Head, Shoulders, Knees and Toes: What concepts should your anatomy students know?

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Concept Survey Development: What to ask?

• **What topics to cover?** Focused on topics of known factual and conceptual misinformation of students entering course, known student difficulties during course, and known areas of poor retention across curriculum.

• **How did we "know" these troublesome topics?** Based on interviews with both anatomy faculty and upper-division faculty and information from physiology student focus groups.

• **How did we create questions?** Interviewed students on broad open-ended essay questions. Created more specific multiple choice (MC) questions and distracters based on interview responses. Interviewed students/experts on MC questions; gave surveys in class requiring students to explain responses. Based on responses revised survey (rev).

TIMELINE

----- Faculty Interviews ----			In-class Surveys with reasoning				Expert Reviews		Final Version Concept Survey!
Focus Group	Essay Interviews		----------Student Interviews----------						
Spr07	F07	REV.	Sp08	REV.	F08	REV.	Spr09	REV.	F09	FINAL REV.	Spr10
	First Survey										

Descriptive Statistics of Human Anatomy Concept Survey

Figure 1. HACS Item Difficulty Index (P) grouped by Learning Goal
The Item Difficulty Index reports the percent of correct answers for each question. Blue bars represent the P values on the pretest; Blue/Purple bars represent the P values on the posttest. (Purple alone represents the gain on that item.) LG=learning goal

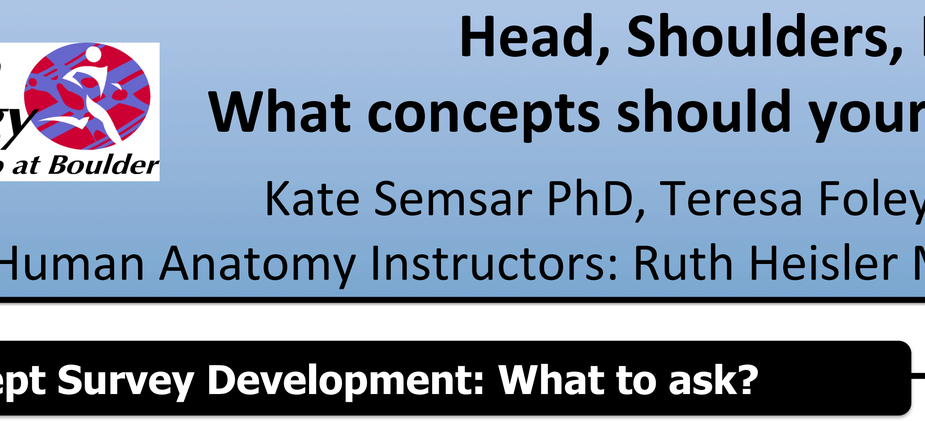
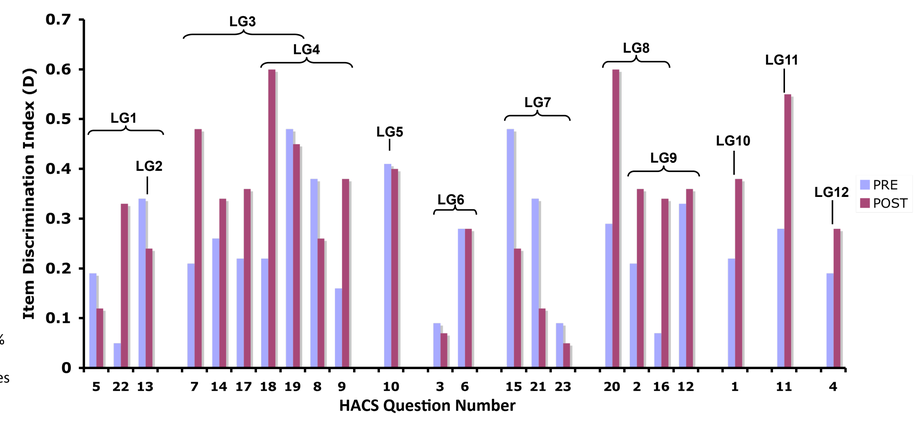


Figure 2. HACS Item Discrimination Index (D) grouped by Learning Goal
The Item Discrimination Index reports the difference in the percent correct between the top and bottom third of overall scores. Items with higher D scores are better able to distinguish between students whose scores identify them as generally strong or weak.
$D=(N_H-N_L)/(N/3)$; N_H= # correct in top 33% (based on overall score), N_L=# correct in bottom 33%, N=total number of responses



Basic Survey Statistics

Average PRE-test Score: 6.2 (27%)
Average POST-test Score: 11.7 (51%)

Ave. Learning Gain per student: 32%
Ave. Learning Gain per question: 34%

Ave. Exam Score Correlations: PRE: r^2=0.05 POST: r^2=0.18 Learning Gain: r^2=0.12

While exam score correlations are quite low, even on the posttest, this was not unexpected. Human Anatomy courses are traditionally highly factual and detailed in nature and remain assessed this way. The HACS was specifically designed to move away from this and assess big picture ideas and common misconceptions known to change little following traditional instruction. Thus as experts reported that they valued the information in the HACS, student performance on the HACS is less likely due to lack of course "coverage" and more to the type of instruction/assessment in the course.

Course Learning Goals Assessed on Anatomy Concept Survey

1. Distinguish the four tissue types by structure, function, and location. (5, 13, 22)
2. Differentiate between lumens of organs interior and exterior to the body. (13)
3. Relate structures of muscles and muscle tissue to their functions. (7, 14, 17, 18, 19)
4. Relate structures of joints to their functions. (8, 9, 18, 19)
5. Relate structures of the heart to their functions. (10)
6. Relate structures of blood vessels to their function. (3, 6)
7. Trace a drop of blood through the circulatory system. (15, 21, 23)
8. Distinguish between central/peripheral nervous systems. (2, 16, 20)
9. Distinguish between a nerve and a neuron. (2, 16, 12)
10. Describe where in the body immune cells are located. (1)
11. Trace the flow of bile from the liver to the small intestine. (11)
12. Illustrate structural adaptations for increased surface area. (4)

Survey Validation

Interviews

39 Students Interviewed on essay survey ("think aloud"): Responses were scored by two reviewers for common answers and misconceptions and used to create survey questions and answer choices.

38 Students Interviewed on MC survey ("think aloud"): Prior to the final survey, questions that received responses (correct or incorrect) with reasoning that did not match the answer choice were revised. This led to 4 dropped questions and 8 with minor and 4 with major revisions. For the questions on the final survey, each question had at least 5 students choose the correct answer for correct reasoning (with the exception of Q23, a particularly difficult question that only received 4 correct responses during interviews). Among distracters receiving more than 15% on the pretest, we collected an average of 5 interview responses (with at least 2) that accurately matched reasoning to the answer choice.

6 Expert Reviews (online survey): Experts answered the survey questions and commented on question accuracy, clarity, and alignment to goal. Of the questions on the final survey, 95% of expert responses were correct. Any questions with issues raised in the comments were either revised (5 Qs) or dropped (6 Qs).

Reliability

Test-Retest (Correlation of percent correct between Spr10 & Fall09):
ALL: **r = 0.89** Excluding Q4,14,16 (due to distracter differences) : **r = 0.92**
Commercially available tests typically range between 0.8 and 0.9.

Distracter Distribution: There were no significant differences among the answer choice distributions between Spr10 & F09. (Chi-Square tests; *p values range 0.27-0.45; no comparison available for Q4,14,16*)

Examples of HACS Utility

EVALUATING INSTRUCTIONAL TECHNIQUES

The HACS has demonstrated how specific homework questions targeting misconceptions can lead to student learning gains on the assessment. E.g., a single homework question appears to increase student learning gain on Q2 (assessing students' mental models of the the overall organization of neuronal connections in the body).

Q2 Gains: PRE Homework Q: 19%, 19% POST Homework Q: 32%, 32%, 29%

For more details see the poster:
Students want homework! Who it helps, how it helps, and ways to make it work for you.
All Departments: Sarah Wise, Jia Shi, and Françoise Bentley

COMPARING FACTUAL KNOWLEDGE & DEEP UNDERSTANDING

Commonly, students possess factual knowledge about biology without having a deep understanding of the underlying principles or ability to apply those principles. We have embedded several pairs of questions on the HACS that illuminate these issues. Here we present data from one of those pairs:

Smooth Muscle Layering (LG3): In Human Anatomy students learn about the arrangement of smooth muscle layers in the intestine. The reason why multiple layers are needed is that muscle cells can only contract in one direction. Thus if the muscle needs to contract in different directions, multiple layers with different cell orientations are required.

While students are very good at memorizing the number of muscle layers in the intestine and even reasoning on the pretest that multiple layers would need to exist (Q14, top), most fail to learn the connection with how muscle cells work (Q17, bottom).

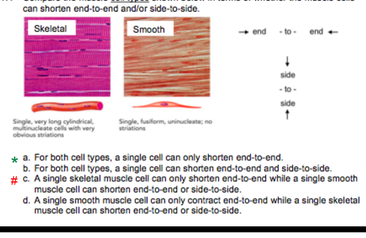
Q14 L.Gain: 75%
P_{pre}=0.40; P_{post}=0.85
D_{pre}=0.26; D_{post}=0.34

14. The small intestine can contract both circularly (squeeze towards center) and longitudinally (shorten). How many layers of smooth muscle are required to perform these functions and why?
a. One. One layer controls both movements.
* b. Two. One layer to contract circularly and one to contract longitudinally.
c. Two. One layer to contract and one to expand back to the original shape.
d. Three. One for each of the layers of the intestine: inner middle, outer.
\# e. Four. Two for contracting circularly (one for contraction and one for expansion) and two for contracting longitudinally (one for shortening and one for lengthening).

Key:
* = correct answer
\# = most common distracter

Q17 L.Gain: 21%
P_{pre}=0.09; P_{post}=0.28
D_{pre}=0.22; D_{post}=0.36

17. Compare the muscle cell types shown below in terms of whether the muscle cells can shorten end-to-end and/or side-to-side.



* a. For both cell types, a single cell can only shorten end-to-end.
b. For both cell types, a single cell can shorten end-to-end and side-to-side.
\# c. A single skeletal muscle cell can only shorten end-to-end while a single smooth muscle cell can shorten end-to-end or side-to-side.
d. A single smooth muscle cell can only contract end-to-end while a single skeletal muscle cell can shorten end-to-end or side-to-side.

Future Directions & Acknowledgments

• General use in Human Anatomy to examine effectiveness of course changes.

• Sharing results with other faculty. For example, sharing results with the faculty teaching upper level courses: Physiology I/II, Neurophysiology, Biomechanics, etc.

• Use selected questions on senior exit survey.

Thank you to all the students who interviewed and/or took the survey in class and to the experts who gave feedback on the HACS. Thank you to Pearson Education for permission to use figures from Human Anatomy by Marieb, Mallatt, and Wilhem. We received IRB approval for survey administration in class (exempt status, protocol 0108.9) and student interviews (expedited status, protocol 0603.08). All work was supported by CU Science Education Initiative in the Department of Integrative Physiology.