Title

A case study describing a novel framework for teaching anatomy and physiology to first-year undergraduate students

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Abstract

The work presented here is one educator's journey into the study of learning and teaching in anatomy and physiology. Three conceptual ideas (Indigenous pedagogies [1, 2] the Learning Cycle [3] and material thinking [4]) have been combined to create a framework for teaching first-year undergraduate university students. Many examples will be provided on this website to guide other educators on how this framework can be used to design effective learning materials and instructional activities to support inclusivity in education. The author's vision is to ensure that anatomy and physiology are accessible to any student who wants to study them, regardless of their socioeconomic background, mode of study or educational experience.

The educator's challenge

According to the literature, health science students are likely to be kinaesthetic learners [5] and they often drop out or repeat their anatomy and physiology subjects before continuing on with their studies in their chosen field [6, 7]. The literature has also shown that such students underestimate the amount of content that is covered in a first-year anatomy and physiology subject and that the teaching methods used can greatly influence their ability to learn concepts [8].

The context of this case study is the teaching of anatomy and physiology to first year health science undergraduate students at a regional university. The student cohort that chooses to study at my institution is very diverse. They vary significantly in education prior to university study [9], many are mature age students, many come from low socioeconomic backgrounds and a significant proportion identify as being Aboriginal or Torres Strait Islander. According to a recent report, diverse cohorts such as this require very specific teaching strategies that includes scaffolding, practice, feedback, engaging learning activities and interactivity to overcome the possibility of attrition and ensure educational success [10].

At my current institution, I found that when I used traditional materials to teach my students, they were not engaged and did not understand the concepts I was trying to teach them. By traditional materials, I mean two, two-hour lectures per week, which delivered information quickly (facilitated by the use of PowerPoint slides) and one two-hour laboratory practical per week (facilitated by the use of laboratory manuals). One could say that these learning materials support a teaching approach where

knowledge is delivered unilaterally (lectures) and somewhat independently (laboratory practical) to the student. The materials used in the first year, first session of university study can influence whether the student continues their tertiary study course. This is a crucial issue in teaching and learning, particularly for first-year first-session undergraduate students, as it relates to a diverse cohort where the predisposition to attrition is amplified. This prompted me to seek a new way to teach anatomy and physiology to first-year undergraduate students. Every educator has a vision, and my vision is to make anatomy and physiology accessible to anyone who would like to study it, regardless of age, socioeconomic background, mode of study, cultural background or educational experience.

The first thing I did when faced with this educational challenge was to peruse the literature. A total of 946 journal articles were perused in the hope of finding a unified approach that could serve as a guide/best practice as it related to the teaching of anatomy and physiology to first-year students. The databases that were searched were A^{+} Education, Education Research Complete, ERIC, Routledge Resources Online (Education) and EBSCOhost (education) Academic Search Complete. The search terms used in all these databases were kept constant and broad intentionally (anatomy OR physiology AND learning OR teaching). The search in each database was further refined by restricting the results to journal articles written in English. A perusal of the literature indicated that many published works in this area involve medical students. It varied in the year of study of the cohort and was specific in nature. By specific in nature, I mean many journal articles focused on the evaluation of one technique (for example, virtual reality, podcasts) or change (flipped, blended learning) in the teaching of specific content (respiratory physiology, specific body part). Some studies focused on such things as learning satisfaction, motivation and learning styles. However, I found one study containing elements of what I searched for in the literature.

The study in question described how the universal design for learning (UDL), which is grounded in cognitive neuroscience, was used in teaching anatomy to medical students. This study described three core principles, each comprising three guidelines. The three core principles were providing multiple means of representation, multiple means of action and expression, and lastly, multiple means of engagement to the student [11]. Given my background in neuroscience, I loved the grounding used by these authors, but unfortunately, several factors limit my ability to use this framework. The first factor is that its description was limited to anatomy. The second factor is the differences in student cohorts. The students I teach in my institution are very different to medical students. The materials used in applying UDL in anatomy can still be considered traditional (prosected specimens, textbooks, problem-based learning). The resources used are beyond the level of Blooms as it relates to my subject learning objectives and finally, we don't have access to those resources due to financial constraints. It is interesting to note that the authors of this paper also mentioned that some students were challenged by this intense cognitive load and left the learning session early [11]. If some medical students are getting overloaded, then it's highly likely that most of my students will too.

Development of a new teaching framework

The teaching framework presented here comprises three conceptual ideas. The first is the Learning Cycle [3]. The Learning Cycle allows educators to understand how the brain learns and how teaching should be structured to efficiently facilitate the learning process. The second conceptual idea, inspired by the 8 Aboriginal Ways of Learning [1] and the more general Aboriginal pedagogical framework, is the "unnamed" [2]. The third conceptual idea is material thinking, which refers to how the educator translates the first two ideas into works or learning objects [4].

I have a neuroscience background, so having one part of the framework based on how the brain learns aligned well with my personal beliefs about teaching and learning. The university in which I teach is committed to providing accessible education for all students and to increasing the number of Aboriginal and Torres Strait Islander people participating in higher education as students. Given the financial constraints of a regional/rural university, it became clear that if I wanted to achieve meaningful learning in my students, I needed to transform how I used the materials available in my current context.

Transforming the traditional lecture

It became apparent to me that the traditional lecture and laboratory practical would not be suitable for meeting the learning needs of my regional/rural diverse cohort of students. While keeping the total student contact hours the same, I needed to think about exactly how those contact hours would be used. I wanted to make sure that the time that students had with me was supportive of deep meaningful learning. At this point, I realised that if I wanted to teach using this teaching framework, my role had to change from lecturer/laboratory practical leader to activity designer and facilitator.

The conversion of traditional lectures and laboratory practicals into new activities took approximately one year to complete, but more can always be done. Some examples of activities that I have created have already been published [12]. Here, I present some guiding principles for the design of learning activities as driven by this teaching framework. The focus is on effective, meaningful learning, given our financial and time constraints.

Time previously spent giving students two-hour lectures is now broken down into individual Learning Cycles [3] that last no longer than 20 minutes each. Each Learning Cycle [3] consists of, firstly, finding out what students already know about the concept, then a period of direct instruction. This is followed by time for discussion/clearing up misunderstandings before ending with an active learning task that tests the students' knowledge about that particular concept. The educator starts by asking the students questions and working backwards until a common concrete example is found from which the learning of the new concept can take place (Fig. 1).

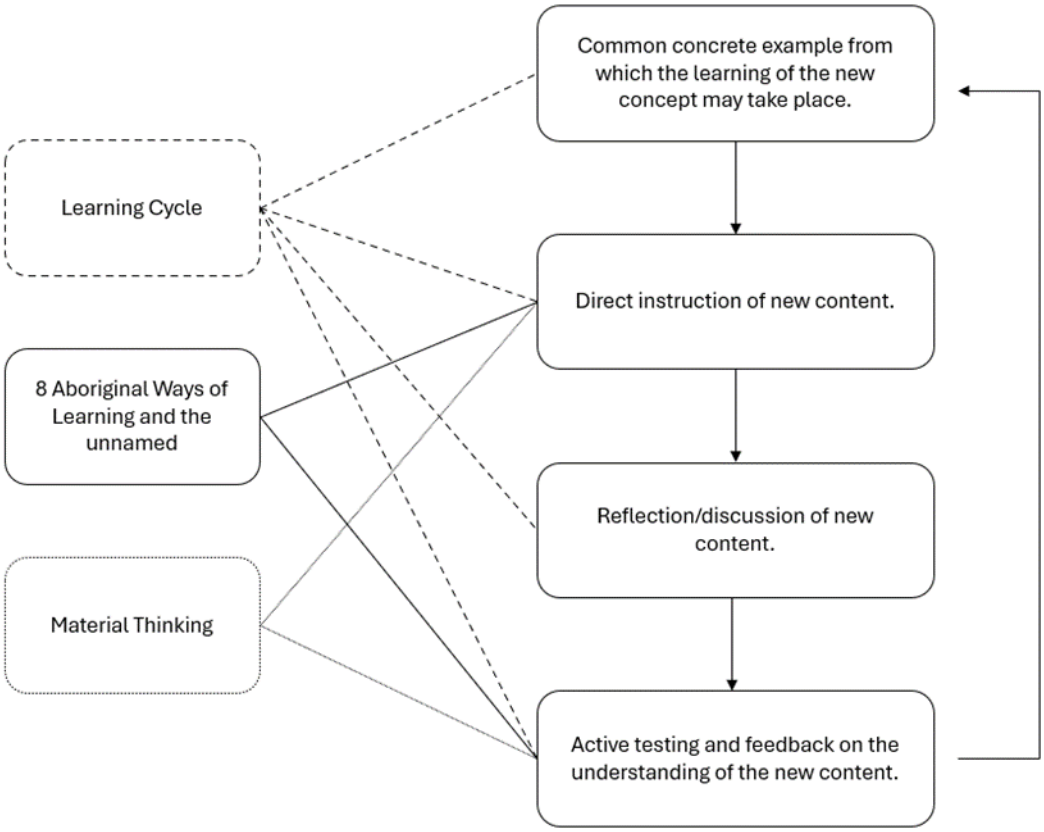

Fig. 1. The three conceptual ideas (represented by solid, dashed and dotted lines) underpinning this teaching framework and the proposed sequence of learning activities where each conceptual idea can be applied.

The inspiration that emerged from the 8 Aboriginal Ways of Learning [1] and the more general Aboriginal pedagogical framework, the “unnamed” [2] supported the design of new ways of presenting information in anatomy and physiology. The Deconstruct/Reconstruct Way of Aboriginal Learning was used as inspiration for teaching the anatomy of the muscle organ. Deconstruct/Reconstruct is about working from the whole to its parts [1]. For this activity, free 3D modelling software was used to create a schematic representation of the muscle organ. The educator then removes layers of this schematic until just the muscle cells are left, then works backwards, adding all the layers back again (Fig. 2).

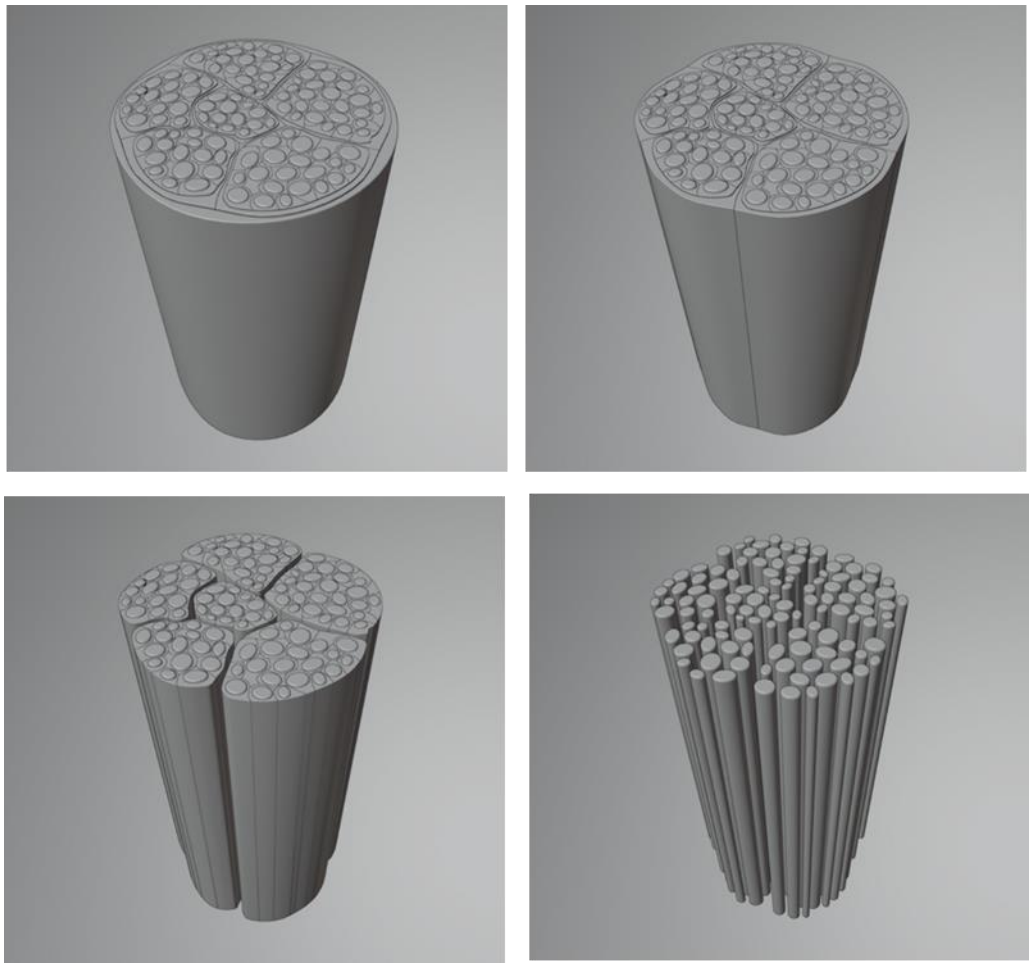

Fig. 2. The Indigenous pedagogy of Deconstruct/Reconstruct as applied to teaching the anatomy of a muscle organ.

This website will contain many examples of how the creation of learning materials can be inspired by the Indigenous pedagogies of Story Sharing, Non-verbal Learning, Symbols and Images, Non-Linear [1] as well as the dreaming mind and pattern mind [2].

Story sharing, which is the role of narrative in knowledge transmission[1], has been, in my experience in teaching anatomy and physiology to first-year undergraduates, the most powerful method of significant or meaningful learning. This is consistent with the story mind as presented by Tyson as the most powerful tool for memorization [2]. Memorization is at the lowest level of Bloom's taxonomy[13] but sometimes this is all that is required to meet an individual and or specific learning objective in first-year anatomy and physiology. According to Fink (2007), memorization supports foundational knowledge and, thus, subsequently facilitates significant learning [14].

If PowerPoint is used for direct instruction, slides are created using these guidelines [15] and with a focus on the student interacting with the resource as much as possible. Three-D drawings created with Microsoft Paint 3D are embedded and schematic drawings/symbols are used instead of text whenever possible. Activities where students create their own representations of the content are included. This supports kinaesthetic-like learning that can be easily deployed in large lecture-type settings.

Students need time to reflect on the stimuli they have been exposed to. According to the Learning Cycle, reflection is the process where images of what you experience go around and around in the integrative cortex. This is consistent with the Ancestor mind, where reflection is about deep engagement, complete concentration, losing track of time and immersive visualization [3]. This teaching framework supports activities where every week, students must create their own representations of the content using simple words and sentences, visualizations and/or analogies. The focus is on what the student does [16]. To further amplify the effectiveness of this teaching framework, not all teaching weeks are filled with content. Two weeks in the session (in addition to the standard breaks) are placed strategically in the study schedule where no new content is introduced to give students more time for reflection and guided independent learning.

When reflection activities are completed, the learner develops ideas and predictions about the content. According to the Learning Cycle, this happens in the frontal cortex, and according to the work by Tyson, it is consistent with the pattern mind, where learners start seeing patterns in entire systems and using these patterns to make predictions [1-3]. Inspired by this notion, activities can be created to highlight patterns that are inherent in many physiological processes.

Re-imagining the tutorial

To counteract the predisposition of attrition that is inherent in my cohort, I had to reconsider the role of the tutorial in my students' learning. Tutorials became a chance to give students authentic formative feedback and relearn/re-expose them to the most challenging concepts in another way involving physicality and material thinking [4]. The physical testing of understanding aligns with the last step of the Learning Cycle [3] and material thinking is where non-human things are considered active elements in social practices [4]. The focus here is on interactional instructional learning activities. Each activity is designed to support the development of literacy skills in anatomy and physiology or the students' knowledge of a challenging concept.

The inspiration that emerged from Indigenous pedagogies along with the concept of material thinking [4] was used to create a learning activity about the structure of a nerve (Fig.3).

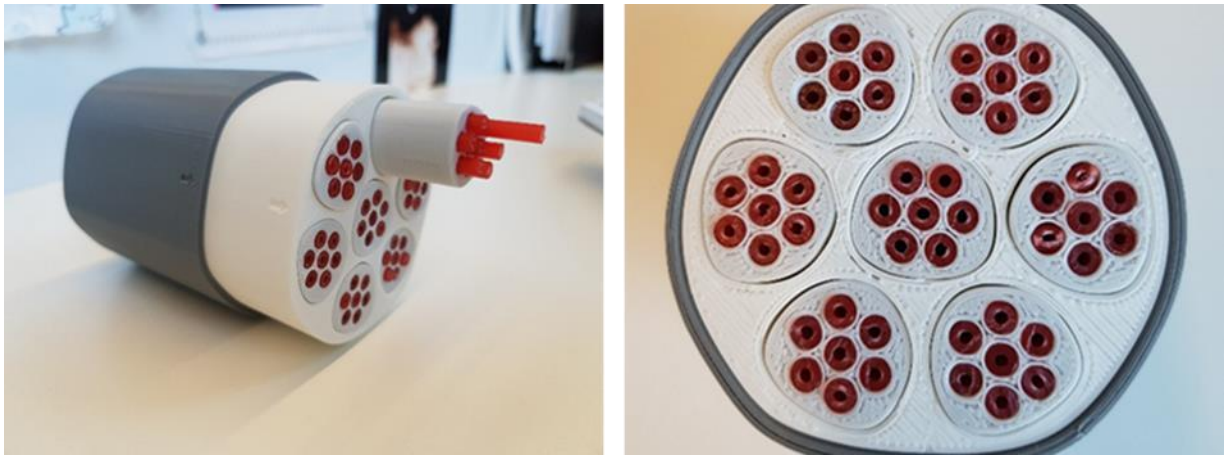

Fig. 3. 3D printing creates an artefact that is cost effective and that can be physically manipulated. The ability to interact with such objects supports student learning of complex anatomical structures.

Simple models, puzzles and 3D-printed objects have been created as the active elements. According to Carter (2004), non-human things are considered active elements in the social practice of learning and are considered to have agency [4]. When I watch the students do these activities, it appears that they do not realise that they are learning. The focus is on what the student does, and the learning happens naturally *through* using the materials. It is fascinating to watch and is consistent with the Dreaming mind, which is about communication between the physical and non-physical worlds, where feedback loops between worlds must be completed with practical action[2].

The ideas of active learning and student-centred learning are not new in the educational literature. Active learning is instructional activities involving students in doing things and thinking about what they are doing [17]. Student-centred learning has been described as interactional at heart, where the learning arises from the interaction between the student and teacher, with the teacher's role being that of facilitator [18]. The belief that what the student does is more important than what the teacher does and that students will engage in activities if they see them as relevant and think they will enhance their learning is also not a recent phenomenon [16, 18]. So, how does this framework fit into what we already know about active and student-centred learning? This framework (if you consider its conceptual ideas important in your teaching) guides you in what kinds of things students should be doing in learning anatomy and physiology in their first year of university study. It can guide you in the kinds of activities we should be creating for our students – instructional activities that would support the interactions we need to facilitate for them to learn the content.

Outcomes and future considerations

The students understand the content much better and feel better about the subject overall. From being the subject they were most anxious about, it is now less overwhelming. Students feel like they are “good enough” to do anatomy and physiology and to do it well. It is now their favourite subject. It has increased their confidence. The following feedback from students exemplifies this. “The educator’s ability to break down complex new concepts into simple, understandable components was brilliant. I went into this subject thinking it would be hard and found it enthralling instead.” And, “I was a bit nervous about how I’d go with the A&P subjects but you’ve delivered it in a way that was really easy to follow. The educator made it easy to understand concepts, especially when there was no prior knowledge in areas.” Student attrition was reduced and progression rates improved [19].

My relationship with the students has also changed significantly. My interactions with them have increased, strengthening student understanding and supporting the educator-student learning relationship. Talking to each other also supports the Aboriginal worldview of the kinship mind, where the relationship between the learner and other learners, as well as places and knowledge keepers, is paramount to quality knowledge transmission [2]. By implementing this teaching framework, I am lucky enough to witness their joy when they successfully complete an activity and I am there to rectify any misunderstandings or provide assurance if they need help. While this approach will not solve all the issues inherent in my cohort of students, I feel it is a step in the right direction in supporting inclusivity in anatomy and physiology education.

To date, the focus has been on developing the teaching framework and describing the learning activities that result. The evaluation of this teaching framework has started but significantly more work needs to be done in this regard. To date, two aspects of the teaching framework have been empirically tested [20].

Conclusions

I hope that sharing this work will help other educators facing similar challenges in their teaching. We all want the best for our students and we want them to succeed. What I have presented here demonstrates that sometimes the solutions to our teaching problems are not based on traditional ways of doing things. New ways of doing things that are associated with minimal cost can be effective in aiding student understanding in anatomy and physiology education.

References

1. Yunkaporta, T., *Aboriginal pedagogies at the cultural interface*. 2009, James Cook University.
2. Yunkaporta, T., *Sand Talk: How Indigenous Thinking Can Save the World*. 2019, Melbourne Australia: Text Publishing.
3. Zull, J.E., *The Art of Changing the Brain: Enriching the Practice of Teaching by Exploring the Biology of Learning*. 1st ed. 2002: Routledge.
4. Carter, P., *Material Thinking: The Theory and Practice of Creative Research*. 2004, Melbourne: University Press.
5. Farkas, G.J., E. Mazurek, and J.R. Marone, *Learning Style versus Time Spent Studying and Career Choice: Which Is Associated with Success in a Combined Undergraduate Anatomy and Physiology Course?* Anatomical Sciences Education, 2016. **9**(2): p. 121-131.
6. Entezari, M. and M. Javdan, *Active learning and flipped classroom, hand in hand approach to improve students learning in human anatomy and physiology.* IJHE, 2016. **5**(4): p. 222-231.
7. Schutte, A.F., *Who is repeating anatomy? Trends in an undergraduate anatomy course.* ASE, 2016. **9**(2): p. 171-178.
8. Eagleton, S., *An exploration of the factors that contribute to learning satisfaction of first-year anatomy and physiology students.* Advances in Physiology Education, 2015. **39**(3): p. 158-166.
9. Anderton, R.S., T. Evans, and P.T. Chivers, *Predicting academic success of health science students for first year anatomy and physiology.* International Journal of Higher Education, 2016. **5**(1): p. 250-260.
10. Government, A.G., *Improving retention, completion and success in higher education. .* Retrieved from https://docs.education.gov.au/system/files/doc/other/final_discussion_paper.pdf, 2017.
11. Balta, J.Y., B. Supple, and G.W. O'Keeffe, *The Universal Design for Learning Framework in Anatomical Sciences Education.* Anat Sci Educ, 2021. **14**(1): p. 71-78.
12. Bilton, N., *Grounding the teaching of anatomy and physiology in Indigenous pedagogy.* International Journal of Innovation in Science and Mathematics Education, 2018. **26**: p. 35-43.
13. Lw, A., et al., *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. 2001.
14. Fink, L., *The Power of Course Design to Increase Student Engagement and Learning.* Peer Review, 2007. **9**.
15. Paul, J.W. and J. Seniuk Cicek, *The Cognitive Science of PowerPoint.* Proceedings of the Canadian Engineering Education Association (CEEA), 2021(0).
16. Biggs, J., *Teaching for Quality Learning at University*. 2003.
17. Bonwell, C. and J. Eison, *"Active Learning: Creating Excitement in the Classroom".* ASHE ERIC Higher Education Report No. 1, 1991.
18. Rogers, C., H. Lyon, and R. Tausch, *On Becoming an Effective Teacher : Person-Centered Teaching, Psychology, Philosophy, and Dialogues with Carl R. Rogers and Harold Lyon*. 2013, Oxford, UNITED KINGDOM: Taylor & Francis Group.
19. CSU, *Town Hall.* Charles Sturt University, 2023.

20. Bilton, N., et al., *Concept mapping in health sciences education: Conceptualizing and testing a novel technique for the assessment of learning in anatomy.* MedEdPublish, 2017.

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