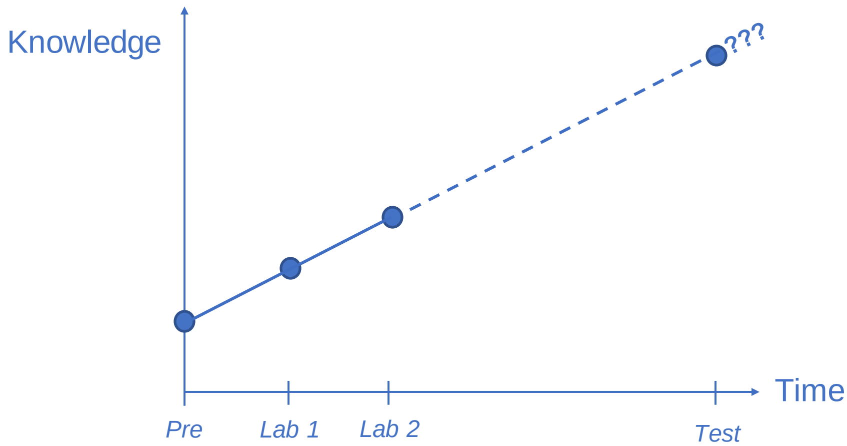
From Isolated Data-Analysis Tasks to General Skills: Bridging the Gap with Question Templates



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Acknowledgments & Disclosures


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Outline

- Introduction: Higher-Order Cognition & Test Question Templates (TQTs)
- Challenges of A&P Labs

Format

- Pseudo-Socratic

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In the Floor chat: introduce yourself!

- name
- affiliation
- undergrads / grads / both
- A / P / both / neither

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Introduction:
Higher-Order Cognition &
Test Question Templates (TQTs)

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CBE—Life Sciences Education
Vol. 7, 368–381, Winter 2008

Article

Biology in Bloom: Implementing Bloom's Taxonomy to Enhance Student Learning in Biology

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We developed the Blooming Biology Tool (BBT), an assessment tool based on Bloom's Taxonomy, to assist science faculty in better aligning their assessments with their teaching activities and to help students enhance their study skills and metacognition. The work presented here shows how assessment tools, such as the BBT, can be used to guide and enhance teaching and student learning in a discipline-specific manner in postsecondary education. The BBT was first designed and extensively tested for a study in which we ranked almost 600 science questions from college life science exams and standardized tests. The BBT was then implemented in three different collegiate settings. Implementation of the BBT helped us to adjust our teaching to better enhance our students' current mastery of the material, design questions at higher cognitive skills levels, and assist students in studying for college-level exams and in writing study questions at higher levels of Bloom's Taxonomy. From this work we also created a suite of complementary tools that can assist biology faculty in creating classroom materials and exams at the appropriate level of Bloom's Taxonomy and students to successfully develop and answer questions that require higher-order cognitive skills.

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Crowe et al. (2008), *CBE-Life Sciences Education* 7: 368-381

Table 1. Blooming Biology Tool

	Knowledge[1]	Comprehension[1]	Application[1]	Analysis	Synthesis	Evaluation
	LOCS[2]	LOCS[2]	LOCS[2] HOCS[3]	HOCS[3]	HOCS[3]	HOCS[3]
Key skills assessed	**IDENTIFY, RECALL**, list, recognize, or label	**DESCRIBE** or explain in your own words, re-tell, or summarize	**PREDICT** an outcome using several pieces of information or concepts; use information in a new context	**INFER**; understand how components relate to each other and to the process as a whole	**CREATE** something new using/combining disparate sources of information	**DETERMINE/CRITIQUE** relative value; determine merit
General examples of biology exam questions	Identify the parts of a eukaryotic cell; identify the correct definition of osmosis	Describe nuclear transport to a lay person; provide an example of a cell signaling pathway	Predict what happens to X if Y increases	Interpret data, graphs, or figures; make a diagnosis or analyze a case study; compare/contrast information	Develop a hypothesis, design an experiment, create a model	Critique an experimental design or a research proposal; appraise data in support of a hypothesis

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In the Floor chat:

Have you used a taxonomy like Bloom's to (formally or informally) check the cognitive levels of your test questions?

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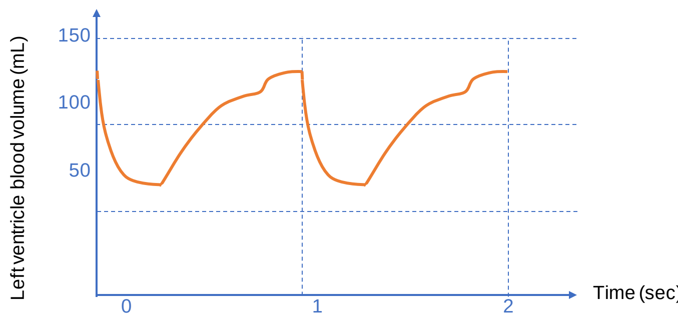
Study guide question:

A patient has a heart rate of 80 beats per minute, an end-diastolic volume of 100 mL, and an end-systolic volume of 40 mL. What is this patient's cardiac output?

Test question (a "mutated" study guide question):

A patient's left ventricle volume over time is shown below. What is this patient's cardiac output?



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What's a Test Question Template (TQT)?

- <u>A template</u>
  - Use to create numerous related questions
- <u>2 parts</u>
  - General input-output statement
    - like a Learning Objective (LO)
  - Specific examples of questions
    - like an actual assessment question
- <u>Goals</u>
  - Transparent alignment of study materials and tests
  - Better, easier-to-write test questions

Crowther et al. (2020), *HAPS Educator* 24(1): 74-81

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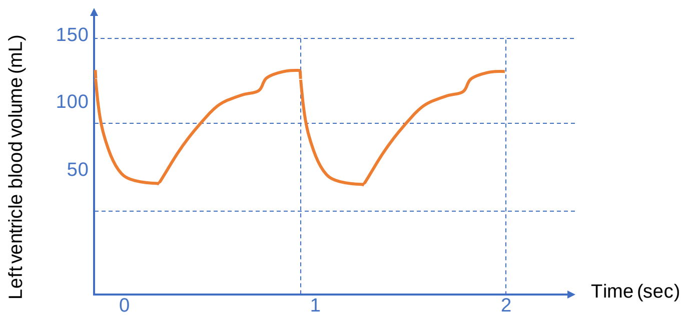
TQT 18.7. Given relevant numerical, graphical, or tabular information, calculate cardiac output.

- Example A: See the graph below. What is the cardiac output? Explain your answer, including correct units.
- Example B: See the table at right. What is the cardiac output? Explain your answer, including correct units.
- Example C: Make up an example and ask your classmates!



Time (sec)	LV blood volume (mL)
4.0	50
4.1	75
4.2	80
4.3	45
4.4	40
4.5	50
4.6	75
4.7	80
4.8	45
4.9	40
5.0	50
5.1	75
5.2	80
5.3	45

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In the Floor chat:

Any burning questions about TQTs so far?

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Challenges of A&P Labs

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Collecting EMG Data Using AD Instruments

We will have completed steps 1-3 below, but I've included them for reference.

Equipment Setup and Electrode Attachment

1. Make sure the PowerLab is turned off and the USB cable is connected to the computer.
2. Connect the 5 Lead Shielded Bio Amp Cable to the Bio Amp Connector on the front panel of the PowerLab. The hardware needs to be connected before you open the settings file.
3. Attach the Shielded Lead Wires to the Bio Amp Cable. Channel 1 will lead to one muscle, Channel 2 will lead to the antagonistic muscle, and the Earth (Green) will be connected to the Dry Earth Strap. Attach the Disposable Electrodes to the end of the Channel 1 and Channel 2 wires and the Dry Earth Strap to the end of the Earth wire.
4. Begin with the lower leg. Identify the tibialis anterior and the lateral head of the gastrocnemius. On each of these muscles, use a ballpoint pen to mark two small crosses 2-3 cm apart on the skin above the muscle (see board for guidance). Remember, muscles shorten during contraction. Are you sure that the muscle will be under the two points you have selected during the entire motion? Abrade the skin over the crosses with Abrasive Gel or Pad. This is important as abrasion helps reduce the skin's resistance.
5. After abrasion, clean the area with an Alcohol Swab to remove the dead skin cells. Wait for the skin to dry, and stick the Disposable Electrodes to the skin. Put the Dry Earth Strap around the volunteer's wrist, with the fuzzy side against the skin.
6. Check that all four electrodes and the Dry Earth Strap are properly connected to the volunteer and the Bio Amp Cable before proceeding. Turn on the PowerLab.

Data Collection – Tibialis anterior and Gastrocnemius

You will be looking at recruitment of these two muscles during the stride cycle. Depending on electrical interference, the strength of your signal, and the mood of the EMG Gods, your signal may be very clear (flat, level baseline with very distinct EMGs during activity) or very noisy (wandering baseline and/or very thick baseline even when the muscle isn't firing, and indistinct signals when it is). Wandering baselines are usually caused by too much movement of the wires ("motion artifact"). We can solve that by holding the wires steady or only doing part of the activity at a time (e.g. record a heel strike, then record mid stance, then record a toe off, etc.). Fuzzy baselines are usually caused by poor connections (check all the connections!) and/or electrical interference. If all the connections seem fine and your baseline is still wide, consult the lab instructor – we may need to adjust electrical filter settings.

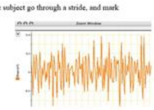
1. Launch LabChart and open the settings file "Voluntary Change Settings" from the **Experiments** tab in the **Welcome Center**. It will be located in the folder for this experiment.

Note: Channels 1 and 2 are the integrated activity of the two muscles – this means the area under all the spikes without regard to whether the spikes are above or below the baseline. Integrated activity is used commonly in the assessment of muscle function because it is easier to quantify. Use these two channels when completing your analysis.

2. Select **Bio Amp** from the Channel 3 Channel Function pop-up menu. Have the subject make a strong contraction of the tibialis anterior muscle (try to rotate the front of the foot upwards against resistance). Observe the signal and adjust the range in the dialog so that the maximal electrical response occupies about one half to two-thirds of the full scale.
3. Repeat step 3 for the lateral head of the gastrocnemius signal in Channel 4. In this case, forcefully contract the gastrocnemius by trying to rotate the front of the foot downward into the floor.
4. **Start** recording. Add a **comment** with the volunteer's name. Have the subject go through a stride, and mark heel strike and toe off on the trace. **Stop** recording.

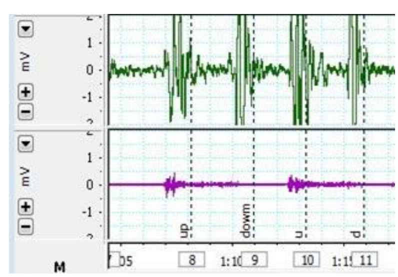
Analysis - Tibialis anterior and Gastrocnemius

1. Examine the raw EMG data in the Chart View. Autoscale, if necessary. Note the changes in activity in the tibialis anterior channel. When during the stride cycle did the tibialis anterior become active? When did it turn off?
2. Select a small part of the muscle activity and examine it in **Zoom Window**. The raw EMG signal is composed of many up-and-down spikes. What do these spikes represent?



Raw EMG Signal

3. Examine the data for the lateral head of the gastrocnemius (Autoscale, if necessary.) Note the changes in activity. When during the stride cycle did the gastrocnemius become active? When did it turn off? How does this relate to the onset and offset of the tibialis anterior?
4. Look at the integrated activity trace for the two muscles (Channels 1 and 2). Does the intensity of activity seem constant throughout the periods when the muscles are used, or are there periods of more and less intense firing?



<u>Rhetorical question:</u>

In what ways might students "miss the point" of this lab?

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In the Floor chat:

How can we help our students use labs to learn transferable skills (not just follow directions)?

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Moving beyond single examples

- connect related labs (e.g. EMG ↔ ECG)
- give additional datasets to analyze outside of lab
- include new-but-related problems on tests

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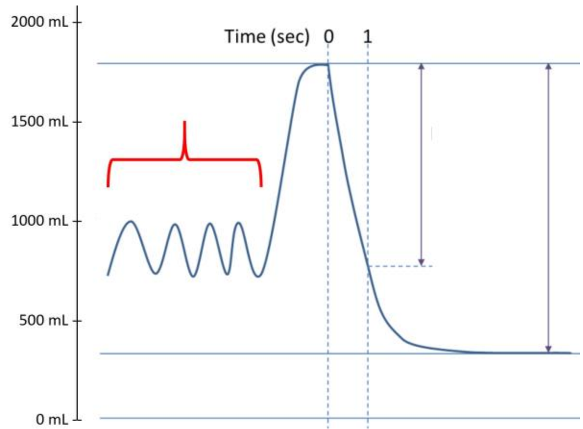
TQT 22.5. Given a graph of volume of air in lung vs. time, estimate or calculate FEV_1/FVC ratio, FVC, RV, TLC, TV, and/or minute ventilation.

- Example A: Estimate minute ventilation for the period indicated by the red bracket (roughly time -6 seconds to time -2 seconds). Show your work.
- Example B: Assume that this child is at their TLV at time 0, and that they exhale as forcefully and as fully as possible starting at time 0. What is their FEV_1/FVC ratio? Show your work.
- Example C: make up an example and ask your classmates!

Figure adapted from bronchiectasis.com.au/bronchiectasis/diagnosis-2/lung-function



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How TQT-informed tests might improve lab learning

Problem	Remedy
Students focus on less important aspects of labs.	TQTs show students which knowledge/skills to prioritize.
Students treat labs casually because they won't be tested on them.	TQTs help students connect labs to tests.
Students don't get enough practice in lab.	TQTs help students create additional practice problems.

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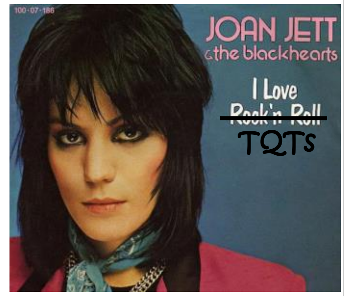
Musical recap (if time permits)



I see them with their books at the library,

Just trying to stay afloat in biology.

These students at this school

Need a brand-new learning tool –

Like a swim coach at the pool

To help you dive down deep.

You can feel that the water's cool,

But you must take a leap! Singin',

I love TQTs, so write another question from the templates, baby!

I love TQTs, so come do another example with me!

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Floor chat OR raise hand:

Questions/comments?

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Bonus Slides

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CROSS-DISCIPLINARY RESEARCH IN BIOLOGY EDUCATION ESSAY

Transfer: A Review for Biology and the Life Sciences

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ABSTRACT

Transfer of knowledge from one context to another is one of the paramount goals of education. Educators want their students to transfer what they are learning from one topic to the next, between courses, and into the "real world." However, it is also notoriously difficult to get students to successfully transfer concepts. This issue is of particular concern in biology and the life sciences, for which transfer of concepts between disciplines is especially critical to understanding. Students not only struggle to transfer concepts like energy from chemistry to biology but also struggle to transfer concepts like chromosome structures in cell division within biology courses. This paper reviews the current research and understanding of transfer from cognitive psychology. We discuss how learner abilities, taught material, and lesson characteristics affect transfer and provide best practices for biology and life sciences education.

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Kaminske et al. (2020): Factors affecting transfer

1. Learner abilities
   - Attention
   - Prior knowledge and expertise
   - Interest

2. Taught material
   - Near vs. far transfer
   - Seductive details

3. Lesson characteristics
   - Multiple examples
     - Different surface features
   - Interleaving

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A caveat

"TQTs can be good as long as students understand how to solve them and understand them. And so I believe for TQTs to work, it would need to be integrated in school learning…. It can be very frustrating and confusing when given something like a TQTs question on the exam and you never came across that type of question before."
[student comment, winter 2021]

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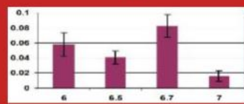
Greg Crowther



Basics
Courses
Research
Educational music
Test Question Templates
Miscellany

Test Question Templates

For many years, I struggled with a common teaching dilemma: how can I help my undergraduate students develop transferrable knowledge and skills in biology courses dominated by traditional high-stakes tests?

In 2019, with the help of colleagues **Ben Wiggins** (University of Washington) and **Kiki Jenkins** (Arizona State University), I had a breakthrough idea -- a framework that would help my students prepare for interesting, complex test questions without giving away the exact questions or answers.

We call the framework **Test Question Templates**, or TQTs for short.

Since TQTs emphasize (A) abundant opportunities for collaborative student practice and (B) transparent alignment of practice and testing, they may be considered a cousin of **TILT**, **mastery grading**, **Deb Donovan's Learning Targets and Success Criteria**, and Ben Wiggins' public exams (**blog post**; **webinar**).

Our first peer-reviewed paper on TQTs is this:

- Gregory J. Crowther, Benjamin L. Wiggins, and Lekelia D. Jenkins (2020). **Testing in the age of active learning: Test Question Templates help to align activities and assessments.** *HAPS Educator* 24(1): 74-81.

That paper's appendix, which listed my TQTs as of March 2020, is now out of date. I am sharing my current TQTs for introductory (sophomore-level) human anatomy and physiology in a publicly accessible **TQT folder** (Google Drive).

Several small TQT-related projects are now underway or are being planned:

- Do Undergraduate Biology Lessons Explicitly Teach Knowledge Transfer? (with **Kiki Jenkins** and Dilan Evans, Arizona State University)
- Afflictions, Animal Athletes, and Aliens: Identifying Optimal Applications for A&P Activities and Assessments (with **Bud Lindstedt**, Northern Arizona University, emeritus)

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