Autonomy pathways to compare active teaching methods in undergraduate Physiology classes

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Physiology is the study of life, specifically, how cells, tissues, and organisms function. Physiologists are constantly trying to answer key questions in areas ranging from the functions of single cells to the interactions between human populations and our environment..”
The discipline of Physiology

Physiology is focused on:

a) the “bigger” concepts such as “homeostasis”

b) integration and communication between various organ systems

Joyner 2011; Nobel 2018

Mansur ibn Ilyas: 1394-1409 AD
Physiology T & L challenges - #1: the discipline

Physiology is “hard” – some student surveys

“difficult to comprehend or explain”
“with a great deal of effort”

Factors making Physiology “hard” for students to learn

• Nature of the discipline
• Ways we teach
• What students bring

Physiology T & L challenges - #1: the discipline

• Requires the students to reason causally (mechanistically)
• Fail to appreciate integrative nature of physiological mechanisms
• Students compartmentalize (pigeon-hole) everything
• Students think learning = memorization of facts (content)
• Teachers talk too much and students talk too little (ranked #13 out of 17 factors)

- Baby Boomers
  - Hard worker
  - Sacrifice family
  - Optimism
  - Loyalty to company
- Gen X
  - Independent
  - Multi-tasking
  - Pragmatic
  - Self-sufficient
  - Skepticism
  - Hard worker
  - Optimism
  - Career = priority
Physiology T & L challenges - #2: the “receivers”

*The world according to Gen Z (born: 1995-2000)*

- Authority: world = flat
- Multi-taskers
- Inadequacy
- Teamwork
- Entitlement
- Instant gratification
- Relevance – individual, world
- Aspire to change, globally
- Global generation
- Less focused
Active learning strategies to begin to counter Physiology T & L challenges

It’s About
More Than Content

Creating a Joy, Excitement and Love for Learning

It’s About
Making Learning Fun!

Inspiring and motivating students is far more important for long term success than delivering information.

Smithsonian Institute lecture hall; 1859

“Positive affect is defined as the experience of pleasurable emotions such as joy, happiness, excitement, enthusiasm, and contentment”.

Positive affect was protective against 10-year incident coronary heart disease; preventative strategies should increase positive affect.
Goals to support student-centered learning

- Selectively reducing body of knowledge required
- Focusing on generalities that are transferable
- Providing foundational scaffolding for learning new content later

Table 1. *The big ideas: a map between two big-picture categorizations of the important conceptual ideas our students should be learning*

<table>
<thead>
<tr>
<th>Core Concepts of Physiology [Michael et al. (38)]</th>
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<tbody>
<tr>
<td>Evolution</td>
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<tr>
<td>Cell theory</td>
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<td>Genes to proteins</td>
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<td>Homeostasis</td>
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<td>Interdependence</td>
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<td>Levels of organization</td>
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<td>Cell-cell communication</td>
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<tr>
<td>Cell membrane</td>
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<tr>
<td>Mass balance</td>
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<tr>
<td>Flow down gradients</td>
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<tr>
<td>Physics/chemistry</td>
</tr>
<tr>
<td>Energy</td>
</tr>
<tr>
<td>Structure/function</td>
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</tbody>
</table>
“students learn more ... from courses that implement active approaches rather than traditional lecture”

“meaningful learning ... students can solve appropriate problems”

“The instructor ... is to help the student by creating environments in which learning is likely to occur.”

Introducing active learning strategies into Physiology classes: cooking up the perfect storm?

Lecturer mindset
Gen Z mindset
Graduate attributes

Have fun!
Joy for learning!
Inspire, motivate!

Problem solving & application
“Big” Physiology concepts

Integration & application of knowledge
Lecturer mindset
Gen Z mindset

Balancing content vs. active learning
Class size: ~225 students
Nature of venue: not ideal
An elderly South African lady (75 years old) fainted at the (crowded) airport while you are waiting for your flight (some delay). She has some medical information on a bracelet: heart rate irregular & high, hypertensive, coronary artery disease.

a) Based on what discussed in our classes, explain to bystanders what could be wrong with her (in terms of her heart & electrical system). Focus on normal & abnormal states.

b) What course of action(s) would you suggest – provide scientific reasons to back-up your choice. Note: 3-4 slides max to answer a) and b).
Active learning strategy #1: Burning Questions

_How:_ e.g. how does this happen?  
_What:_ what causes it e.g. risk factors  
_Why:_ why is a certain response initiated; why is it important to know?  
Ability to explain to laypersons

"Spine" of Critical Reflexivity and Reflection for all lectures, tests/exams & post-assessment discussions

"..from this perspective, teaching focuses on enabling students to think more critically about themselves, their assumptions, actions, and situations they encounter" (Ann Cunliffe p.411 [2004]).
Active learning strategy #1: Burning Questions
Earlier this morning, your res room mate (art student) stumbled while getting up from her bed. You are not the prying type but have vaguely heard before that she has some “blood pressure trouble” and also a diabetic (using “water” pills). You also know that she spends prolonged times lying down whilst busy on Instagram and What’s app – literally hours at a time. Since you are a final year Physiology student, she requested you to explain why she felt dizzy and tumbled down (quite few times now).

Any advice how to deal with this?
Atrial or ventricular fibrillation (arrythmia)? – discuss normal pathway of electrical conductance in the heart (e.g. SA node, inter-atrial & inter-nodal pathways, Bundle of His, Purkinje fibers, AV node delay, normal ECG pattern, tachycardia).

Discuss atrial fibrillation – what happens (atria contract too fast, insufficient time for atria to contract properly, blood pooling, ectopic firing, AV node increased firing, ventricles increase contraction but cannot match atria, abnormal ECG) & why this could have happened (why in this individual?). She is old, hypertensive – impact on cardiac function in this case? Crowded airport, delayed flight = stress! Hypertension, coronary artery disease, stress – linked to atrial fibrillation. Familial/genetic?

Outcomes? Blood clots, stroke, edema, fainting due to insufficient oxygen delivery to the brain by the heart.

What can be done? CPR, defibrillator (if available), β-blockers, ECG, pacemaker.

Legitimation code theory

Uncovering/making explicit knowledge practices or organizing the principles underlying them

Maton & Howard, 2018
Legitimation code theory

Uncovering/making explicit knowledge practices or organizing the principles underlying them

Positional Autonomy (PA):
Relations between positions (the things within it: actors, ideas, objects, theories, practices, ways of doing) within a context and positions from outside it.

Relational Autonomy (RA):
Relations between the principles (ways things are arranged, what they are for) from within the context and from elsewhere.

Maton & Howard, 2018
Positional autonomy

Refers to the *objects* included in the teaching

PA+
Teaching theories, objects, methods and/or concepts from *inside* the curriculum

PA-
Teaching theories, objects, methods and/or concepts from *outside* the curriculum
Relational autonomy

Refers to the *purpose* of the pedagogy/curriculum

**RA+**
To learn Physiology

**RA-**
To learn something other than Physiology
Towards integration..

- **Physiology (curricular) content for teaching physiology**
- **Other (not in this curriculum, though it could still be physiology) content for teaching something else**
- **Physiology (curricular) content for teaching something else**
- **Other (not in this curriculum, though it could still be physiology) content for teaching physiology**
Best practices in Physiology teaching: the ideal

Quizzing students on some application level of content from other domains

Physiology (curricular) content for teaching physiology

Other (not in this curriculum, though it could still be physiology) content for teaching something else

Reminding students that they have seen similar problems before (i.e., in Math or Chemistry)

Best practices in Physiology teaching: the ideal

Physiology (curricular) content for teaching physiology

Case Studies

Other (not in this curriculum, though it could still be physiology) content for teaching something else

Case Studies

Legitimation code theory: translational device

Positional autonomy

3rd year Physiology curriculum at SU
- cardiovascular module content
- content from other Physiology modules
Legitimation code theory: translational device

- Relational autonomy

- Learning to integrate 3rd year Physiology topics to solve real-world problems
  - Integrate to solve real-world problems
  - Integrate to solve simplified problems
  - Principles of problem solving in Physiology
  - Principles of solving problems
Burning questions

An elderly South African lady (75 years old) fainted at the (crowded) airport while you are waiting for your flight (some delay). She has some medical information on a bracelet: heart rate irregular & high, hypertensive, coronary artery disease. Based on what discussed in our classes, explain to bystanders what could be wrong with her (in terms of her heart & electrical system). Focus on normal & abnormal states. What course of action(s) would you suggest – provide scientific reasons to back-up your choice.

Other (not in this curriculum, though it could still be physiology) content for teaching something else

Other (not in this curriculum, though it could still be physiology) content for teaching physiology

Autonomy tours: integration & application
• “..good way of **forcing** oneself to read..”
• “..**forced** me to do additional research..”
• “The burning questions were a **way for me to comprehend** what is taught in class and **apply it to real life examples**”.  
• “It is not about parrot studying the theory but **actually understanding it**”.  
• “I also love the idea of **applying** the knowledge we learn in class”.  
• “The prospect of the **research work to be completed** excited me more than anything else”.  
• “Burning Questions **activate your brain and forces you to look at the information given in class critically**. Through this, you learn a lot more than sitting in a lecture for 50 minutes. It also...**promotes integrative learning**”.  

**Burning Questions: some student feedback**
“In terms of the research methodology itself, I learnt that you need to try understand everything that you read in the article or in the lecture notes before moving on to research.”

“It required us as students to think about the topic critically, engage and to formulate one’s own ideas, as opposed to being given all of the information.”

“It taught me that everything I communicate has to be backed up by relevant and accurate knowledge.”

“This exercise made me realise that you must start by analyzing the question – what exactly is being asked.”

“It taught me that we have access to such an immense amount of information, that it is sometimes more difficult to figure out where to start, rather than actually formulating an answer.”
Eight-year-old Finnish girl on visit to Cape Town has gone missing while walking in Jonkershoek valley – 30 mins ago. Two Stellenbosch University Physiology friends are around and volunteer to assist to help find her.
Active learning strategy #2: CSI-type problem

Maybe the girl had a little snack before disappearing?

I know! My grandma uses it to check her blood sugar!
Active learning strategy #2: CSI-type problem

By the way, the Physiology 364 class will also assist us in our little adventure!

Hang on laddie, let me bring a little clarity to help in your quest..

What does a reading of 18.8 mean?? This may help us..
Dietary intake

Post-meal rise in circulating blood glucose levels

Postprandial glucose test – amount glucose in blood following a meal

- Magnitude & time of peak plasma glucose varies
- Non-diabetics usually peaks at 60 mins; rarely exceeds 7.7 mmol/L
- Returns to preprandial levels 2-3 hr

JACC 2008; 51: 249-255
Active learning strategy #2: CSI-type problem

Just got a call from the lab & her insulin levels are very low, virtually not detectable.

This seems like a good clue, how does insulin fit in though?
Active learning strategy #2: CSI-type problem

Normal (Non-diabetic) Blood Glucose and Insulin Levels over 24 Hours

- Blood Glucose
- Natural Insulin Secretion

- Breakast
- Lunch
- Supper

Diabetes Care 1997; 20(8): 1279-1286
Insulin values usually given as $\mu$IU/mL (micro international units/mL) or pmol/L

To convert pmol/L values: divide it by a factor of 7.715

NHANES III Study: mean fasting level 60 pmol/L (n=17,319 US individuals)  Diabetes Metab Res Rev 2002; 18(2): 149-155

Mixed data re ideal fasting insulin levels: some suggest below 8.4 $\mu$IU/mL are optimal
Active learning strategy #2: CSI-type problem

Been away and managed to get hold of two histological slides of the girl’s pancreas!
Active learning strategy #2: CSI-type problem

Islet of Langerhans
Red: alpha cells
Green: beta cells

Islets 2011; 3: 131-138

Diabetologia 1987; 30: 757-762

Mmm.. I ‘m stumped..

364 Class please help us!?
Active learning strategy #2: acknowledging contributions of others (not from the “West”)

• 1552 BC: Hesy-Ra, a physician in the 3rd Egyptian Dynasty documents frequent urination (polyuria)
Active learning strategy #2: acknowledging contributions of others (not from the “West”)

1552 BC: Hesy-Ra, a physician in the 3rd Egyptian Dynasty documents frequent urination (polyuria).

500-400 BC: Charak & Sushrut, Hindu physicians – “madhumeha” (sweet urine); also noticed ants congregated around urine of sick individuals; noticed most prevalent in those overweight and indulging in sweet & fatty foods.
Active learning strategy #2: acknowledging contributions of others (not from the “West”)

• 980-1037 AD: Avicenna, provided detailed account in his “Canon of Medicine” describing abnormal appetite, decline of sexual function and emphasized taste i.e. sweet urine; urine tasters.
Some clinical outcomes of type 1 diabetes

- Breakdown muscle protein
- Hyperglycemia
  - Absorption of glucose by kidney
  - Excess glucose secreted in urine
  - Osmotic diuresis – increased urination
  - Dehydration, thirst
  - Blood pressure
  - Circulatory failure
- Ketone bodies
  - Metabolic acidosis
- Lipolysis
  - Tissue loss

Silverthorn, Figure 22-16, p737 - adapted
The case is solved, well done!

Two relatively easy articles on type 1 diabetes onset:

Will make articles available on Sunlearn!
An eight-year-old Finnish girl on visit to Cape Town has gone missing while walking in Jonkershoek valley – 30 mins ago. Two Stellenbosch University Physiology friends are around and volunteer to assist to help find her.
“Recently, my hyper-health conscious Aunt and Uncle had my 16 year old cousin do a 7 day juice cleanse to “make her body more alkaline”. This concerned me because none of them are medical professionals or physiologists and I was not sure upon what they were basing this cure-all-vegan diet. I also know that the pH of the body has a very fine range within it should stay; or else you die.

So, I read from my textbook and other sources and quickly realised that what they were measuring (the pH of the urine) is not a reflection of the pH of the blood. I also read that although there is little to no science backing the wonder of a juice cleanse, it should not do too much harm if a person is healthy. And alas, my cousin is still around (and I realized I don’t really need to intervene). A real life burning question.”
Your father is saddled with two partly blocked arteries, an enlarged heart and is scheduled for a percutaneous coronary intervention (PCI) at the Stellenbosch General Hospital. He is 70 year-old diabetic, BMI is 33, blood pressure is 150/100, ejection fraction is 32% and his ankles quite swollen. He has recently changed his diet but for most of his life has enjoyed a lot of processed foods. A family meeting is called to discuss the impending surgical procedure and to help clarify any queries/uncertainties that may still exist. As a final year Physiology student at Stellenbosch University, you are now expected to play a vital role in the ensuing family discussions and to provide insight regarding the following questions:

1. Your mom indicated that the doctor used the term “myocardial ischemia” but that she did not really follow what he was trying to convey. Define “myocardial ischemia” and further explain the meanings of the terms “hypoxia” and “myocardial infarction”. In addition, provide an opinion whether hypoxia is associated (or not) with myocardial ischemia – provide rationale.

2. “What does the ejection value indicate in your father’s case - in terms of his heart functional ability” enquires Uncle Sifiso. Explain to the family what disease state is likely associated with his low ejection fraction. Provide a motivation for your choice (refer case study for clues).
3. “How did his heart become enlarged?” your mom enquires. Explain how this may have occurred in your father’s case. What is the medical term for this condition?

4. “Does Dad suffer from high or low blood pressure?” your youngest brother Pietie asks. Answer his question by comparing your father’s blood pressure data with the normal values and then describe how the baroreceptor reflex regulates blood pressure by focusing on the sympathetic nervous system – use high blood pressure as an example.

5. Your aunt notices some tablets for blood pressure on the table – “ACE inhibitors” and now seeks clarification. Explain which reaction ACE inhibitors targets. You then proceed to explain the various downstream, physiological effects of such inhibition that should lead to a beneficial outcome in your father’s case.
Active learning strategies - bringing it all together..

Outcomes

- LCT a valuable tool for planning & analyzing research
- LCT can help explain the value of various teaching methods
- Student-centered approach – can be widely applied
- Real world contexts – social aspects of learning emphasized
- Promotes integration, critical thinking & problem solving skills
- Spine of critical reflexivity & self-reflection (class, mentor, assessments & post-assessment) to enhance Gen Z’s class experience

For lecturer

- Create calm & safe climate, respect, inclusivity
- Requires minimal amount of resources
- Act as mentor – set example, sincerity, care, share (authenticity)
- Aim to make it a transformative & inspirational experience
- Balance between content & active learning opportunities
- Need to dedicate significant amount of time (in-class and outside)
- Have fun (everyone) – always!
Thank you!

Thanks to Dr. Hanelie Adendorff for excellent assistance with LCT work.