Investigating the Effect of Question Order on Student Understanding of Structure and Function

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Introduction

- Structure and function is a core concept identified in biology and physiology (AAAS, 2011; Michael & McFarland, 2011)
- Question order may affect students' ability to cognitively retrieve information (Duit, 1991; Gentner & Toupin, 1986)
- 'Define' questions require students to recall knowledge. 'Give example' questions require conceptual understanding and may be more difficult, but may provide contextual cues that guide students in their response (Anderson et al, 2001; Marzano, 2001)
- Lexical analysis of written assessments may decrease grading time and increase grading consistency (Nehm & Haertig, 2012)

Research Questions

- How do students understand the physiology core concept *structure and function*?
- Is there a difference in student explanations of the core concept when question order is varied?
- Can lexical analysis be used to examine student understanding of the core concept?

Methods & Results

We collected written responses to the questions below from students in a junior level General Physiology at a large southeastern public university. The class was randomly split in half and each half received two short answer questions in different orders. Using human coding and lexical analysis, we compared how question order influenced students' use of the core concept and relate structure and function.
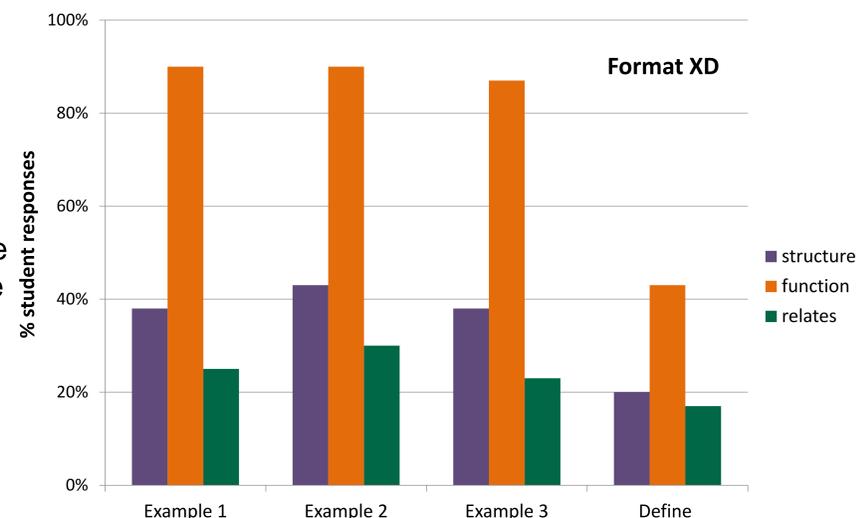
Format DX: Define the principle: form reflects function *followed by* Give an example of the principle form reflects function from the human body N=62

Format XD: Give an example of the principle form reflects function from the human body *followed by* Define the principle: form reflects function N=69

When asked to provide a definition first, 2% of students related structure and function in their definition while 41% related structure and function when giving examples
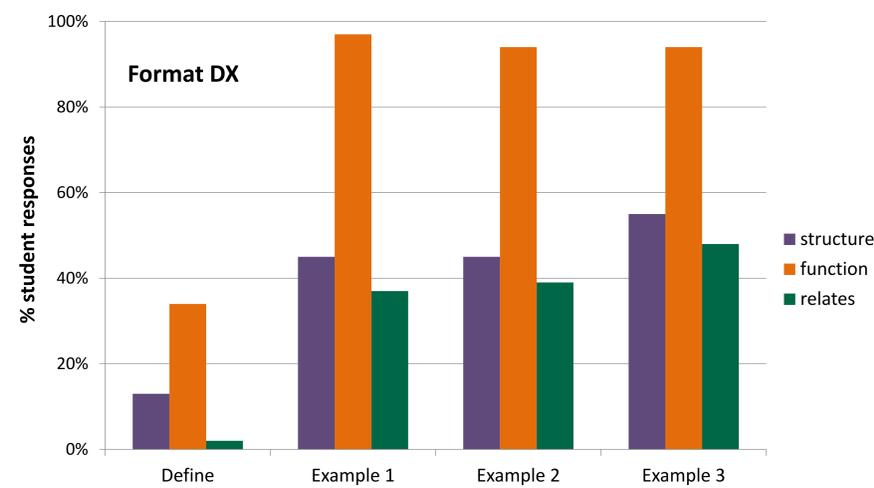
When asked to provide examples first, 17% of students related structure and function in their definition, while 26% related structure and function when giving examples

Students have more heterogeneous ideas (more lexical categories) when giving examples compared to providing a definition

Regression coefficients and odds-ratios of the lexical categories for binomial logistic regression for the 'Define' question and 'Relates structure and function', n=254

Lexical category	β	OR
Process	-0.902	0.406*
Structure/biomolecules	2.095	8.125*
Structure/part	3.628	37.622**

Regression coefficients and odds-ratios of the lexical categories for binomial logistic regression for the 'Give example' question and 'Relates structure and function', n=517

Lexical category	β	OR
Process	1.626	5.085**
Mechanism	0.739	2.093*
Function	-3.077	0.046**
Function/general	0.996	2.707*
Structure	1.996	7.360**
Structure/cell	2.615	13.667**
Structure/cell component	3.416	30.440*
Structure/tissue	1.826	6.210**
Structure/organ	3.102	22.247**
Structure/organ system	1.529	4.614**
Structure/complex structure	1.828	6.221*

Accuracy (kappa) of logistic regression models for 'Define' and 'Give example'

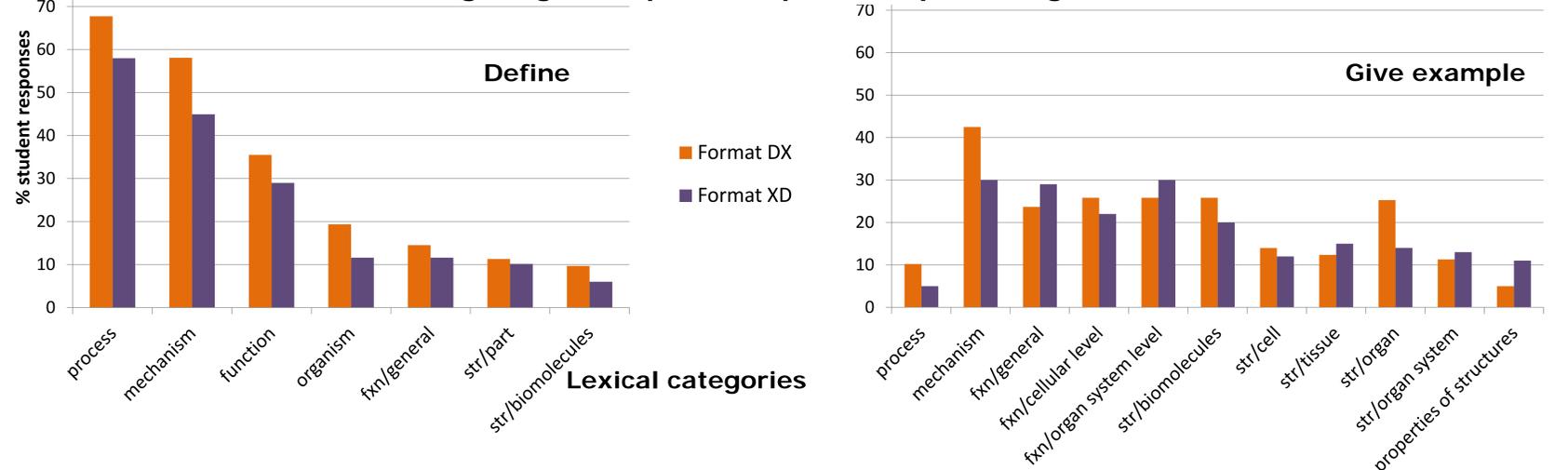| Define (n=254)	Accuracy (kappa)
Structure	0.917
Function	0.594
Relates structure and function	0.894
Give example (n=517)	**Accuracy (kappa)**
Structure	0.890
Function	0.921
Relates structure and function	0.876

Students held misconceptions about:
- Relationship between resistance, flow and pressure
- Diffusion of nutrients, wastes and gases
- Blood pressure throughout system
- Direction of blood flow
- Metabolism during exercise

Conclusions

- More students related structure and function in their examples when asked to provide a definition first
- Students had difficulty relating structure and function in their examples when asked to provide examples first
- Students used more lexical categories when asked to 'Give example' compared to 'Define'
- Lexical analysis tools can identify student ideas (lexical categories) and measure student understanding of core concepts in physiology with high agreement to human scoring. This approach can help support using written assessment and student feedback in physiology courses.

References: American Association for the Advancement of Science, (2011). Vision and change in undergraduate biology education: A call to action. Anderson, et al. (2001). A taxonomy for learning, teaching and assessing. Duit, R. (1991). *Science Education* 75(6):649-672 . Genter, D. & Toupin, C. (1986) *Cognitive Science* 10:277-300. Michael, M.J. & McFarland, J. (2011). Advances in Physiology Education 35:336-341. Marzano, R.J. (2001). Designing a new taxonomy of educational objecitves. Nehm, R.H. & Haertig, H. (2012) *Journal of Science Education and Technology* 21:56-73.