Using Concept Maps to Encourage the Meaningful Interpretation of Immunology Facts and Processes

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The breadth of physiological impact and the specific, fine details of immunology are major barriers for students new to the field of immunology. It is attractive for some to embark on rote learning of the facts. While memorization is better than nothing, that approach offers little insight into the details in the context of a grander picture. Evidence shows that the interpretation of the meaning of facts as they relate to each other is essential to efficient cognitive learning.[1]

Our institution provides a series of required graduate physiology courses enrolling 35 to 40 students across master's and doctoral programs in biology, education, biomedical science, and exercise science. BIO553 focuses on distributed control systems, with only the last quarter of the course dedicated to immunology. In addition to the challenge of relatively little time, students' backgrounds in immunology and basic science vary widely. To encourage them to search for and interpret the meaning of facts in a scaffolded manner, I employ a type of free-form graphic organizer, or concept map.

Concept maps as a deliberate instructional tool were introduced by Joseph Novak and Bob Gowan, interestingly in the context of students learning science.[2] In response to an overarching content theme, students illustrate their current knowledge with related ideas/facts represented as nodes (often circles, bubbles, or illustrations such as of a cell) connected by processes (often lines or arrows). Concept maps may be very hierarchical in appearance (*e.g.,* reflecting strong top-down tree thinking), or might not (*e.g.,* displaying an expanding, web-like, fractal pattern with many nested and interconnecting nodes).

My students independently produce concept maps along three classical themes in basic immunology: innate, adaptive, and overlap. They may produce one large map or several, so long as the maps fit the guidance of a detailed rubric. Essential elements of the rubric include significant penalty for regurgitation of web/textbook Venn diagrams, points for complexity of connections (number of secondary and tertiary relationships), and guidance for the minimum numbers of primary connections and nodes. I believe it is important to minimize points awarded for aesthetics, so long as the map(s) can be understood, and I do not restrict the medium of production.

There is a substantial heterogeneity in concept map outputs,[3] which is a good indicator of individuals' cognitive processing, difficult as that can be to interpret. For large enrollment classes, evaluation can be done in groups, with the understanding that the individual's processing of the content is not being assessed strictly in terms of the concept map outputs.

Instructors should reflect on how often and/or over what period of time concept maps should be assigned, constructed, and used. Similarly, they should weigh: (1) how much detail to require, (2) when to implement the concept map, (3) whether to use the map as a formative assessment, and (4) which types of rubrics to include and their detail. Additionally, instructors are strongly encouraged to consult straightforward resources such as those found in the references.[4-6]

It is very important to model an example in class early on to foster students' discernment of where to start and what relationships are relevant. As with other types of assessment, it is also important to have a clear and detailed rubric. Ultimately, concept maps are useful for spotting misconceptions in the classroom and quickly re-tooling the presentation of content. Students have commented that this is a helpful exercise, with some applying it to other coursework.

Finally, concept maps are a rich data source for those interested in educational research. Such a coding project is underway on the part of graduate students in my lab in connection with a physiology course for pre-nursing students.

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References

1 Davis JR & Arend BD. *Facilitating Seven Ways of Learning.* 2013. Stylus. Chapter 5 efficiently, and practically, discusses Cognitive Learning.

2 Novak JD & Gowan DB. *Learning How to Learn.* 1984. Cambridge University Press.

3 Nesbit JC & Adesope OO. Learning with Concept and Knowledge Maps: A Meta-Analysis. 2006. *Review of Educational Research* 76(3) 413-48.

4 Angelo TA & Cross KP. *Classroom Assessment Techniques: A Handbook for College Teachers.* 1993. Wiley. Pages 197-202 model concept map implementation.

5 Novak JD & Cañas AJ. The Theory Underlying Concept Maps and How to Construct and Use Them, Technical Report IHMC Cmap Tools 2006-01 Rev 01-2008, Florida Institute for Human and Machine Cognition, 2008, available at: *https://cmap.ihmc.us/docs/theory-of-concept-maps.php*. This provides a contemporary treatment of concept maps with examples by Novak.

6 *www.draw.io* (by JGraph Ltd.). This free, high-quality, web-based diagramming resource plugs into Google Drive, OneDrive, or syncs locally to a hard drive.

Student Example: Concept Map of Immune System