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Received: 8 August 2022 | Revised: 1 September 2023 | Accepted: 11 September 2023

DOI: 10.1002/ase.2338

DISCURSIVE ARTICLE

Anatomical Sciences Education WILEY

Constructive alignment: Teaching introductory gross anatomy to sport science students

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Abstract

The purpose of this descriptive article was to illustrate the process of using constructive alignment in redesigning an introductory gross anatomy unit that is taught specifically to sports science and physical education students at Victoria University. The unit was redesigned as an intensive learning unit in 2017 as part of a broader university-wide process. The teaching team decided that the first stage of the constructive alignment process should be necessarily focused on an understanding of the career destinations of graduates from the courses. With this understanding, it became easier to work through the redesign of intended learning objectives, the shift from systemic to regional anatomy changes in content and learning support mechanisms, and alterations to assessment practices. A comparison of student pass rates for the unit from 2018 to 2023 with pass rates in the previous semester-long version of the unit, suggests optimism about the changes that were made through the constructive alignment process. However, there were a number of other factors that may have contributed to this result, and more research is needed on the specific effectiveness of the changes made during the constructive alignment process before a confident conclusion about the success of the process can be made.

KEYWORDS
career-focused, curriculum, gross anatomy education, pedagogy, sport science

INTRODUCTION

There is a large and expanding body of literature regarding the content of gross anatomy units, the decline in teaching time, the advantages and disadvantages of different methods of teaching and learning, new technological innovations in the field of gross anatomy education, and resource pressures on all of these things, when applied in the training of medical doctors (Regan de Bere & Mattick, 2010; Azer et al., 2013; Drake et al., 2014; Fillmore et al., 2015; Leveritt et al., 2016; McBride & Drake, 2018; McMenamin et al., 2018; Viana et al., 2019; Peeler, 2022). There is a smaller, but still growing literature, about these issues when dealing with the undergraduate training of other health-based professionals, such as physiotherapists, nurses, dentists, and allied health professionals (Zimanyi et al., 2019; Carroll et al., 2022; Giuriato et al., 2022; Rutenberg et al., 2022; Veazey & Robertson, 2023). In contrast, there is little literature on dealing with decisions about content, teaching practices, and the use of technologies when teaching gross anatomy to undergraduate sport scientists and physical education teachers (Catena & Carbonneau, 2019; Viana et al., 2019; Rabattu et al., 2022) although some research (Chakraborty & Cooperstein, 2018; Green et al., 2018; Zimanyi et al., 2019; McDonald et al., 2021) deals with

sport or exercise scientists doing a combined gross anatomy unit with other allied health professionals.

At Victoria University, the introductory anatomy unit, called "Structural Kinesiology", is taught to sports science, physical education, and fitness undergraduate students. Since its inception as a required unit in these courses during the 1990s, the unit had been taught using a typical, if diluted, medical science model (Klein et al., 2019). Students experienced in-person and teacher-directed lectures in principle-based systemic anatomy (Green et al., 2018; Trelease et al., 2020), and then completed model-based and/or cadaver-based laboratory work. This included structure labeling and short questions, which were completed by students in laboratory table groups. Lectures were delivered in ways that offered little opportunity for two-way interaction between students and lecturers (Parmelee et al., 2020; Hortsch & Rompolski, 2023). Assessments were all test or examination based. Theory-based, short answer tests examined student understandings of foundational concepts associated with anatomical principles and systems anatomy [e.g., what structures are common in synovial joints?]. Pinned anatomical examinations assessed student knowledge of anatomical structures and related functions [e.g., Identify muscle 'A'. What movements does muscle 'A' produce?]. Both types of questions were based on a traditional gross anatomy curricula.

A shift to a block learning model of four-week intensive units in 2018 at Victoria University (McCluskey et al., 2019; Tripodi et al., 2020) allowed the teaching team involved in the redesign of Structural Kinesiology to reconsider the established delivery and assessment approach. It was decided that rather than attempting to fit the current twelve-week unit into a four-week block model, the team would engage in a constructive alignment process that could/would completely change the unit. This process was aimed at meeting the University's objectives regarding the importance of engaged and active student learning to student success and retention (Chakraborty & Cooperstein, 2018; Klein et al., 2019; Viana et al., 2019; Chan et al., 2020).

More significantly, this redesign of the unit was necessitated by the demands of teaching a comprehensive introductory anatomical sciences unit in a four-week block (Trelease, 2020; Tripodi et al., 2020; Peeler, 2022). A difficulty in teaching an introductory anatomical sciences course in any format is finding the time to cover both the volume of content, and the development of necessary skills in using anatomical language successfully. For the learner, the demand to use both surface and deep learning approaches to simultaneously memorize structures and develop analytic skills, is an inherent challenge (Pandey & Zimitat, 2007; Bergman, 2020; Tripodi et al., 2020). Regardless of delivery mode, the combination of complex language, dense content, and the desire to engage the learner in deeper analysis makes anatomy challenging for students (Chakraborty & Cooperstein, 2018; Tripodi et al., 2020). The aim of this unit re-development was to retain the importance of the underpinning conceptual principles and language of anatomy while reducing some memorization by emphasizing the logic of the body and the relationship between structure and function (Regan de Bere & Mattick, 2010; Veazey & Robertson, 2023). In addition, it was intended that students would develop a growing understanding of the application of these conceptual principles by analyzing the structures that produce movement and stability in the human body (Miller et al., 2002). The hope was that in adopting a constructivist delivery approach and focusing the syllabus toward graduate outcomes for these cohorts, the labor-intensive challenges in teaching and learning anatomy for teachers and students would be reduced (Regan de Bere & Mattick, 2010; Estai & Bunt, 2016; Krause et al., 2020; Smith et al., 2020; Veazey & Robertson, 2023).

DESCRIPTION OF THE CONSTRUCTIVE ALIGNMENT PROCESS

In sports science or kinesiology related programs, gross anatomy is the predominant delivery model as it educates students about body movement in ways that graduates would be able to use in the field (Catena & Carbonneau, 2019; Viana et al., 2019). The teaching team chose to use an outcomes-based approach in the unit redevelopment that was strongly underpinned by constructive alignment. This is a form of delivery where both teaching and assessment are linked to intended learning outcomes (ILOs), which describe the body of knowledge expected of students by the completion of the unit (Biggs & Tang, 2020).

Step one: Aligning with student destinations

The first stage of the constructive alignment process occurred prior to writing ILOs (Biggs & Tang, 2020). It was deemed important by the teaching team to consider the graduate destinations for students doing this unit. Graduates in these courses would be taking up positions as sport scientists, fitness leaders and physical education teachers where neither professional practice requirements nor accreditation bodies required the detailed knowledge of the body's internal structures as required in medical science courses (Estai & Bunt, 2016; Smith et al., 2020; Tripodi et al., 2020). Less than 2% of the students enrolled in these courses progress on to medical schools, and those that hope to make that transition must complete higher-level anatomy-based units in biomedical science courses to be considered for entry into medical science programs.

The syllabus for students completing the Structural Kinesiology unit was shifted to the development of knowledge and analysis around twin foci of athletic performance, training, and conditioning and rehabilitation of sport injuries (Krause et al., 2020; Smith et al., 2020). This shift in syllabus foci suggested that it would be better to move to a regional orientation in anatomical education. Seven of the ten teaching sessions had a heavy focus on musculoskeletal anatomy covering 6 main course topics; (1) Pelvis and hip; (2) Thigh and knee; (3) Leg, ankle, and foot; (4) Trunk and spine; (5) Shoulder girdle and arm; (6) Elbow, forearm, wrist, and hand. The last three sessions investigated nervous, cardiovascular and respiratory

systems, while maintaining the same orientations of athletic performance and injury rehabilitation. An associated benefit of this shift was that it produced greater engagement for the student cohort allowing members of the cohort to draw on past athletic training and injury experiences.

Step two: Rewriting intended learning objectives

Once this initial shift was made, the teaching team could then move to the next step of constructive alignment, which was to rewrite the ILOs of each session in terms of these new foci for the unit. The skillful writing of ILOs requires a statement of what the student is intended to learn, how this learning will be done, what level the learning will be done to and in what context (Biggs & Tang, 2020). The teaching team developed a set of ILOs for each of the ten content-based sessions listed above. As an example, the ILOs for the session on the thigh and knee are in Table 1.

Each session included at least one learning outcome that was related to either injury analysis or sport specific training. This allowed students to develop their analytical skills when viewing injury and training situations. These applied objectives were supported by selected educational videos and academic literature.

While the teaching team continued to aid students in learning/memorizing the important concepts and structures of the moving body and its systems, the team also progressively developed students' abilities to analyze these structures in terms of their tissue make-up, position, orientation, and function (Azer et al., 2013; Bergman, 2020; Tripodi et al., 2020). The syllabus was focused toward learning outcomes that allowed students to visualize and analyze the coordination between different structures and systems in producing joint movement and stability (Pandey & Zimitat, 2007). The team moved students beyond the widely held view that surface-level memorisation was an endpoint of anatomical learning as opposed to a step in the process of developing deeper-level understanding of the content (Regan de Bere & Mattick, 2010; Bergman, 2020).

TABLE 1 Intended learning outcomes for session 3 on the thigh and knee.

1. Understand and outline the functions of the two articulations that are part of the knee joint complex
2. Analyze the shape and congruency of bony articulation surfaces in the tibiofemoral joint and list/explain the various supportive structures that assist in the production of tibiofemoral joint stability
3. Analyze the shape and congruency of the patellofemoral joint and list/explain the various structures that assist in the production of patellofemoral joint stability
4. Detail the movements that are possible at the knee joint complex and name and describe the muscles responsible for each movement and the position of these muscles relative to the axis of rotation for each movement
5. Investigate and explain the anatomical events associated with ACL damage including other structures that can be damaged when athletes suffer this injury

The inclusion of librarians and technology experts in the unit design team was important in producing resources to facilitate this shift in ILOs. This shift in orientation meant that standard anatomy textbooks no longer completely suited our objectives. These textbooks were neither focused on the applied elements that the team wanted students to achieve nor at the different level of understanding needed by the students who completed this unit. This judgment was made in light of future study units in resistance training, biomechanics, and exercise prescription, where an understanding of the application of anatomy is crucial. The librarians helped to produce an online learning management space that included e-book links to specific textbook sections on basic anatomy and on injury conditions and various other learning resource materials including videos, powerpoints, and labeled images. This space was supported by the regional anatomy e-learning computer database, anatomy.tv (Primal Pictures, 2001) which assisted students in the achievement of the learning objectives.

Step three: Developing engaging activities to achieve student understanding

The third level of the constructive alignment process involved the redesign of the unit away from traditional teacher-led instruction. This method of instruction would not be suitable in achieving the ILOs related to the production of analytical skills required for deeper learning in anatomy. A movement toward more engaged and hands-on analysis of anatomical parts and relationships was coincidently made more possible in the relatively small class [$n < 30$] workshops of the Victoria University block model.

Students in this unit had previously used textbooks, drawings in atlases and working with plastic models or wet specimens in laboratories, with most work done relatively independently from each other and from the laboratory tutor. The team developed a new set of interactive workshops that commenced with deep bone and joint anatomy and worked in layers of tissue toward the skin. Students in small groups built structures with bones and plasticine in workshops, guided by both the anatomy.tv database and the interactive workbooks. Anatomy.tv (Primal Pictures, 2001) was chosen because it allowed students to 'build' joints from deepest articulating bone layers, through the mid-level stabilizing features of capsules, ligaments, special structures and muscles/tendons, to more superficial layers of prime moving muscles (Shultz, 2012). The 3D nature of anatomy.tv allowed students to understand the layering of muscles and the relationship between layers and muscle attachment position (Estai & Bunt, 2016; Chakraborty & Cooperstein, 2018; Talip et al., 2022). Anatomy.tv also allowed students to easily draw the action lines of muscles (Krause et al., 2020). In addition, the database has a text descriptor for structures that can be pulled up on the same page as the image. This is important in introductory anatomy classes as representative and sense-making cognitive processing needs to be closely aligned (Trelease, 2016, 2020). The design team checked the topics in the syllabus against the core regional anatomy

syllabus put out by the Anatomical Society (Smith et al., 2016). While acknowledging that the unit would not be able to cover all elements of the Society's medical-centric curriculum the team was satisfied that there was appropriate delivery of the suggested topics in the areas of musculoskeletal, nervous, cardiovascular, and respiratory anatomy to a suitable level for sport scientists.

Furthermore, the team encouraged active learning by the students in using anatomy.tv to produce labeled images (Chan et al., 2020) to accompany their weekly joint reports and their major injury presentation (Figure 1).

This active building of joints, both in the hands-on workshops and on anatomy.tv, enabled students to develop understandings of the position and relationship of structures to the functions of joint stabilization and mobility. Furthermore, the team could then use this building as a foundation to develop student understanding, and visualization, of what is going on around a joint when an athlete is moving, and when an athlete suffers an injury (Miller et al., 2002; Pandey & Zimitat, 2007). Students were encouraged to watch weekend sport and compete for who could find 'the most gruesome injury video' to initiate class discussions. Finally, and perhaps in contrast to the students in the study by Klein et al. (2019), the cohort in this unit enjoyed using the anatomy.tv database, as indicated by a selection of comments to the question of 'what was most enjoyable about the unit' from the student evaluations in the university's formal feedback surveys included in Table 2.

This support for anatomy.tv was because the constructively aligned ILOs were oriented around the 'building' of anatomical structures. In using anatomy.tv, students' understandings of the three dimensional relationship of structures in the body were developed, and students learnt to manipulate their images to suit their intended learning purposes (Talip et al., 2022).

This was by far the longest stage in the constructive alignment process. It took the teaching team around three years to produce and refine the set of engaging student activities that are now used

TABLE 2 Student feedback on anatomy.tv.

'Anatomy tv is amazing'
'Having access to great resources like Anatomy TV'
'Anatomy tv was pretty cool. It helped me learn'
'For me the best aspect was Anatomy.tv. I got lost in the program but it was fun to build a body limb, etc and I found this a great way to learn. The time to break out and make pictures was great'
'I would encourage students use Anatomy.tv as a learning tool. I believe that the information on each body part would help build on the information in the texts and slides. I like to build and this program allowed me to do that'
'This is personal preference but less Anatomy.TV. I'm sure if we were in person we would have real models but the experience of Anatomy.TV on zoom is not great'

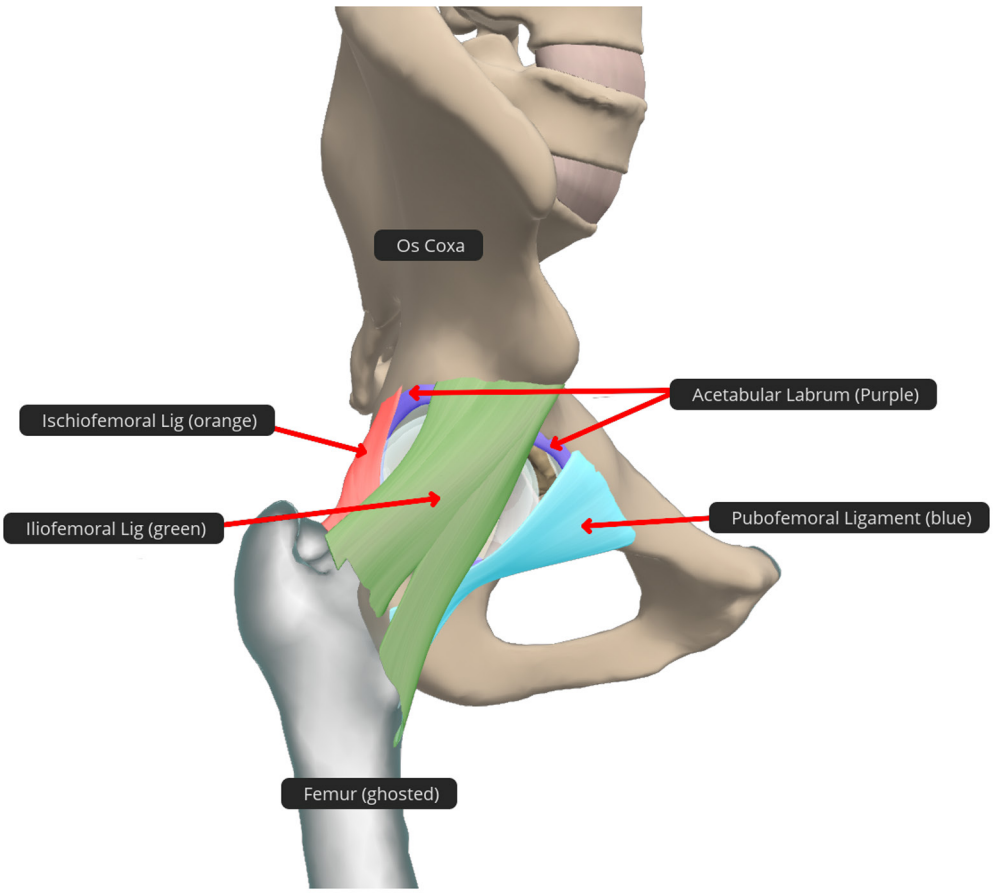

FIGURE 1 An example of an anatomy.tv image produced by a student.

in class. The process of refinement was sped up significantly in the period before isolation from the university campus due to Covid. During the short period before isolation, the teaching team quickly produced learning activities that students were able to engage with remotely. This necessitated some cleaning up of the existing learning management space and development of new material including the production of step-by-step student lesson plans and greater use of applied video (Morton, n.d.; Sutterer, n.d.) and online learning content. This material, developed and refined through 2018–2020, has remained on the learning management space with minor updates through the period 2020–2023.

Step four: Rethinking assessment of student learning

Constructive alignment also had a strong effect on the design of assessment practices in the unit. As mentioned previously, the assessment tasks in the old version of the unit were entirely test and examination based. This restricted assessment as the academic can only address a limited number of memorization-based ILOs (Biggs & Tang, 2020). In addition, many of the questions in the exams were about structures that were not particularly germane to the narrower professional outcomes that our students would face as graduates. The unit design team made two changes to assessment. The external accreditation body, Exercise and Sport Science Australia [ESSA], for some of the courses that do the introductory anatomy unit required some form of exam-based assessment, so the final pinned anatomical examination and some of the theory-based foundational tests remained. However, the orientation of questions, at least in the musculoskeletal parts of both of these assessment items, shifted to the twin foci of body/joint movement and stability, with a major emphasis on prime moving muscles and muscle groups, and joint stabilizing structures.

Other assessment items were replaced by the comprehensive and progressive injury and rehabilitation report. Students applied their anatomical understanding to case-based presentations on specific [mostly sporting] injuries and conditions (McLean, 2016). The scaffolding for the report occurred during the first two weeks, where students were required to write submissions on healthy joints, with information sourced from group-based library research. During weeks three and four, students would do individual presentations on a joint or tissue injury that builds from their weekly assessments on anatomically healthy joints.

The ILO associated with the injury presentation was: '*to explain the anatomical and mechanical events associated with a sporting injury and to outline the treatment protocol and the rehabilitation program necessary for returning the athlete to sporting competition*.' This meant that there was some framing of ILOs around *introducing* the student to the prediction and design objectives of learning anatomy (Biggs & Tang, 2020). This report encouraged student development of both deep anatomical analytical skills and broader soft skills including research, academic report writing, and presentation skills.

While the team did not feel confident in shifting entirely to a problem-based learning [PBL] curriculum in a foundational unit of study (Klein et al., 2019), some PBL or case-based strategies were adopted in the classroom (McLean, 2016; Chan et al., 2020; Parmelee et al., 2020). Sessions on musculoskeletal, brain, and heart anatomy were introduced with the use of video on a specific sporting injury (Sutterer, n.d.). The hope here was that students would begin to develop an understanding between preclinical anatomical knowledge and clinical applications of that knowledge (Bergman, 2020). While students certainly were not at a level which allowed for higher-order tasks of creation of rehabilitation programs or hypothesizing the anatomical causes of certain injuries in sports, they could research, analyze, synthesize, and explain the information that they had gathered about these injuries or conditions. In their major injury presentations, the tightly worded rubric required students to return to anatomical structure and function and the relationship between these, rather than simply rely on superficial investigation (Bergman, 2020). Finally, students assessed the work of their peers through a targeted feedback system that graded the presenting student as if they were a treating professional and offered feedback on how they conveyed anatomical-based information to their injured client (Biggs & Tang, 2020).

DISCUSSION- WAS THE REDESIGN SUCCESSFUL?

Were we successful as a design team? With over thirty blocks of the unit taught since 2018, the following successes can be reported:

1. It would appear from an observation of publicly available data on student pass rates in the unit that the blocked approach taken by the teaching team has delivered positive impacts. Pass rates for the period of 2018 to 2023 for students who completed all assessment items were 90.7%. In 2017, the pass rate for students who completed all assessment items was 82.7%. Over this period, entrance criteria for these courses decreased both for entrants straight out of secondary school and for entrants through other pathways, as competition with other local university providers for students increased, and more local university providers entered the field of sport science. There are several aspects of the approach to teaching and learning in the VU blocked system that were adopted, outside of the unit design and assessment changes outlined in earlier sections of the article, that could also explain an improvement in student results. The delivery of unit content is supported by a heavy use of anatomy-based videos in conjunction with other computer-aided instruction that allowed students to develop spatial awareness about anatomical structures and relationships. This combination has previously been linked with better performance in anatomical pinned examination assessments (Saxena et al., 2008; Topping, 2013; White et al., 2018), an assessment item that has remained part of the new unit. In

addition, the new university-wide blocked format for units implemented both a blended learning approach and hands-on and engaging independent learning modules to support student-centered learning in anatomy. Both these interventions have also been previously associated with improved performance by students on assessments (Serrat et al., 2014; Gross et al., 2017; Green et al., 2018; Wilson et al., 2019). For these reasons, further research would be needed to isolate elements of the constructive alignment process from other variables associated with the blocked approach to teaching at Victoria University.

2. Attendance rates increased markedly over the rates in the old twelve-week model (Klein et al., 2019). In the final year of the twelve-week model in 2017, recorded student attendance at laboratory sessions was just over 80% for the first six weeks of classes, prior to the mid-semester pinned anatomical examination completed during week 7, and then dropped to around 65% for the final five weeks from week 8 to week 12. Attendance rates at lectures were not recorded but it was apparent that there was a significant reduction in attendance during the semester, with attendance at very low levels in the last four weeks of lectures. Across the years of physical attendance at the university during 2018 (3 blocks), 2019 (4 blocks), and 2022 (8 blocks), the attendance rate at the block sessions remained stable across all sessions and was recorded at between 78 and 90% for all fifteen blocks. This was especially remarkable when returning to campus in 2022, given that some students, affected by the COVID illness, were necessarily absent from sessions during a block. No university-mandated change was made to attendance requirements during the changes to blocked learning. In agreement with previous research, any increase in student performance could have also been partially produced by greater student attendance at, and engagement with, in-class sessions after the changes were made (Gonsalvez et al., 2015; Viana et al., 2019; Herbert & Guenther, 2020; Rokusek et al., 2022).
3. The constructive alignment process allowed for a shift in the orientation of some students toward learning for preparation for both future units in biomechanics, physiology, resistance training, and exercise prescription and eventual professional practice, rather than learning to pass memory-based examinations and tests in this unit. A contrast with the previous version of the unit was that students were now provided with an assessable opportunity for an analysis of the anatomical events associated with various injuries and conditions. The demands of the research assessment item necessitated some level of critical thinking and depth in the assessed work of students (Biggs & Tang, 2020). A proportion of students demonstrated a strong understanding of the relationship between anatomical structure and acute treatment and chronic rehabilitation practices, which would benefit them in later units in their course and in professional practice. A small sample of student responses on the standard unit evaluation at Victoria University, presented as Table 3, attested to this point.

TABLE 3 Student feedback on applicability of unit to future study and work.

'Opportunities for applied learning with the healthy and injured joint reports/presentation were good. Provides a good solid foundation for later units in the course'
'More application and working with models instead of just straight theory linked the content to sports science'
'The work was always hands on and we are encouraged to use as many resources as possible to help us further understand the content, and its application in training and rehabilitation'
'Learning about joints and muscles and applying to injuries'

There is much more that still needs to be done. The shift to regional anatomy with a focus on movement, stability, and injury around articulations, may produce a tendency in students to view the body as a set of largely unrelated parts (Bergman, 2020). The next unit redesign will contemplate this issue, but it is likely that the introductory unit will not solve this issue on its own. Some form of "spiral curriculum" (Harden, 1999; Bergman, 2020) using a number of first year and later year units in functional kinesiology, resistance training and exercise prescription, will need to reinforce with students the importance of anatomy to the clinical and professional competencies that sport scientists require (Veazey & Robertson, 2023). Also, the use of other models or supports in student learning such as team teaching (McDonald et al., 2021), near-peer teaching programs (Viana et al., 2019; Krause et al., 2020; Parmelee et al., 2020), reciprocal peer-teaching (Krause et al., 2020; Parmelee et al., 2020) and more engaging practical components like body-painting (Estai & Bunt, 2016; Krause et al., 2020) and case-based learning (Mclean, 2016; Trelease, 2020) could drive even greater student engagement.

Could the apparent 'success' of this constructive alignment process be replicated in other sport science programs? The constructive alignment process commenced with the specific notion of graduate destinations of students doing these courses. Different universities who offer such courses, both in Australia and overseas, may have significantly different proportions of their cohorts moving into medical science-based courses. However, the authors have some confidence that the constructive alignment process outlined above would be useful for consideration in some other programs in sport science across the globe.

ACKNOWLEDGMENTS

The authors would like to thank all the teachers who have taught into this unit over the last five years including Sam Howe, Steven O'Bryan, Teghan Butler, Dale Harris, and Lisa James. The authors would also like to thank members of the Victoria University Connected Learning team, especially Sonia Wilkie and Ghaith Zakaria, who helped to develop some of the materials used on the Learning Management System for the unit. In addition, university librarians, Sarika Singh and Linda Forbes, were instrumental in assisting in the development of anatomy.TV learning guides. The authors thank Dr. Jason Organ and the anonymous reviewers for their comments that greatly improved this manuscript. Open access publishing facilitated by Victoria University, as part of the

Wiley - Victoria University agreement via the Council of Australian University Librarians.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest with this research.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Downie C, Burke M. Constructive alignment: Teaching introductory gross anatomy to sport science students. Anat Sci Educ. 2023;00:1–8. https://doi.org/10.1002/ase.2338