presented clearly and allows for a basic level of understanding	information is presented and some understanding can be gained	information is not clear, very difficult to understand

²<http://dmc.umn.edu/activities/mindmap/>

Relational Scoring Method McClure, Sonak and Suen³ score each “proposition”, that is, two concepts joined by a labeled link, out of 3 based on this decision tree:



Select-and-Fill-In Zeilik et al.⁴ describe an assessment tool in which students are given a concept map that is nearly complete except for 10 blank concepts or link labels. Students fill in the blanks by selecting items from a reservoir of words and phrases.

Field-tested Learning Assessment Guide (FLAG) See Michael Zielik’s description of concept mapping at <http://www.flaguide.org/cat/conmap/conmap1.php>

³John R. McClure, Brian Sonak and Hoi K. Suen, “Concept Map Assessment of Classroom Learning: Reliability, Validity, and Logistical Practicality,” *J. Res. Sci. Teach.* **36**, 475–492 (1999).

⁴Michael Zeilik, Candace Schau, Nancy Mattern, Shannon Hall, Kathleen W. Teague and Walter Bisard, “Conceptual astronomy: A novel model for teaching postsecondary science courses,” *Am. J. Phys.* **65**, 987–996 (1997).