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EDUCATION

Investigating the anatomy learning experiences of undergraduate paramedic students

Anthony Carnicelli[1,2]; Anne-Marie Williams[1]; Dale Edwards[1]

Abstract

Introduction: The study of human anatomy forms a foundational knowledge base essential for healthcare professional practice including paramedicine. However, little is known about the experiences and perceptions of undergraduate student paramedics towards learning anatomy. The aim of this study was to investigate this, utilising a questionnaire previously validated in medical students.

Methods: To explore anatomy learning experiences, a 32-item anatomy learning experiences questionnaire (ALEQ) modified for use with paramedicine students was distributed online to students enrolled in the Bachelor of Paramedic Practice at the University of Tasmania. Quantitative statistics were used to identify differences in responses between student groups. Cronbach's alpha assessed the reliability of the modified ALEQ.

Results: Fifty-one usable responses were obtained (20% response rate). Psychometric analysis demonstrated good overall reliability (Cronbach's alpha of 0.88). The students perceived several learning activities as positive including textbooks, online learning and practical classes. However, it was generally felt the amount of content to learn was daunting. Furthermore, the students indicated working with cadavers would be highly beneficial for their learning. The relevance of anatomy was also recognised as being important to future clinical practice.

Conclusion: Despite the low response rate, the modified ALEQ was a reliable instrument to investigate the anatomy learning experiences and perceptions of paramedicine students. Further research with a larger cohort is required to confirm the reliability and generalisability of the results.

Keywords

anatomy; bioscience; paramedic students; undergraduate education

Corresponding Author: Anthony Carnicelli, Anthony.Carnicelli@utas.edu.au
Affiliations:
[1]Tasmanian School of Medicine, College of Health and Medicine, University of Tasmania, Hobart, Tasmania, Australia.
[2]Ambulance Tasmania, Tasmania, Australia

INTRODUCTION

The study of human anatomy and physiology form an integral part of tertiary healthcare and medical curricula.(1–3) This is also true for undergraduate paramedicine, as it provides the scientific basis for differential diagnosis and clinical decision making; thus ensuring a high degree of clinical competency to inform patient management.(1–4) Despite the body of literature specifically investigating the study of anatomy across varying health professions, little is known about the learning of anatomy in undergraduate paramedicine students.(3,5–9)

The importance of paramedicine students studying human anatomy is recognised by Lim et al. who state that to be competent and confident in several invasive procedures such as advanced airway management or needle thoracocentesis, a strong working foundation is required including exposure to both normal anatomy and its variations.(10) This solid foundation in bioscience knowledge should be viewed as essential to paramedicine, especially considering the scope of practice is rapidly increasing and it is now recognised in Australia as a registered health profession.(11,12) As a result, over the past two to three decades paramedicine education has followed other health professions such as nursing in moving from post-employment vocational training to primarily pre-employment university degrees.(13,14) In addition to the development and expansion of bachelor degree level qualifications for paramedics, there has been a significant increase in postgraduate programmes, with several ambulance services in Australia now requiring a postgraduate qualification for their advanced training courses such as intensive/critical care and aeromedical retrieval.(15) Paramedics undertaking training and independent practice in these higher-level roles are now performing more advanced procedures once restricted to physicians,

including surgical cricothyroidotomy, thoracic and abdominal ultrasound and finger thoracostomy.(16–19)

As a result of increasing knowledge and scope of practice, the educational gap between paramedics and medical practitioners in performing a range of emergency procedures is decreasing. As paramedic roles continue to grow, these educational requirements are not just confined to the emergency setting but are expanding across various areas of healthcare where paramedics are becoming increasingly more qualified to work. An example of this can be seen in the United Kingdom, where general practitioners are now employing paramedic practitioners.(20) These paramedic practitioners have additional academic qualifications enabling them to diagnose, treat and refer patients while performing home visits or reviewing patients in the practice rooms.(20) Considering the expanding field of paramedicine in Australia and internationally, it is necessary to ensure that undergraduate paramedicine students have a solid grounding in the clinical sciences that form the foundations of practice and future professional development.

While undergraduate paramedicine programmes have been in existence for several years, there appears to be a paucity of literature investigating the experiences of students towards the underpinning knowledge for clinical practice such as anatomy. The main aim of this study was to utilise the anatomy learning experiences questionnaire (ALEQ),(21) which has been previously validated in medical students, to investigate the perceptions of paramedicine students towards learning anatomy. Further objectives included comparing responses between first- and second-year students, identifying which learning approaches were associated with positive experiences; and validating the reliability of the ALEQ in the paramedicine student context.

METHODS

Study design

This study employed a cross-sectional survey design using a modified ALEQ to collect responses from first- and second-year paramedicine students studying the Bachelor of Paramedic Practice (BPP) at the University of Tasmania (UTAS). Demographic data were also obtained as part of the questionnaire.

Participants and setting

Participants were first- and second-year paramedicine students at UTAS undertaking the BPP between late 2019 and early 2020. The BPP is a two-year full-time accelerated programme with three semesters of study per year. The programme runs across two campuses including Hobart, Tasmania and Sydney, New South Wales. The Hobart campus has approximately 50 students in each year group and the Sydney campus around 100. The students progress through the same curriculum including core units in bioscience, pharmacology and clinical practice. During the early years of the programme some of the course units including bioscience were shared with nursing. However, over time the programme has evolved, and bioscience is now more aligned to paramedicine. The biosciences have three separate units of study, incorporating a foundation unit in semester two of year one and two further units in semesters one and two of second year, including one double unit. These units integrate concepts of anatomy, physiology, microbiology, and then later pathophysiology organised by body system. Teaching strategies include lectures, practical classes (utilising images and plastic models), online content, tutorials, assignments and examinations. The first two units are largely delivered face-to-face, while the final unit is primarily delivered online due to the demands of a significant clinical placement during the semester. These subjects are run alongside clinical practice units but due to numerous course constraints, bioscience teaching does not fully align with clinical practice instruction.

Instrumentation

The original 38-item ALEQ developed by Smith and Mathias (21) was modified for the BPP context. This contained 32 items grouped into the same six clusters as described by Smith and Mathias,(21) which included: (1) your learning (preferred learning activities and resources); (2) learning with cadavers (experiences and feelings about possibly working on cadavers); (3) learning problems (challenges in learning anatomy); (4) using anatomy (applying anatomical knowledge in clinical and other contexts); (5) overall perceptions of anatomy (relevance of anatomy to paramedic practice); (6) specific to final year. A 5-point Likert scale was used ranging from 1 = strongly disagree to 5 = strongly agree; not applicable (NA) was also an option (items 3–7), as some students may have been granted recognition of prior learning for one or two of the bioscience units, thus not all questions may have been perceived as relevant.

Cluster 2 was changed to seek information about the opportunity to work on cadavers as part of their learning, which is not currently available in the BPP. Additional minor alterations were made to questions in other clusters to ensure relevance to the BPP. In cluster 4, an original question regarding radiology anatomy knowledge was removed and two questions added to differentiate between anatomy knowledge applied to teaching situations and clinical placements. In cluster 5, a question referring to cadaveric material was removed. Cluster 6 also had a question removed as it was not relevant to paramedicine. As these changes were minor alterations, they were not pilot tested, which aligns with the approach by Choi-Lundberg et al.(22) when they modified the ALEQ for their study.

Recruitment and data collection

The questionnaire was distributed online via SurveyMonkey® by UTAS paramedicine administration to student email lists (to ensure student anonymity). This included all enrolled first-year paramedic students (N = 138) who would have completed the foundational bioscience unit at the time, and all enrolled second-year students (N = 120) who

would have completed all three bioscience units. Email reminders were sent at one and three weeks after the survey opened. Participation in the study was voluntary and anonymous.

Data analysis

Questionnaire responses were analysed using Microsoft Excel (Microsoft Corp., Redmond, WA) and SPSS version 26.0 (IBM Corp., Armonk NY). Descriptive analysis described the participants' demographic data. To obtain an indication of both positive and negative perceptions of students to each questionnaire item, the results of the 5-point Likert scale were reduced to three possible outcomes: (1) agree, which included students who indicated either strongly agree and agree responses; (2) neutral, which included students who indicated neither agree nor disagree; and (3) disagree, which included students who indicated either disagree or strongly disagree. The main findings of ALEQ responses are summarised by each main cluster of questions as percentages, means and standard deviation (SD).

The Mann-Whitney U (MWU) test was used to identify differences in responses between first- and second-year student groups. A non-parametric test is generally recommended when the sample size of a study is small.(23) Using the MWU for multiple group comparisons increases the risk of type I error.(24,25) To account for this, the Bonferroni correction was used for post-hoc analysis.(25) When comparing scores on the first 29 questions of the ALEQ which related to both groups, a conservative statistical significance level of $p = \leq 0.002$ was calculated. For the comparison of differences across the entire 32-item questionnaire between gender (male and female) as well as the highest level of education achieved prior to the BPP (year 12 and non-year 12), $p = \leq 0.001$.

As the ALEQ was originally designed for undergraduate medical students, the reliability of the questionnaire was also determined for use in paramedicine students utilising Cronbach's alpha.(26) Responses to negatively worded questionnaire items (items 10–17, 19, 29, 30) were reverse coded for the purpose of reliability analysis.

Ethics

Ethics approval was granted by the Tasmanian Social Sciences Human Research Ethics Committee (H0018322).

RESULTS

Fifty-eight questionnaire responses were received from a potential 258 students, representing a response rate of 22%. Seven responses were excluded from analysis as less than 90% of the total questionnaire had been completed. The final sample for analysis was 51 (20% response rate). Demographic data of the respondents are reported in Table S1.

Overall, 55% (n = 28) of respondents were from first year and 45% (n = 23) from second year. Most respondents identified as female (63%, n = 32) with 37% (n = 19) identifying as male. This was relatively consistent with the overall gender demographic across the entire student cohort (58% female, 42% male). Mean age was 22.2 years, and over half of the group entered the degree directly from year 12. Between the two university campuses, the Sydney campus represented 63% (n = 32) of responses compared to 37% (n = 19) from Hobart.

Comparison of ALEQ scores between student groups

The MWU test was used to separately analyse the differences in scores between student year groups (year one and year two), gender (male and female) and those that entered the BPP directly from year 12 versus those that had undertaken previous studies prior to commencing the BPP (year 12 and non-year 12). No significant differences were found across the entire 32-item questionnaire when comparing male and female scores or for year 12 and non-year 12 groups. When comparing student year group for ALEQ items 1–29, the analysis initially revealed significant differences ($p = \leq 0.05$) in scores between first-year and second-year

Table 1. Overall results from ALEQ cluster 1: your learning (preferred learning activities and resources)

Item	Statement	Agree (%)	Neutral (%)	Disagree (%)	NA (%)	Mean	SD (±)
1	Reading textbooks is an effective way of learning anatomy.	62.75	19.61	17.64	–	3.55	1.14
2	Searching the internet for online materials assists my learning of anatomy.	88.24	9.80	1.96	–	4.25	0.72
3	Using the MyLO resources is an effective way for me to learn anatomy.	76.47	17.65	5.88	0	3.86	0.75
4	Using imaging material (eg, X-rays, MRI) is an effective way for me to learn anatomy.	39.21	41.18	7.84	5.88	3.16	1.19
5	Online quizzes were useful for my learning of anatomy.	80.4	15.69	3.92	–	4.18	0.84
6	Bioscience practical classes (eg, CXA107, CXA204) were an effective way for me to learn anatomy.	90.19	3.92	1.96	3.92	4.35	1.11
7	Practical skills sessions in CAA units (eg, CAA205, CAA206) were effective supports for learning anatomy.	66.67	11.76	3.92	17.65	3.37	1.74
Total		71.99	17.09	6.16	10.79	3.82	1.91

NA: not applicable; SD: standard deviation; MyLO: My Learning Online (UTAS online learning management system); CAA: UTAS coding for paramedic practice subjects; CXA: UTAS coding for bioscience subjects.

students for items 5, 15, 24 and 29 (Table 1). However, after the Bonferroni correction was applied, these results were no longer statistically significant. Therefore, for further evaluation of the questionnaire, the data were collated and analysed as a whole.

Questionnaire analysis

The main findings of the questionnaire are summarised by each ALEQ cluster. The tables for each cluster display the total response percentages, means and SD for each item. Higher scores indicate a more positive response on the 5-point Likert scale.

Cluster 1: preferred learning activities and resources

A total of seven items explored students' preferred learning and resources (Table 1), with mean responses being generally positive ranging from a low of 3.16 to a high of 4.35. The highest mean score was recorded for bioscience practical classes (M = 4.35, SD = 1.11), followed by online learning (M = 4.25, SD = 0.72) and online quizzes (M = 4.18, SD = 0.84). The lowest score was recorded for the use of imaging, eg, X-rays, MRI (M = 3.16, SD = 1.19).

Cluster 2: experiences and feelings about possibly working on cadavers

Cluster 2 included two items exploring the students' feelings towards working on cadavers (Table S2). The students felt strongly (M = 4.31, SD = 0.86) that access to cadavers would help them to visualise and therefore learn anatomy more effectively. It was also agreed that working with cadavers would help to positively address the issue of death.

Cluster 3: challenges in learning anatomy

Cluster 3 questioned the participants regarding the challenges encountered in learning anatomy (Table 2). The majority (68%, n = 35) found the amount of learning daunting (M = 3.73, SD = 1.10). Two items in this cluster explored problems in learning anatomy related to perceived relevance (item 12) and teaching style (item 13), with means of 1.59 and 2.25 respectively, indicating overall disagreement with these statements.

Of the respondents, 96% (n = 49) disagreed with having problems learning anatomy because they did not see it as relevant (M = 1.59, SD = 0.64). Furthermore, 70% (n = 36) disagreed that the main motivation for learning anatomy was to pass exams (M = 2.14, SD = 1.06). Only 13% (n = 7) agreed, with six of those being first-year students. Lastly, 47% (n = 24) of the group found learning anatomy difficult because they perceived it to be memorisation based (M = 3.18, SD = 1.14).

Cluster 4: applying anatomical knowledge in clinical and other contexts

In exploring how respondents applied their anatomical knowledge (Table 3), 94% (n = 48) agreed that their anatomical learning helped to inform learning in other areas of the course (M = 4.27, SD = 0.57). Other course areas included in-class clinical practicums, where 80% (n = 41) of respondents agreed that they used such knowledge in these situations (M = 4.02, SD = 0.65). This also translated to the application of surface anatomy in the clinical teaching environment. A slightly less positive response (M = 3.82, SD = 0.89) was found for the application of anatomy knowledge while on clinical placement (item 24) with an ambulance service, with only 67% (n = 34) of the total cohort in agreement.

Cluster 5: relevance of anatomy to paramedic practice

Cluster 5 revealed a strong positive response to the statements that communicating in anatomical language will be important, as well as that understanding anatomy is an important aspect to both becoming a paramedic (M = 4.71, SD = 0.54) and the profession in general (Table 4).

Cluster 6: specific to final year

Cluster 6 contained three items specific to second-year students, asking participants to reflect on their anatomy studies during the BPP (Table S3). Of final year students, 56% (n = 13, N = 23) disagreed that their knowledge of

Table 2. Overall results from ALEQ cluster 3: learning problems (challenges in learning anatomy)

Item	Statement	Agree (%)	Neutral (%)	Disagree (%)	Mean	SD (±)
10	The amount of anatomy I need to learn is daunting.	68.57	11.76	19.61	3.73	1.10
11	The anatomy resources for teaching within the school are limited.	37.25	35.29	27.45	3.10	1.01
12	I have problems learning anatomy because I don't see its relevance.	1.96	1.96	89.08	1.59	0.64
13	I have problems learning anatomy because the teaching styles do not suit me.	9.8	25.49	64.71	2.25	0.89
14	Examinations do not reflect my understanding of anatomy.	19.6	33.33	47.05	2.69	1.09
15	My main motivation for learning anatomy is to pass exams.	13.72	15.69	70.59	2.14	1.06
16	Learning anatomy is difficult because it is memorisation based.	47.05	21.57	31.37	3.18	1.14
17	I struggle to build on my anatomy knowledge as I often forget what I learned last semester/year/s.	43.13	35.29	21.57	3.25	1.09
Total		30.14	22.55	46.43	2.74	1.20

SD: standard deviation.

anatomy was inadequate to practise as a paramedic (M = 2.75, SD = 1.16). The same number also reported that they would have preferred the anatomy teaching to be more integrated with their clinical practice subjects (M = 3.39, SD = 1.08). It was also found that the second-year students' attitude towards the importance of anatomy increased as the course progressed, with 74% (n = 17, N = 23) agreeing this was the case (M = 3.75, SD = 0.89).

Reliability and factor analysis

Reliability analysis was performed to measure the internal consistency of the ALEQ scores across the 32 items as well as within each individual question cluster. The Cronbach's alpha demonstrated acceptable reliability of the questionnaire, α = 0.88. This is similar to a previous validation study revealing a Cronbach's alpha of 0.85.(22) Most, if not all, the items were worthy of retention except for item 28. If this is excluded, the alpha demonstrates minimal increase (α = 0.89). Of the six individual item clusters, clusters 2, 3 and 4 demonstrated acceptable reliability (α > 0.7) with α = 0.71, 0.79 and 0.73, respectively. Clusters 1 and 5 had lower scores with α = 0.47 and 0.290 respectively, demonstrating poor internal consistency. Initially the reliability analysis for cluster 6 resulted in a negative alpha (α = -0.02). However, when item 31 was also reverse coded, the alpha increased to α = 0.015.

To determine if the data were suitable for factor analysis, a correlation matrix demonstrated that the data were not positive definite with a determinant of zero. As a result of a zero determinant, a Bartlett's test of sphericity and a Kaiser Meyer Olkin measure of sampling adequacy could not be conducted. Thus, as a factor analytic solution could not be obtained, the data were unsuitable for exploratory factor analysis to determine if there were underlying relationships between the questions and clusters.

DISCUSSION

It would appear this is the first study to use the ALEQ in paramedicine students. Despite the limitation of a low response rate, the findings revealed some interesting perspectives and some of these may be worth considering for future course design.

Overall, those who responded to the questionnaire indicated positive experiences and perceptions towards learning anatomy. This was observed in the preferred learning activities and resources, with a strong preference towards online learning materials and practical sessions. Similar positive findings to online learning were also reported using the ALEQ in a group of medical students.(22) However, the small paramedic cohort reported a stronger preference for this modality.(22) The incorporation of online resources into traditional face-to-face subjects in a blended learning approach (27) is now common in tertiary education,(28) including several undergraduate and postgraduate paramedicine programmes being offered in Australia. The benefits of this are convenience, flexibility and reach to students across multiple locations.(27,29) Such convenience and flexibility may be a reason why the paramedicine students rated this method of learning as positive. It has been demonstrated that utilising blended learning within medical education may have beneficial effects on knowledge acquisition compared with traditional learning.(28) Whether this is transferrable to the paramedic context is an area for further research. The ALEQ could be adapted to undertake a large-scale contemporary assessment across health disciplines to investigate the potential advantages and disadvantages of various blended learning approaches.

The ALEQ does not explore why some activities and resources were preferred over others. As suggested by a previous study, further research including focus groups or interviews would be required to discern this.(21) In addition to online learning, paramedicine students also

Table 3. Overall results from cluster 4: using anatomy (applying anatomical knowledge in clinical and other contexts)

Item	Statement	Agree (%)	Neutral (%)	Disagree (%)	Mean	SD (±)
18	The organisation of the paramedicine course allows me to quickly put anatomy knowledge into use.	56.86	21.57	21.57	3.43	1.04
19	I have problems using my anatomy knowledge because I am not confident with my knowledge base.	35.92	23.53	41.17	2.94	1.12
20	My anatomy learning informs learning in other areas of the course.	94.11	5.88	0	4.27	0.57
21	I use anatomical terms and language at every opportunity (eg, home/uni/clinical).	54.91	25.49	19.61	3.49	1.03
22	I use my anatomy knowledge frequently in clinical teaching situations.	80.39	19.61	0	4.02	0.65
23	I use my surface anatomy knowledge frequently in clinical teaching situations.	90.2	9.8	0	4.10	0.54
24	I use my anatomy knowledge frequently while on placement.	66.67	25.49	7.84	3.82	0.89
25	I use my surface anatomy knowledge frequently while on placement.	62.75	33.33	3.92	3.80	0.83
Total		67.73	20.59	11.76	3.75	0.93

SD: standard deviation.

Table 4. Overall results from ALEQ cluster 5: overall perceptions of anatomy (relevance of anatomy to paramedic practice)

Item	Statement	Agree (%)	Neutral (%)	Disagree (%)	Mean	SD (±)
26	To become part of the paramedicine profession, it will be important to communicate fully in medical (anatomical) language.	84.32	11.76	3.92	4.25	0.82
27	Understanding anatomy is a very important part of becoming a paramedic.	96.08	3.92	0	4.71	0.54
28	My opinion of anatomy's relevance has increased as the course has progressed.	82.35	11.76	5.88	4.20	1.00
29	Anatomy is of little importance to me in my future profession.	1.96	1.96	96.08	1.51	0.90
Total		66.18	7.35	26.47	4.41	0.85

SD: standard deviation.

found using textbooks a positive experience. This may seem somewhat counterintuitive as paramedicine is very much an action-based profession where clinical acumen is often judged on practical competency.(10) In contrast, a study investigating the preferred bioscience learning methods in nursing students found that visual tasks such as reading were the least preferred method.(7) It should be noted that practical elements of studying bioscience were rated highly by paramedicine students, which has also been observed in nursing students.(7) However, our study suggests that paramedicine students may be more aligned with medical students in their approaches to learning anatomy, based on their responses to the ALEQ.(22)

An additional finding of note was the response to cadaver-based learning. The original ALEQ questions for this section were modified as BPP students at UTAS do not currently have access to cadavers. The responses to these statements (Table 2) were highly positive with an overall Cronbach's alpha of 0.71. This result is consistent with findings from other studies that revealed over 90% of first- and second-year medical students positively identified that viewing and having tactile interaction with cadavers was essential to learning and understanding anatomy.(6,22) Choi-Lundberg et al.(22) also reported positive responses towards using cadavers, with a high level of agreeance for dissection being an effective learning tool.

Education and training using cadavers have been shown to be rated highly by paramedicine students.(30) Lim et al.(10) reported a statistically significant improvement in skill self-confidence among a group of undergraduate paramedic students practising a range of procedures utilising fresh frozen cadavers. This enabled students to appreciate variations in normal surface anatomy and the location of specific landmarks. It was concluded that working with cadavers complemented simulation training and provided for the effective transfer of theoretical knowledge to clinical practice. Similar positive experiences and conclusions have been reported in paramedicine and allied health programmes, often utilising interprofessional learning.(31–35) The use of cadavers is also reported to be associated with the adoption of deeper learning strategies and understanding.(8,9,32,36,37) However, there is significant expense and resources required to establish suitable facilities should they not already be accessible as they were in the study by Lim et al.(10) Based on the strong interest of paramedic students for cadaveric learning in this study, it is suggested this resource be explored in other paramedic programmes where accessible. It is recognised this may not be possible and other learning modalities such as virtual reality may be a suitable alternative.

The findings in this study are also concurrent with the literature on some of the challenges in learning anatomy. Of note was the high proportion of respondents indicating they found the amount of learning daunting. Again, similar issues are noted in nursing, here it is reported that the content-heavy and conceptually challenging nature of anatomy and physiology has resulted in the development of several issues, including a fear of the biosciences, lower grades, high examination failure rates and low levels of confidence in applying theory to practice.(7,38–41) Much like the BPP, anatomy and physiology teaching in nursing are often taught as combined subjects.(11,41–44)

Additionally, students in the UTAS BPP are undertaking an accelerated two-year degree, as opposed to traditional three-year or four-year programmes. Thus, its fast-paced nature, and the fact that one bioscience subject is a double unit, may be influencing their experiences, including the ability to adopt a deep learning approach. Smith and Mathias commented that to foster deeper learning in anatomy, appropriately designed courses should consider activities that encourage application.(21) They further remarked that factors promoting rote memorisation, which was also noted by paramedicine students, should be decreased.

Despite the challenges in anatomy learning, the students indicated high levels of agreement with the questions in cluster 4 (Table 3). This related to the application of anatomy learning and knowledge to other areas of the programme, in clinical teaching situations and during clinical placements. Of note is the response to question 19, where there appeared to be varying opinion within the group. Again, while there is general agreement in terms of the value of applying anatomy knowledge within this cluster, it cannot be determined why there was relatively little separation between those acknowledging they were not confident with their knowledge base and those who were. It may be that there is a need for expanding the anatomy knowledge base to improve student confidence in its application; this is an area for further research.

Overall, the positive responses to the questions in cluster 5 indicate that the BPP students perceive anatomy to be highly valuable to their future practice (Table 4). As previously mentioned, the ALEQ does not ascertain why this is the case, including why the students felt the relevance of anatomy increased during the course. It can only be assumed that as they progressed to later phases of the course, greater connections between anatomy and clinical practice were made. This leads to the question of how much anatomy knowledge is relevant to practice? Meskell and O'Connor (45) reported that nursing students felt their level of knowledge should be equivalent to any other healthcare professional. However, this will vary in accordance with the particular profession. It has been suggested that the minimum knowledge required is that which allows for independent and safe practice.(46)

The level of anatomy knowledge in paramedicine relevant to clinical practice is relatively unknown and may vary depending on several factors, including curriculum design, clinician experience and the level of qualification. For example, a very general level of knowledge may be required for the graduate paramedic,

whereas more detailed anatomy of some body systems/areas may be more relevant for the extended/primary care paramedic. This is an area for future study.

A second aim of this study was to investigate the reliability of the modified ALEQ. The 32-item questionnaire demonstrated good overall internal consistency measuring a Cronbach's alpha of 0.88. Of the six clusters, clusters 2, 3 and 4 had an $\alpha > 0.7$. However, the data were not suitable for exploratory factor analysis. The main reason for this was the low number of respondents to the questionnaire. It is stated that at least 300 cases are generally required for factor analysis and that sample sizes of 50 are very poor for such analysis to be used.(46)

Further evaluation of the ALEQ is warranted to allow for the completion of exploratory factor analysis, which may identify common variances and an underlying structure to the questionnaire as established by Choi-Lundberg et al.(22) Their study had a response rate of 75% and revealed three main factors resulting in the number of items being reduced from 34 to 27. Research to achieve similar results in undergraduate paramedicine students is required.

Limitations

There are several limitations in this study. The main limitation is the small sample size which affects the reliability and validity of the results. Therefore, these data should be interpreted with caution and considered to be hypothesis generating rather than definitive. As the questionnaire response rate was only 20%, the study suffers from a non-response bias of 80%.(47) It is suggested that response rates of approximately 60% should be a general goal.(47) This study relied on paramedicine students to voluntarily complete the ALEQ online via an email link. One option to potentially elicit a higher response rate might be to allocate time during a bioscience or clinical practice tutorial. A similar method was employed in a previous study using the ALEQ, resulting in an 88% response rate.(22) Using this methodology, greater group and therefore statistical comparison could be made between students as they complete each individual bioscience unit and its corresponding practice unit. However, it has been commented that lower response rates do not inevitably mean less accuracy and lower validity compared to studies with high response rates.(48) While it is a risk to validity, there may not always be a direct correlation between the two.(48)

Furthermore, the small sample size resulted in the data being unsuitable for exploratory factor analysis. This meant no determination could be made regarding correlations between the ALEQ items and potentially grouping them into common factors and thus potentially reducing the total number of questionnaire items as demonstrated in a previous study.(22) The small sample size also limits the generalisability of the results. The study population was a cohort of paramedicine students at one Australian university. The research should be repeated to include paramedicine students from other universities around Australia and possibly internationally. This would address the issues of generalisability as well as confirm the reliability of the ALEQ in this setting.

A further limitation is the ALEQ does not establish the reasons for the student choices. For example, and as noted in a previous study, statements in the first cluster focused on preferred learning activities and resources. However, it does not explore why particular activities were viewed as effective or how they were used to assist with learning.(22)

CONCLUSION

This study, within the context of its limitations, indicates that the ALEQ was a reliable instrument to investigate the experiences and perceptions of undergraduate paramedicine students towards learning anatomy within their degree. Further research is required across a wider cohort of paramedicine students from other degree programmes to confirm its reliability and allow for the generalisability of the results. Consistent with research from other health professional courses, paramedicine students found that the amount of anatomy to learn was daunting, but this did not negatively impact its perceived relevance or importance to becoming a paramedic. Students reported positive experiences with various delivery methods such as textbooks, online learning and quizzes. Lastly, it was identified that the students felt they would benefit highly from learning with cadavers. Currently, this is not part of the bioscience curriculum for paramedicine students in the BPP. However, it is well demonstrated in the literature that this is an invaluable source of learning, bridging the gap between theory and practice.

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COMPETING INTERESTS

The authors declare no competing interests. Each author has completed the ICMJE conflict of interest statement.

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SUPPLEMENTARY MATERIALS

Table S1. Demographic profile of questionnaire respondents (n = 51)

Demographics	Criteria	n	%
Gender	Male	19	37.3
	Female	32	62.7
Age	18–19	10	19.6
	20–24	19	37.2
	25–29	14	27.4
	30–34	2	3.9
	40+	6	11.7
Education level	Year 12	28	54.9
	VET certificate	8	15.7
	Diploma	5	9.8
	Bachelor's degree	10	19.6
Previous health worker	Yes	5	9.8
	No	46	90.2
Previous anatomy education	Yes	13	25.5
	No	37	72.5
	Unsure	1	2.0

VET: vocational education and training.

Table S2. Overall results from ALEQ cluster 2: learning with cadavers (experiences and feelings about possibly working on cadavers)

Item	Statement	Agree (%)	Neutral (%)	Disagree (%)	Mean	SD (±)
8	I feel working with cadavers would help me to visualise and learn anatomy more effectively.	78.43	19.61	1.96	4.31	0.86
9	I feel working with cadavers would help me to positively address the issue of death.	76.47	19.61	3.94	4.10	0.85
Total		77.45	19.61	2.95	4.20	0.86

SD: standard deviation.

Table S3. Overall results from ALEQ cluster 6: specific to end of final year

Item	Statement	Agree (%)	Neutral (%)	Disagree (%)	Mean	SD (±)
30	I am concerned that my knowledge of anatomy is not good enough to practise safely as a paramedic.	17.39	26.09	56.52	2.75	1.16
31	In hindsight, I would have preferred the anatomy teaching to be more integrated with the paramedic practice units.	56.52	21.74	21.74	3.39	1.08
32	In hindsight, I see very clearly the importance of anatomy which I did not see earlier in the course.	73.91	17.39	8.70	3.75	0.89
Total		49.27	21.74	28.99	3.27	1.25

SD: standard deviation.