REAL-WORLD ANALOGIES FOR STUDENT UNDERSTANDING OF ABSTRACT SCIENTIFIC CONCEPTS

Christopher A. Love

Presenting Author: Christopher A. Love (c.love@griffith.edu.au)
School of Natural Sciences, Griffith University, Brisbane QLD 4111, Australia.

KEYWORDS: Real-world analogies, abstract concepts, visual learners

Problem

One of the challenges in biochemistry is that students have difficulty understanding many of the complex scientific concepts, especially as many concepts are abstract and thus difficult to comprehend or envisage. Making comparisons between known examples allows students to develop knowledge, applying what they already know, to developing an understanding of complex concepts (Orgill and Bodner, 2007).

Plan

To develop real-world analogies to enhance understanding of protein evolution and diversity in Protein Science (2005NSC), a second year course in biochemistry. Such analogies may aid in student understanding, by bridging the divide between known/familiar concepts and abstract biochemical concepts. Many analogies appear in textbooks, and the classic analogy used in biochemistry is the specific interaction between ligand and receptor represented as a 'lock and key'. Analogies are designed for the comparison of a familiar domain (concepts familiar to students) and a less familiar domain (complex scientific concept) in order for students to clarify thinking, overcome misconceptions and visualise concepts (Orgill and Bodner, 2007). Biochemistry instructors frequently use analogies to help students construct and organize their own knowledge (Orgill *et al.*, 2015), and it has been suggested that analogical reasoning should is an essential component of expert knowledge and skill competence, and should be part of the biochemistry curricula (Schönborn and Anderson, 2008). However, Brown and Salter (2010) has suggested that due care should be taken when designing analogies to ensure they are used as intended, to minimize misconceptions.

Action

Four everyday examples were designed to assist in explaining protein evolution and diversity. Figure 1 illustrates an analogy which relates the biological roles of isozymes to the functions of different bicycles. Others include relating divergent and convergent evolution of proteins to the evolution of mobile phones, and alternative splicing of RNA used to create similar proteins with slight variations in function compared to the components that make up a cordless drill with variation based on particular drill bit used. The impact of using real-world/common place examples to improve student understanding was evaluated by student survey.

Reflection

A survey to gage students' perceptions of the real-world analogies was performed (94% response rate), and 89.4% (39.4 % strongly agreed & 50% agreed) of the respondents agreed that the real-world examples improved, supported or helped their understanding of these scientific concepts, and 86.4% agreed they would benefit from additional real-world analogies. Of the respondents, 43 provided comments, and three students stated that the examples helped because they were visual learners, with one student commenting, "*they provide a relatable reference which makes it easier to visualise the concept*." Several students commented that the real-world examples helped their understanding of the science, for instance, "*helped me understand the concept in simple terms, then I was able to refer to the scientific figures to get a better understanding of the concepts in scientific terms*." Many students commented that the real life examples gave '*perspective*' or a 'reference' which they '*relate to*' or '*clarify*' the scientific concept (20 comments, 21%). Students also suggested the examples were helpful in reinforcing the concept. Asked in the survey if they could think of a non-scientific example to one of the concepts, 14 students (15%) provided examples. Students creating their own examples are evidence of higher level learning (Bloom, 1956; Anderson & Krathwohl, 2001). From a students' perspective the real-world examples appear to have a positive effects on student learning although it will be interesting to see if this translates into improved performance when assessed formally.

Isozymes

Isozymes (or iso-enzymes) are slightly different forms of the same protein encoded by different genes. Isozymes perform the same catalytic reaction but their roles vary in different cell and tissue types due to: **1.** Different metabolic patterns in different organs; **2.** Varying locations and metabolic roles in the same cell; **3.** Changing metabolic patterns in different stages of development (embryonic, foetal or adult tissue); and different responses to allosteric enzyme modulators.

Eg: Hexokinase - 4 isozymes. Each isozymes catalyzes the same reaction (Figure 1) at different rates (Figure 2) in order for different cell types to metabolise glucose differently, and thus the requirement of a different isozyme.

Hexokinase I	muscle
Hexokinase II	myocytes in blood
Hexokinase III	muscle
Hexokinase IV	liver

Fig. 1

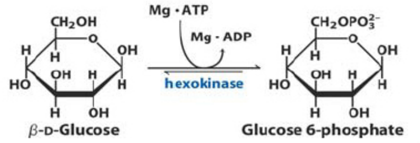
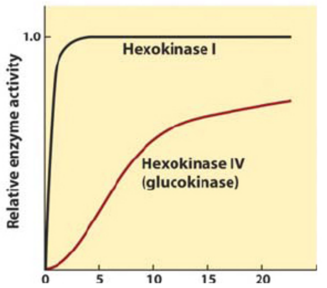


Fig. 2



Real-world example: Bicycles can be used as an analogy to explain to the concept of isozymes (Figure 3). The primary function of a bicycle is a means of transport. Therefore, depending on where the bicycle is ridden would determine which type of bicycle to choose. For example, a cyclist in the Tour de France would choose the racing bike as it has been designed to be fast but for a trip to the shops to pick some groceries, the bicycle with the basket would be more practical. Choosing the correct bicycle for the associated task or terrain is no different from a cell using the correct isozyme for a particular metabolic process.

Fig. 3

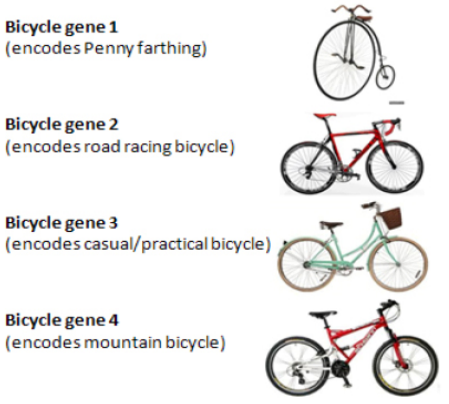


Figure 1: **An illustration showing the scientific concept related to a real-world example. This analogy compares different bicycles to different isozymes.**

References

Anderson, L.W. & Krathwohld D.R. (2001). *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives.* New York: Longman

Bloom, B.S. (1956) *Taxonomy of Educational Objectives, the classification of educational goals – Handbook I: Cognitive Domain.* New York: McKay

Brown, S. & Salter, S. (2010) Analogies in science and science teaching. *Adv. Physiol. Educ.* **34**:167-169.

Orgill, M. & Bodner, G.M. (2007) Lock and keys: An analysis of biochemistry students' use of analogies *Biochem. Mol. Biol. Educ.* **35**:244-254.

Orgill, M., Bussey, T.J. & Bodner, G.M. (2015) Biochemistry instructor's perceptions of analogies and their classroom use. *Chem. Educ. Res. Prect.* **16**:731-746.

Schönborn, K.J. & Anderson, T.R. (2008) Bridging the educational research-teaching practice gap: conceptual understanding, Part 2: Assessing and developing student knowledge. *Biochem. Mol. Biol. Educ.* **36**:372-379.

Proceedings of the Australian Conference on Science and Mathematics Education, The University of Queensland, Sept 28th to 30th, 2016, page 84-85, ISBN Number 978-0-9871834-5-3.