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Developing anatomy demonstrators of the future: The role of team-teaching

Diane L. Hughes
La Trobe University, disey2008@live.com.au

Laura Y. Whitburn
La Trobe University, l.whitburn@latrobe.edu.au

Meg Colasante
University of Melbourne, meg.colasante@unimelb.edu.au

Aaron C. McDonald
La Trobe University, a.mcdonald@latrobe.edu.au

Heath McGowan
La Trobe University, h.mcgowan@latrobe.edu.au

See next page for additional authors

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Keywords

team-teaching, sole-teaching, teaching development, anatomy education

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Introduction

Historically, gross anatomy was team-taught in a dissection laboratory by career anatomists and either surgical registrars or surgeons with an interest in teaching (Craig et al., 2010; Heidenreich et al., 2016). However, medical courses have experienced a decline in the number of hours dedicated to teaching anatomy (particularly dissection-based) in Australasia (Craig et al., 2010) and elsewhere (Drake et al., 2009; Gartner, 2003; Heylings, 2002) influencing the standards and number of future anatomy teachers or demonstrators (Fraher & Evans, 2009; McCuskey et al., 2005; Sugand et al., 2010). In recent decades anatomy has also been taught by a broader range of staff whose discipline background might not be anatomy focused (Flack & Nicholson, 2016; Schaefer et al., 2019). A shortage of anatomy teachers has been reported since the 1960's but still persists, with most surveyed department leaders reporting moderate to great difficulty in hiring appropriately qualified anatomy teachers (Schaefer et al., 2019; Wilson et al., 2020).

In Australian universities there is an increased focus on vocationally oriented degrees (such as allied health) in which anatomy is a prerequisite. Such degrees are taught by a broad range of staff whose discipline background is not anatomy focused, resulting in a range of course structures and teaching approaches potentially lacking a strong focus on anatomy teaching (Flack & Nicholson, 2016). Increasing research expectations has further contributed to the decreased recruitment of qualified anatomy educators and also the time available for development of teaching skills in anatomy (McCuskey et al., 2005; Schaefer et al., 2019). Furthermore, most undergraduate teaching in Australian universities is now performed by casual staff who may have limited access to professional development (May, 2013). Therefore, it is incumbent on the increasing diversity of anatomy teaching courses outside traditional anatomy departments to also develop future anatomy demonstrators.

At the University where this study was conducted, anatomy is taught to a large range of Allied Health courses (e.g., physiotherapy and exercise science) and has traditionally been sole-taught using prosected specimens in laboratories accommodating 20 to 25 students. This is mainly due to the smaller size of teaching laboratories, which is common for a University that does not have a body donor program. Sole-taught anatomy practical subjects have been adopted elsewhere including in medical courses (Whelan et al., 2016), and therefore it is important to determine the best teaching environment for medical and allied health students.

This article first discusses the concepts of sole-teaching and team-teaching in higher education contexts. It then offers the background and research methods, which closely aligns the teaching context, research design and the teaching intervention (team-teaching) in relation to educational design research, followed immediately by data collection and analysis. The results, discussion and conclusion sections complete the paper, with a focus on the team-teaching model that emerged in our work, of *observe-learn-support*.

Literature review: The concepts of sole-teaching and team-teaching

The definition of team-teaching is variable and can apply to a range of 'team' contributions to subject design, implementation and classroom delivery (Anderson & Speck, 1998; Carpenter et al., 2007). It has been suggested that the definition should relate to the potential benefits associated with team-teaching rather than focus on teaching logistics (Anderson & Speck, 1998).

An important benefit of team-teaching is the ability to learn by observation of another faculty member's interaction with students, and this is only practical when both faculty members are in the same classroom at the same time. Therefore, in the context of training future anatomists, the definition of team-teaching may be best defined as 'an approach in which two or more persons are assigned to the same students at one time for instructional purposes' (Gurman, 1989). The traditional dissection hall approach (Craig et al., 2010) described earlier clearly fits this definition as do many other reports of anatomy teaching involving surgeons (Klima et al., 2017), postgraduate teaching fellows (Cheng et al., 2011; DeFriez et al., 2011) or a range of peer or near-peer teaching approaches (Durán et al., 2012; Reyes-Hernández et al., 2015; Smith et al., 2018; Stephens et al., 2016). Many of these courses, particularly for medical students, are aimed at developing medical students as teachers for future residency programs rather than developing the anatomy demonstrators of the future.

Whether students prefer sole-taught or team-taught subjects has been explored for undergraduate computer science students with an outcome of an overall preference for sole-taught subjects (Money, 2016). Such preferences were based around consistency of both content and teaching style and greater continuity of subject content; however, the study also found team-taught subjects provided students with greater insight into content (Money, 2016). In contrast, undergraduate business students rated a team-teaching approach highly, with improved outcomes for lower-performing students (Colburn, 2012).

While the questions of whether team-taught and sole-taught approaches to teaching in the same subject are equally effective in terms of student outcomes and perceptions are important, the focus of the current study is on the benefits of team-teaching in terms of developing adequate numbers of high-quality anatomy demonstrators. Team-teaching in other disciplines, including biology (Bondos & Phillips, 2008) and statistics (Carpenter et al., 2007), has been described as important for mentoring postgraduate students in teaching skills (Bondos & Phillips, 2008) and in professional development for faculty (Anderson & Speck, 1998; Carpenter et al., 2007). Pairing of sessional teaching staff in an undergraduate science subject also provided teaching development opportunities for staff (Wevill & Savage, 2020). Therefore, it is presumed that the same benefits to staff may be possible in the anatomy discipline.

Near-peer demonstrators, such as students who have previously completed the subject, offer another role in the anatomy teaching laboratory. Medical students who participated as teaching assistants in a near-peer role reported that this was a positive experience that improved their anatomy knowledge (Reyes-Hernández et al., 2015) and helped prepare them for a teaching role as resident physicians (Jay et al., 2013). However, to our knowledge there are no reports on the perceptions of the anatomy faculty members involved in these medical courses.

Some of the advantages of near-peer team-teaching include improved social and cognitive congruence for students with their near-peer teachers (Hall et al., 2014). This suggests the distance between teaching staff and students (in terms of factors like age, education, professional status) influences student perceptions of teaching (Stephens et al., 2016), and may relate to the 'curse of knowledge' first described in economics (Camerer et al., 1989) but later applied to educational settings (Froyd & Layne, 2008). That is, near-peers do not take the same thinking shortcuts as experts do and can better remember what was difficult about learning a concept (Froyd & Layne, 2008). They are thus well placed to improve the student learning experience, as well as benefiting other teaching staff.

While previous studies have described outcomes of their teaching approaches, there are no apparent studies comparing staff experiences and perceptions in team-taught and sole-taught formats in the same subject. The aim of this study is to compare the teaching experience of anatomy teachers, particularly practical class demonstrators, contributing to either a team-taught or sole-taught format of the same anatomy subject.

Background and methods

Teaching context

This study examined a second-year undergraduate anatomy subject that covers regional anatomy of the vertebral column, lower limb and thorax. This subject was delivered to cohorts on two campuses in Victoria, Australia (a metropolitan capital city campus, and a regional city campus) in 2018. The subject was completed by students enrolled in Physiotherapy, Exercise Science and Exercise Physiology courses. The twelve-week subject involved a blend of face-to-face and online study, and the teaching style aimed to encourage self-directed learning. In brief, the weekly classes included online video-based content, a one-hour lecture and a two-hour cadaveric practical class, plus four functional anatomy practical classes for the semester and one-hour tutorials prior to in-semester assessments; see (Green & Whitburn, 2016) for further details.

The subject was taught by both tenured and casual demonstrators at both campuses and the subject coordinator was located at the regional campus with a metropolitan campus deputy coordinator. The practical classes that are the major learning forum for the subject (see full description below) have been sole-taught on both campuses for many years, but with increased student numbers it has been increasingly difficult to source adequately experienced demonstrators at the metropolitan campus. This context, plus declining student performance and satisfaction scores at the metropolitan campus meant that a modification to the teaching approach was designed and trialled.

Research design

The overall project was designed using educational design research (EDR). While the study involved data collection at multiple points throughout the semester, including student (McDonald et al., 2020) and staff generated data, this paper focusses solely on the experiences of the teaching staff. Easterday and colleagues (2018) present EDR as a logic of iterative phases which broadly involve: a focus on the problem to build understanding, defining goals and restraints, and conceiving and building a solution which is tested and presented to others. The problem, introduced in the teaching context above, involved the increasing difficulty in sourcing experienced demonstrators at the metropolitan campus and a lack of anatomy teaching development opportunities for demonstrators. This latter point, along with consistency in teaching across the demonstrators (which emerged as a further focus during iterations of EDR phases), form the problem-focus of this paper. Given the context-bound nature of designing interventions in real settings (McKenney, Nieveen & van den Akker 2006), it is important to note the wider context of this study. That is, the broader problem also involved divergent student satisfaction and success rates between campuses, aligned with goals to improve teacher-student interactions and students' learning experiences. While student perspectives and related outcomes are reported elsewhere (McDonald et al., 2020), this paper focusses on the analysis of the experiences of the teaching staff.

To help develop anatomy demonstrators, the researchers set the goals of providing career development through mentoring in teaching skills and anatomy content knowledge and, ultimately,

improving the consistency of teaching methods. A solution was conceived to employ a team-teaching approach in the metropolitan campus with mentoring and support from senior anatomists. We planned, refined and built a team-teaching solution comprising the roles of lead demonstrator, clinical demonstrator and near-peer demonstrator. Once departmental approval was obtained, the solution was implemented at the metropolitan campus and tested via data collection from key stakeholders in both the team-taught and the sole-taught formats in the current study. This paper compares demonstrator experiences of team-taught versus sole-taught practical classes in the same subject across the two campuses. For the teaching practice focus of this paper, the value of an EDR approach lies in validating (or otherwise) 'the resulting implications for the design of learning environments' (Nieveen et al., 2006, p. 152). However, we also recognise that this project represents an instantiation of the design process and that subsequent design iterations are probable in the ongoing design cycle (McKenney et al., 2006).

Teaching intervention

At the regional campus the weekly practical classes continued to be sole-taught with demonstrator to student ratios of approximately one to twenty for a cohort of 81 students, and one demonstrator had a repeat class. In contrast, the teaching intervention at the metropolitan campus meant the practical classes were team-taught with a team of three demonstrators in a larger laboratory (created by opening the door between two adjacent laboratories) and demonstrator to student ratios of approximately one to seventeen. The metropolitan student cohort had 292 students, and some staff took repeat classes.

Interventions involving team-teaching have long been viewed positively, yet the selection of team composition is not always reported including what constitutes an effective team such as capability requirements (Anderson & Speck, 1998). Within each metropolitan practical anatomy class, demonstrator teams deliberately comprised a lead demonstrator (an experienced anatomy demonstrator), a clinical demonstrator (typically a clinician with some teaching experience), and a near-peer student demonstrator acting as a student mentor. The near-peer demonstrators were third year students who had previously completed the subject with good results and showed aptitude and enthusiasm for teaching. They were encouraged to share their experiences of learning anatomy especially regarding effective study techniques. Near-peer demonstrators were not included in the ratio calculation to maintain equivalent student access to qualified staff. The lead demonstrator was responsible for introducing the class and leading major group discussions. Otherwise, all three demonstrators aimed to interact equally with students by moving around the lab facilitating student learning consistent with the subject teaching style of self-directed learning. A high level of awareness of classroom dynamics by staff was necessary to help ensure equal interaction of demonstrators with students.

Demonstrators at both campuses were provided with support for teaching including demonstrator guides with sample answers, suggested timings for class activities and regular demonstrator meetings. All demonstrators had both informal (during semester) and formal (end of semester) peer-review of teaching. The review of teaching involved commenting against a checklist of criteria shared in advance. The same criteria were used for all staff, so this was an equitable process where every demonstrator was reviewed. Near-peer demonstrators received additional support in the form of a three-hour teaching philosophy (emphasising self-directed learning principles) and practical skills workshop prior to semester. Additionally, both near-peer and clinical demonstrators had content revision briefings immediately prior to a practical class. This range of support was deemed necessary to avoid issues in sharing one class with multiple teachers due to insufficient planning or communication between the teachers (Bondos & Phillips, 2008).

Data collection

At the end of semester, data regarding demonstrators' experiences were collected via an anonymous online survey tailored to either the continuing sole-taught or new team-taught experience. Lead demonstrators had between six to thirty years of demonstrating experience, whereas clinical demonstrators ranged between one to five years and near-peers had no anatomy demonstrating experience. To ensure further anonymity the survey questionnaires did not ask for responses to identify the three different demonstrator categories. Likert scale survey questions sought information from demonstrators regarding confidence and perceived improvement over the teaching semester and support received. Four open-ended questions asked demonstrators to describe the benefits and challenges of teaching either individually or in a team (depending on their campus).

Most of the researchers in this project were involved in teaching the anatomy subject under focus. They are 'insiders' in that they undertake research in a setting where they have existing and established roles (Sikes & Potts, 2008). A criticism of insider research is the inability to maintain adequate distance while continuing to conduct daily work requirements (Sikes & Potts, 2008). This challenge was mitigated in the current study as analysis was performed by both an anatomist not involved in teaching the subject, and a non-teaching researcher from a different part of the university. Additionally, guidance in research design was taken from the University Human Ethics Committee that approved the current study (approval number HEC18017).

Data analysis

Qualitative data were imported into NVIVO 11 Software (QSR International Pty Ltd, 2015) for data management prior to thematic analysis. Data were initially grouped under the two categories: *benefits* and *challenges* based on the focus of the survey question it related to. The coding procedure recommended by Creswell (2018) was followed utilising descriptive and focused coding methods (Saldaña, 2016). Data were coded independently by two investigators, and a very high level (>98%) of inter-coder reliability was established (based on NVIVO Coding Comparison query). Two deductive themes of b*enefits* and *challenges* formed the parental nodes in NVIVO, with a large range of the emergent child nodes falling under either of these.

For quantitative data, Likert scale question responses of strongly agree and agree were collapsed to 'agree', while disagree and strongly disagree were collapsed to 'disagree' to improve stability and generalisability of the five-point Likert scale. The Likert scale question responses generated non-normal data and were analysed by non-parametric Mann-Whitney U tests in GraphPad Prism (version 6.00 for Windows, GraphPad Software, La Jolla California USA). Statistical significance was set at $p < 0.05$ for all tests.

Results

The surveys yielded a 100% participation rate representing all teaching staff involved:

- sole-taught at the regional campus $n = 5$
- team-taught at the metropolitan campus $n = 18$

Overall, the anonymous online survey responses provided rich data from the teacher-demonstrator perspectives. The survey responses spoke to the support received, confidence levels, and the benefits

and challenges of teaching either individually (sole-teachers) or within a team (team-teachers). These themes are discussed in this results section..

Outcomes

Demonstrators at both campuses rated highly the support for teaching; with most demonstrators agreeing they received a lot of support, but results did not vary enough to represent any bias toward one teaching style (U= 40.50, , p=0.859). The Mann Whitney result of U = 40.50 did not reach the critical value of 18 we accepted the null hypothesis that there was no difference in sample rankings. A z-score represents the number of standard deviations away from the mean; our z value

The Likert scale survey question results (see Table 1) for the teaching domains of anatomy content knowledge, classroom management skills and responding to student questions had most responses as positive (i.e. agree or strongly agree). Results are presented as changes to confidence levels over the teaching semester and there were no significant differences between campuses. There were only two negative responses about confidence in anatomy content knowledge and with responding to student questions. There were some neutral responses (neither agree or disagree) for questions relating to improvement in class management and answering questions over the semester.

Table 1

Likert Scale Survey Questionnaire Results

		Likert Scale: % Responses		
Question	**Campus**	**Disagree[1]**	**Neutral**	**Agree[2]**
I am very confident in my anatomy content knowledge	**REG**	0	0	100
	MET	6	0	94
My confidence in my anatomy content has improved over the semester	**REG**	0	20	80
	MET	0	11	89
I am very confident in my classroom management skills	**REG**	0	0	100
	MET	0	6	94
My confidence in my classroom management skills has improved over the semester	**REG**	0	20	80
	MET	0	33	67
I am very confident in responding to student questions	**REG**	0	0	100
	MET	6	11	83
My confidence in responding to student questions has improved over the semester	**REG**	0	20	80
	MET	0	28	72

Sole-taught Regional Campus (REG)

Team-taught Metropolitan Campus (MET)

[1] Strongly disagree and disagree. [2] Strongly agree and agree.

Team-teaching practical classes: Benefits

For team-teaching demonstrators, the benefits identified fell into two sub-categories: firstly, benefits for staff and secondly benefits for students as perceived by staff. Presented first are the benefits for staff, which are described by the theme *observe-learn-support.*

The team-teaching demonstrators made many positive comments about the benefits to their own development as demonstrators in the classroom. Benefits to all demonstrator categories were evident despite anonymous responses (17 of the 18 demonstrators made positive comments). These benefits included on-the-spot assistance as well as the chance to observe the teaching approaches of other staff, typified by this comment: 'It is beneficial to observe the way other demonstrators introduce or explain various concepts.' This enables additional opportunities to learn and develop as an anatomy demonstrator, and hints at the benefits to both anatomical knowledge and teaching techniques also made explicit by others, for example: 'Having the opportunity to teach with a senior demonstrator has allowed me to develop my anatomy knowledge and confidence …' Other comments were made about the value of the teaching collaborations, such as: 'I learnt at least one thing from both demonstrators every class, which was wonderful as it felt like a collaborative approach to teaching.'

The inverse also occurred, in that some staff reported satisfaction from the opportunity to offer direct support to other demonstrators. This mentoring role occurred during class time so may have additional benefits in temporal terms, as exemplified by this comment: 'I enjoyed the opportunity to mentor new demonstrators - particularly the student demonstrators. I found it very useful that demonstrators were available to help each other when needed…'

Student benefits, as perceived by team-teaching demonstrators, can be described by the themes of a *sense of more time with students* as well as *catering for student differences*. Beginning with the *more time* theme, the team-taught format tended to have an impact on class dynamics, despite the qualified staff-to-student ratios being comparable across the two campuses. Team-teaching demonstrators commented that they felt less rushed with students: 'If one group was monopolising the time of one demonstrator, the other two could see to the needs of other groups. There didn't seem to be the same fight for demonstrator time that you sometimes get when teaching solo.' This extended to a direct benefit for students as shown by the following quote: 'Helping each other with answering the students [sic] questions. Made the environment less stressed and more inviting...'

The *catering for student differences* theme describes the value that the team-teaching demonstrators placed on having staff with different backgrounds (anatomy discipline or clinical) answering student questions: 'It was great to have a range of experiences from other demonstrators to draw upon. Having a student's, clinician's and academic's perspective on weekly content was definitely a big bonus', or to utilising different approaches to teaching. The theme catering for student differences was mentioned by demonstrators, for example, one demonstrator described that it was

> *... much easier to account for students [sic.] different methods of learning' as 'each demonstrator has a unique… [way] of teaching and explaining things meaning students have… more opportunity to learn in a way that might better suit them. As opposed… [to] having to learn from only one.*

Finally, a powerful quote about the benefits of team-teaching: 'It gave me great insight into teaching at a tertiary level, helping me increase and maintain my anatomical knowledge.' This could be viewed as an endorsement of team-teaching as supporting staff development for teaching skills and anatomy discipline knowledge.

Team-teaching practical classes: Challenges

When asked about the challenges experienced during team teaching, the most common response was that there were no challenges. For example: 'Nil. I enjoyed the semester teaching with other demonstrators.' The two themes that did emerge as challenges were *consistency in teaching* and *team dynamics*.

Team-teaching demonstrators were aware that anatomical concepts may be explained differently by other demonstrators, thus potentially creating issues with *consistency in teaching*, and, '…whilst this may help in some cases i [sic.] can see how it might be confusing in others.' Staff concerns about different information being given to students is extended by the method of arrival at the information, as related to 'teaching styles of the different demonstrators in each class,' and 'Being sure that we are all giving the same type of information and in the same way...'

Another issue of *consistency in teaching* reported by team-teaching demonstrators related to the need to be aware of which students had just received help from other staff: 'It was difficult to keep tabs on which groups of student had been recently tended to by other demonstrators, and those that were maybe 'being neglected'.'

The second challenge emerging for team-teaching demonstrators was management of the *team dynamics* in the classroom. For example, the demonstrators found it 'took some time to find the balance between the personalities', with comments about establishing trust and clear roles in the classroom. There was 'an inherent need to trust your team members when working in any team, and this can take some time to develop when working in a new team.'

However, once the demonstrator team had established their classroom dynamic, this challenge seemed to resolve. The classroom dynamic became established over time by getting to know the other demonstrators and establishing clear roles. The resolved challenge became a positive; 'Once roles were defined there were no challenges.' Other teams may have benefitted from establishing their respective roles early, as indicated by this comment:

> Mostly, I really enjoyed the collegiality and sense of working in a team. I felt the clearly defined roles of each team member made it easy to function, but at the same time acknowledged that each team member had something unique to contribute.

Sole-teaching Practical Classes: Benefits

Demonstrators in the sole-teaching format saw three main benefits for their students. First, a consistent learning experience. They were reassured that their students received both consistent information and teaching approaches: 'I can be confident that all students are getting the message, the information and the teaching style that I want them to have.' A second benefit expressed was the opportunity to develop a stronger rapport with students. The demonstrators in the sole-teaching format expressed a relationship between 'develop[ing] more rapport with the students' and making them feel 'comfortable'. Finally, demonstrators in the sole-teaching format noted the ability for flexibility in their teaching, with more opportunity to change the class in response to student needs. For example, 'The lesson structure can be more flexible.'

Sole-taught Practical Classes: Challenges

The main challenge highlighted by sole-teaching demonstrators related to providing enough support to all the students, given time constraints with the practical classes. For example, 'Meeting the needs of all students' or 'Providing support to all students in the group'. Sole-teaching demonstrators were asked to comment on their prior experiences with team-teaching with responses related to either a lack of experience, or past experiences that were viewed positively:

> *My last experience of team teaching was when I first started teaching and I found it advantageous to have senior staff around because I was still learning the content myself so the backup support was really appreciated.*

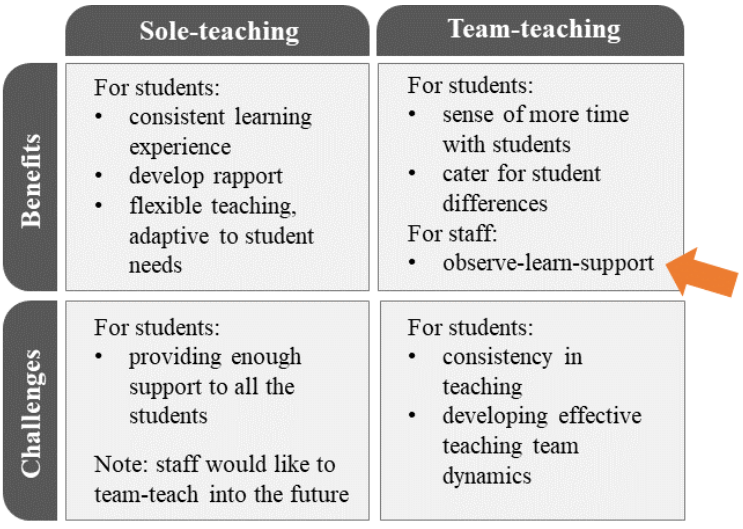
Importantly, staff at the sole-taught campus '…would really like to be involved in team-teaching in the future'.

Discussion

The purpose of the current study was to seek appropriate solutions to optimise teaching in cadaveric-based practical classes. The difficulty in finding appropriately qualified and experienced demonstrators across a large subject and the lack of staff development opportunities for either new or existing staff as a result of the sole-teaching format in use at our university led to trialling a team-teaching approach. Staff survey findings illustrate that the benefits of offering a team-taught format outweigh the challenges and that team-teaching offers longer-term benefits in the development of future anatomy demonstrators. Benefits and challenges from the findings are summarised in Figure 1.

Figure 1

Sole-teaching and Team-teaching Benefits and Challenges as Perceived by Staff



Note: Arrow for emphasis on the key theme of *observe-learn-support*.

Interestingly, the benefits of team-teaching can be discussed by elevating the theme of *observe-learn-support* (and as emphasised with an arrowhead in Figure 1) as a focal point for most other themes in the findings. This theme provides an important indication of staff awareness of their own professional development needs. It also relates to on-the-spot assistance as well as the chance to observe the teaching approaches of other staff. The subject has high student numbers necessitating numerous practical groups so this on-the-spot assistance can assist with ensuring a consistent teaching message is being conveyed, by allowing for checking of content with other demonstrators. This compares to the sole-teaching format where demonstrators felt supported (Table 1) but their comparative isolation in practice does not inherently provide staff development opportunities. A trade-off between formats relates to autonomy. Sole-teachers have the autonomy to plan and conduct their practical sessions, compared to team-teachers who trade their autonomy for the promotion of team-work skills and establishing time for collective planning (Vesikivi et al., 2019).

The value of team-teaching extends beyond a one-way transfer of knowledge and experience, with all demonstrators reporting benefits from interactions with each other that created a collaborative approach to teaching. Such aspects are key considerations for developing the anatomy demonstrators of the future. Additionally, the observe-learn-support theme is open to be tested for ongoing implications, including the potential for structuring future academic development outside of anatomy teaching.

The three factors of *observe-learn-support* will now be further discussed in the following sections.

Observe

There are benefits for anatomy demonstrators, as related to observing others and hearing their perspectives. This is evidenced by the appreciation of the ability 'to observe the way other demonstrators' practice, which can help their own development as a demonstrator. This can be referred to as 'on the job' training for novice teaching assistants (Liebel et al., 2017). Additionally, the collaborative preparations undertaken by the team-teaching demonstrators to provide support and ensure consistency in teaching approach can act as a suitable substitute for the training of near-peer demonstrators (Harvey, 2014; Stephens et al., 2016; Wilson et al., 2020).

To learn in context or authentically from other staff, there are benefits from learning *in situ*. While affording development of teaching skills by on-the-spot feedback (Liebel et al., 2017), the team-taught format has the inherent challenge of maintaining consistency of how content is described compared with the sole-taught format. Two sole-teaching demonstrators valued giving a consistent message, however it is less clear if students would agree given students reportedly appreciate the multiple perspectives from team-teaching, as reviewed by Carpenter and Crawford (2007). The importance of providing different perspectives within the classroom was strongly expressed by team-teaching demonstrators, and contrasts with the likelihood that decisions to run sole-taught subjects probably comes to down to teaching laboratory logistics rather than pedagogical considerations.

Learn

There are benefits for anatomy demonstrators, as related to learning from experience and a majority of the demonstrators surveyed (in both teaching formats) indicated they had gained more confidence over the semester in all the teaching domains. However, it can be daunting for new demonstrators to learn how to teach at university level; even more so in a sole-taught format. Team-teaching

develops and improves teaching skills of staff (Higgins & Litzenberg, 2015; Liebel et al., 2017), and has been advocated as an effective method to pass on some of the knowledge and experience to the next generation (Higgins & Litzenberg, 2015). The Benchmarking Leadership and Advancement of Standards for Sessional Staff project includes a key standard in its framework to support sessional teachers through team teaching (Harvey, 2014).

Regardless of the expertise of anatomy demonstrators, the ability to provide an authentic clinical perspective is generally going to be beyond anatomy staff unless they also have both clinical training and experience in clinical practice. Similarly, experienced anatomy demonstrators may not relate to current students in the same way that a near-peer demonstrator can, in part due to 'the curse of knowledge' (Liebel et al., 2017). The relatability of near-peer demonstrators, and the perspectives of clinical demonstrators was described as 'a big bonus'. Stephens et al (2016) attribute the benefits of near-peer demonstrators partly to their enthusiasm for teaching which compensates for their limited teaching experience, and partly to their similar cognitive and social levels compared with the students.

Support

For the final part of the *observe-learn-support* overlay, there are benefits for anatomy demonstrators as related to support mechanisms. These include contextual conversational opportunities and team dynamics.

For contextual conversational opportunities, introducing more demonstrators allows for class content to be questioned and discussed (Liebel et al., 2017). Thomson (2015) advocates conversation during professional development events as organic mechanisms between colleagues to help them learn about teaching. Thomson found that mid-career and novice academics use informal conversation to 'manage their teaching contexts', 'reassure themselves about their teaching practice', and to 'improve their teaching' (Thomson, 2015, pp. 143-144).

The team-teaching demonstrators created their own structures of receiving and giving support while developing effective teaching team dynamics. This support depends on effective conversations between team-teaching demonstrators and can further act as a substitute for training near-peer demonstrators (Stephens et al., 2016).

Such conversations reach a formal level via the intra-discipline approach established by the anatomy demonstrators involving preparation meetings, peer-review of teaching reflection and discussion opportunities, which position the demonstrator conversations as formalised but conversational support mechanisms. Team-teaching gives the opportunity for reflection that involves input from the perspective of another staff member (Liebel et al., 2017), either after the class or during it, e.g., redirecting off-task students (Main, 2015). Team-teaching is one way to extend the benefits of peer-review to include collaborative reflection (Liebel et al., 2017) to assist staff to move beyond just individual reflection on their teaching (Main, 2015).

Sole-demonstrator survey responses did not indicate any awareness of a lack of support or professional development opportunities. However, sole-teaching demonstrators reported feeling under pressure to meet the needs of all students, while team-teaching demonstrators expressed the opposite experience despite approximately equivalent staff to student ratios. This seems to indicate that sole-teaching roles may benefit from more support mechanisms to reduce the pressure they experience.

In a subject with complex content the team-taught experience of not rushing interactions with students may have substantial benefits. Staff recognised that students in the team-taught subject had the option of deciding which demonstrator to approach with a question 'that might better suit' their learning needs. Multiple explanations of complex concepts are an important benefit of team-teaching (Liebel et al., 2017).

Finally, the team-teaching intervention benefitted from departmental approval and support. Managerial support is considered 'of utmost importance' behind such initiatives (Vesikivi et al., 2019).

Cost

Finally, demonstrator motivation can increase with team-teaching (Carpenter et al., 2007; Higgins & Litzenberg, 2015), but so can the planning time needed and costs (Davis, 1995; Liebel et al., 2017). In a climate of constrained higher education funding for teaching and learning activities (Krause, 2017), it is important to justify any additional expenditure in terms of improved student and staff outcomes. In this teaching intervention, expenditure on salaries decreased as class sizes increased, and staff were paid based on demonstrator classification, so the cost was lower than employing lead demonstrators in a sole-teaching model with smaller class sizes. The cost-effectiveness of our approach, along with the absence of sustained time imposts on team-teaching demonstrators are both strengths for sustainability of team-teaching within our anatomy discipline.

Limitations

The current study was limited to the single discipline of anatomy, but findings may well be applicable to other subjects with large practical classes or with science content taught by staff with diverse discipline backgrounds. The current study had a small sample size for quantitative purposes but nevertheless all teaching staff (n=23) completed the surveys and generated rich qualitative data that does not necessarily need to be generalisable. For the quantitative analysis, improvements in the teaching domains of anatomy content knowledge and classroom management skills were unlikely to be reported since almost half of team-teaching demonstrators (40%) reported being very confident already.

Due to the aforementioned requirement to ensure that demonstrator responses to survey questions remained anonymous, it was not possible to conduct separate analysis of results per the three different demonstrator categories. Thus, we cannot clearly distinguish comments made by categories of demonstrators and hence we have lost the 'identity' of some of the different viewpoints in our analysis. This could be resolved in future studies by the addition of focus groups and/or semi-structured interviews, which would also enable comparison of the teaching experience from the different perspectives of each demonstrator category. It is possible that the predominance of 'insider' researchers as authors on this manuscript biases the results in favour of the team-teaching intervention, but this is reduced by the presence of external authors in the analysis of the data and it is also evident that the sole-teaching demonstrators were also positive about their teaching experience.

Conclusions

Whilst the sole-taught format may facilitate rapport between staff and students and ensure consistent information is presented within a subject, it does not offer opportunities for the development of new

demonstrators. Team-teaching can offer opportunities to develop anatomy demonstrators and provide for quality control of teaching across large subjects. As well as enabling on-the-spot mentoring, peer review of teaching can help foster a subject's desired teaching approach as expressed by the theme of *observe-learn-support*. The model of team-teaching used in the current study helps develop our anatomy demonstrators of the future at no additional cost and has important additional benefits for anatomy teachers. The staff development offered by team-teaching gives insight into the complexity of teaching at university level, as well as supporting staff to develop or maintain their anatomy knowledge.

This team-teaching approach was implemented before the global pandemic of COVID-19. However, the nature of the pandemic significantly moving university teaching online means there is potential for future research to determine if a team-teaching approach in anatomy has future application in terms of developing technology-based teaching skills such as in augmented and virtual reality. Team-teaching has the capacity to assist in developing our anatomy demonstrators and will play an important role in future anatomy teaching at both campuses of our university.

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