Research Article

The role of prelaboratory assignments in the improvement of academic performance and enhancement of intrinsic motivation in human cadaveric anatomy

Abstract

Cadaveric dissection is a core component of teaching in human anatomy. However, students often attend the cadaver laboratory with limited preparation, which detrimentally impacts their learning. The use of pre-laboratory assignments (PLAs) that require students to prepare for a cadaver dissection session has been reported to improve student performance and encourage higher-order understanding of educational material. In the context of active learning, high levels of intrinsic motivation (IM) in students are associated with greater effort, and consequently better overall academic success. However, the maintenance of the IM of students in anatomy is often challenging for educators. This study aimed to explore the role of PLAs in the improvement of academic performance and enhancement of IM in occupational therapy students enrolled in a human anatomy course. One cohort of students were expected to complete PLAs prior to each cadaveric dissection session. The PLAs required students to write a brief anatomical description of each anatomical structure. The control group consisted of students who were not required to complete similar PLAs. Students who were advised to complete PLAs had a higher score on the practical examinations, and enhanced IM as compared to students in the control group. Further, the qualitative responses of students indicated that students perceived PLAs to be useful in the learning of anatomy. Therefore, PLAs are a valuable teaching tool, and represent a crucial element in revitalizing the anatomy curriculum.

Keywords: prelaboratory assignments, human anatomy; academic performance, intrinsic motivation

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Joydeep Dutta Chaudhuri,[1] Venugopal Rao[2]

[1]College of Health and Pharmacy, Husson University, USA
[2]Department of Anatomy, Government Medical College, India

Correspondence: Joydeep Dutta Chaudhuri, College of Health and Pharmacy, Husson University, 1 College Circle, Bangor, Maine, USA, Tel 207 852 8747, Fax 207 973 1061, Email chaudhurij@husson.edu

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Abbreviations: PLAs, pre-laboratory assignments; IM, intrinsic motivation

Introduction

It is universally acknowledged that anatomy is considered a stressful subject by students across all healthcare disciplines.[1,2] This has been attributed to the rigor of the anatomy course and the reliance on declarative memory that involves the storage, and recall of a large volume of facts.[3] Reports also that suggest that while anatomical knowledge is fruitfully acquired by students during the course,[4] it is not adequately retained in their future professional career.[5,6] This has led to universal concerns among educators about the preparedness of students for clinical practice.[1,7]

The attrition of anatomical knowledge in students has been attributed to curricular reforms that are largely driven by constraints of material and manpower resources.[2,4,8] The most striking consequence has been the reduction in the time devoted to human cadaveric dissection.[9,10] This is relevant since cadaveric dissection parallels lecture-based teaching and is a core component of teaching in human anatomy. It allows students to appreciate the natural variations of human structure,[11] improves manual dexterity, and hand-eye coordination[12,13] that is essential for clinical procedures. Additionally, the cognitive process involved in cadaveric dissection requires keen observation skills that enhance the clinical reasoning process.[14] Thus, cadaveric dissection enables students to acquire and practice key manipulative skills,[15] while learning to move concepts from an abstract into a more concrete setting.[2,7,16] In addition, human cadaveric dissection represents the first formal contact of students with the healthcare profession.[17] This experience has been reported to help students to appreciate the vulnerability of human life and inculcate a sense of care and responsibility that is essential for good healthcare practice.[13,18] This underscores the necessity to maximize the utilization of the unique learning opportunities presented by cadaveric dissection.

The cadaver laboratory is a complex learning environment that requires students to recall and conceptualize large volumes of information in a short time.[5,19] This imposes a considerable cognitive load on students since anatomy is codified in a specialized language that requires the performance of a large number of tasks.[20,21] This cognitive load can inhibit learning and prevent students from discerning the learning expectations of the course.[5] In addition, the logistics of organizing cadaveric dissection for a large numbers of students makes it challenging for educators to ensure that the content being offered in lectures directly aligns to the dissection being carried out.[13,22]

Further, considering the increasingly dense healthcare curricula, students are burdened with the expectation of learning an exceedingly large amount of anatomical content in a limited period of time.[23] However, while cadaveric dissection immensely facilitates the comprehension of the complex anatomy of the human body, it consumes a considerable of time and resources.[5,24,25] Therefore, students often enter the laboratory with limited preparation, with detrimentally impacts learning outcomes.[10,12,26,27]

Thus, there is considerable conflict between time spent by students on preparation for cadaveric dissection and the actual time devoted to learning through cadaveric dissection.[26,28] Therefore, it is suggested that while students are able to recognize the usefulness of cadaveric dissection sessions in learning anatomy, many find its time-consuming nature to outweigh its benefits.[1,25,28] Further, the default preparation for cadaveric dissection has typically been a brief oral presentation of theoretical knowledge just prior to commencement of the dissection.[11,24] Hence, the onus is often on students to prepare for cadaveric dissection based on the content that has been covered in the lectures.[9,29] Therefore, many students report having difficulty in identifying the aims and expectations of the cadaveric dissection sessions.

Thus, an effective way to reduce this cognitive load and increase meaningful learning in students is through adequate preparation for cadaveric dissection.[30] The use of pre-laboratory assignments (PLA) that encourage students to prepare for a practical session are a commonly used teaching technique in biology,[31,32] technology,[15] engineering[33] and mathematics.[34,35] The creation of appropriate PLAs has been reported to reduce the preparation time[36,37] and increase the opportunities for active learning[17] in students. Further, completion of PLAs have been observed to encourage higher-order thinking,[12,28] and reduce the achievement gap between advantaged and disadvantaged students. Finally, since the anatomy course is typically offered in first year of a professional healthcare program, most students have limited experience with tertiary learning.[35,38] Therefore, the provision of PLAs represent a useful preparatory resource in anatomy learning.

In the context of encouraging active learning, the role of intrinsic motivation (IM) is particularly important.[23,39] The term IM involves the engagement in learning opportunities because they are seen as enjoyable and interesting.[40] As a result, high levels of IM are associated with greater effort,[12,26] improved memory,[2,7] and consequently better overall academic performance.[1,13] Further, motivation has been intimately linked to metacognition, which refers to an individual's awareness[36] and critical analysis of their own thought processes[21] and cognitive ability.[26] However, one of the most challenging issues that anatomy educators encounter is in the maintenance of the motivation of their students to remain engaged in the construction of their knowledge.[7,11,25] Further, since the development of motivation in students represents a continuum from a motivation to motivation[22,27] it is consequently malleable during the progression of the course.[12] Therefore, PLAs offer the opportunity to provide a disciplined approach that allows students to shift their focus from memorization of content to the development of IM to achieve the desired outcomes.

Considering that this study was carried out in occupational therapy students, a brief overview of the role of the anatomy in their curriculum is presented. The practice of occupational therapy enables clients to eliminate or minimize the barriers that interfere with their ability to perform tasks of self-care, and productive and leisurely activities.[17] Anatomy education in the occupational therapy program in this institution is integrated into the 1st year occupational therapy curriculum, along with other occupational therapy specific courses. The anatomy course aims to provide relevant knowledge of the structure of the human body, and success in anatomy in the occupational therapy program requires the same degree of effort as in other healthcare programs.[19] Further, anatomy knowledge in occupational therapy is tested in the same rigorous manner.[3,8] In addition studies have reported that all students enrolled in an anatomy course, regardless of their discipline, have similar learning preferences.[1,20,26] Therefore, data generated from studies on occupational therapy students can be extrapolated to the overall practice of teaching anatomy across all healthcare disciplines.

Aim

The impact of some instructional approaches in the teaching of anatomy have been tested empirically, However, accurate comparisons are hindered by the confounding effects of concurrent multiple approaches that have been adopted in these studies.[3,13,17] Therefore, this study aimed to analyze the effectiveness of PLAs as a single learning support tool for a human cadaveric dissection based anatomy course. It is hypothesized that the introduction of PLAs will complement cognitive learning, augment academic outcomes and enhance IM in students.

Material and methods

Study participants

The study was carried out over two successive years in 1st year professional graduate students enrolled in an occupational therapy program. It included 44 and 39 students in cohorts 1 and 2 respectively. All the students admitted to the program had met the required admission standards set by the university, and permission to conduct the study was obtained from the Institutional Review Board of the university (Protocol # 18OT01). Since the study was anonymous, it was deemed that no harm could arise to respondents from this study. The option to participate in this study was offered to all students. Informed written consent was obtained from students, and it was explicitly stated that they had the option of withdrawing from the study without any detriment to their grades. The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Learning environment in anatomy

The anatomy course in both cohorts, was taught for 16 weeks through a combination of lectures and human cadaveric dissection based practical classes. All the lectures in both cohorts were delivered by the investigator of the] study. The cadaveric dissections in both cohorts were also conducted by the investigator of the study along with another faculty member.

In both cohorts the instructional material was delivered through PowerPoint based lectures that were delivered twice a week. All students were provided with written notes before the start of each lecture. The lectures preceded the cadaveric dissection and so relevant information had already been provided to student commencing dissection.

The cadaveric dissection was also organized twice a week in both cohorts. Students in cohort 1 were instructed to refer to the Grant's Dissector[11] for specific directions during cadaveric dissection. The students in cohort 2 were also asked to refer to the Grant's Dissector[11] for specific directions during cadaveric dissection. In addition, these students were required to complete PLAs that closely aligned with relevant lecture topics for each cadaveric dissection session. The PLAs consisted of a list of structures that students were expected to dissect and identify during the dissection session. As part of the PLAs, students were asked to write a brief description of the anatomical location of those structures before commencing dissection, and a sample of an expected student response is provided in Table 1. All students were expected to hand the PLAs to the researcher before the commencement of the dissection session, and a record was maintained of how many students completed their PLAs.

Table 1 Expected responses of prelaboratory assignments related to upper and lower extremity cadaveric dissection session

Sl. no	Structure	Identification features
1	Brachioradialis muscle	Located on the lateral side of the forearm, superficial to the Extensor carpi radialis longus and Extensor carpi radialis brevis muscles
2	Brachial artery	Located on the ventral aspect of the cubital fossa
3	Femoral nerve	Located lateral to Psoas major muscle

Assessment of learning outcomes

The anatomical knowledge of students was assessed by three multiple choice question examinations (MCQs) and practical (bellringer) examinations. The MCQs constituted 80% of the course, while the practical examinations comprised the remaining 20% of the course.

The MCQ format of assessment was chosen because of the opportunity to reliably and accurately examine a large number of students with minimal resources (Mitchell et al. 2018). The MCQ questions were based on the material that was covered in the lectures, and the MCQ exam was modelled on the Blooming Anatomy Tool.[41] Hence, it consisted of lower order questions related to recall of anatomical structures, and higher order questions that required students to interpret, judge, or analyze clinical vignettes. The examinations were designed to accurately and consistently align with the learning objectives of the course. Each MCQ had a detailed and unambiguous question, and four answer options from which the student was required to select only the most appropriate answer. The answer options followed grammatically and logically from the main stem, were plausible and lay on a continuum of least correct to most correct. All negatively phrased MCQs were avoided since they required students to switch from identifying the correct option to looking for the wrong option, and hence did not mimic typical clinical reasoning.[19] Based on accepted literature, the MCQ examinations were designed to have an overall p-value of item difficulty between 0.3-0.8.[14] The MCQs were also designed to have an appropriate Point Biserial Index (PBI) of 0.4-0.7 to enable accurate item discrimination,[21,29] and a Kuder-Richardson Formula 20 score (KR-20) of above 0.5 as an indicator of the reliability of a test with binary variables.[17] The MCQs in this course were delivered through the legacy portal of ExamSoft student assessment software (Examplify), version 2.1.0. (ExamSoft Worldwide Inc., Dallas, TX).

The practical examinations were organized according to the traditional format utilized in anatomy. Therefore, they required active recall of knowledge[25] and avoided the phenomenon of cueing.[17,19] Students were required to identify well dissected individual structures only by observation within a limited of one minute for each structure. In alignment with the requirements of the occupational therapy program students were only required to identify muscles, ligaments, arteries, veins and nerves from well dissected cadaveric specimens.[6,13]

The first examination was held on week 6 and was focused only on the upper extremity. It included 50 MCQs (Exam-1), and the practical examination (Cad Exam-1) required students to identify 30 anatomical structures on dissected human cadavers. The second examination was held on week 11, and while the main focus was on the lower extremity it also included material from the upper extremity. Therefore, the second examination (Exam-2) included 40 MCQs from the lower extremity and ten MCQs from the upper extremity. The practical examination associated with this unit (Cad Exam-2) required students to identify 25 anatomical structures in the lower extremity and five structures in the upper extremity. The final examination was held on week 16, and focused predominantly on the thorax, abdomen, back, pelvis, face and neck regions though it also included material from the upper and lower extremities. In keeping with the same format, the final examination (Exam-final) consisted of 50 MCQs of which 30 MCQs were from the new material that had been taught, and ten MCQs each from the upper and lower extremities. The final practical examination (Cad Exam-final) required students to identify 20 anatomical structures in the thorax, abdomen, back, perineum, pelvis, face and neck regions, and five structures each from the upper and lower extremities.

The same format of assessment of student learning was used in cohorts 1 and 2, and all the examinations had similar psychometric values. There were no significant differences ($p>0.05$) in the p-value of item difficulty, PBI and KR-20 scores in all the examinations, implying that the methods of assessment of learning were comparable in both cohorts of students.[11,13]

Survey instrument

A modified survey questionnaire was designed from an amalgamation of questions utilized in previously published studies.[2,41] The survey questionnaires were administered on weeks 5, 10 and 15, and were one week prior to the examinations.

The first questionnaire was administered to all students in cohorts 1 and 2 at week five. The first part of the questionnaire collected demographic information of participants. Students were instructed to avoid including any personal details, so that the responses remained anonymous. The second part of the survey was designed to measure the IM of students using the Post-Experimental Intrinsic Motivation Inventory (IMI) which is accessible online at http://www.selfdeterminationtheory.org. It is a valid and reliable multidimensional inventory of questions that is intended to measure the overall subjective experience of a participant towards a particular activity. The validity (Mitchell et al. 2018) and reliability[16] of these questions in the measurement of IM have been firmly established. The overall IM of students was measured through questions that were chosen from the IMI and assessed the interest/enjoyment, competence, and effort put into learning anatomy through cadaveric dissection. It also assessed the perceived usefulness and tension associated with cadaveric dissection. The questionnaire consisted of two statements each of the individual parameters stated above, and questions were randomly arranged. The students were asked to rank each statement based on a five-point Likert scale where 1=strongly disagree, 2=disagree, 3=undecided, 4=agree, 5=strongly agree.

The second questionnaire was administered to both cohorts on week 10. It only consisted of the same questions related to assessments of IM of students that were included in questionnaire 1.

The third questionnaire was administered on week 15, and was designed to measure the IM of students and assess the perceived utility of PLAs in the learning of anatomy. It also consisted of the same questions for assessment of IM as in questionnaires 1 and 2.

In addition, opportunity was provided to students to express their opinion of the utility of the PLAs in learning anatomy. The open-ended comments of students were collated, and a thematic evaluation was performed as described by Braun & Clarke[31] The responses were coded using an open approach,[11,22] and initial themes were identified and further grouped to construct relevant subthemes.

The questionnaires were only considered valid if at least 80% of the questions were answered by students. The reliability of the survey instrument was assessed by Cronbach's alpha coefficient, and values greater than 0.7 were considered reliable.[10,28]

Data analysis

All categorical data are reported as frequencies and percentages, while continuous data are described by their mean value and standard deviation. The age and gender distribution of the participants in both cohorts were compared using the one-way analysis of variance (ANOVA), and the Chi-square test respectively. The scores of the MCQs and practical examinations met the assumption of normality ($p<0.050$), as determined by the Shapiro-Wilk test for normal distribution. The means of examination scores of the three cohorts were compared using ANOVA, and the Tukey's test was used to determine the significant differences between groups. As a measure of effect size, Cohen's d was calculated with a value around 0.2 indicating a small effect, 0.5 a medium, and 0.8 a strong effect size (Cohen, 1988). The five point Likert scales responses for the questions and statements had acceptable internal consistency and validity,[4] as assessed by the Kendall's tau B correlation coefficient and Cronbach's alpha tests. All quantitative analysis of data were carried out using the Statistical Package for the Social Sciences (SPSS), version 26.0 (IBM Corp., Armonk, NY).

Results

Study participants

The average age of the students in cohort 1 and cohort 2 were 23. 99 ±1.54 and 24.01±1.46 years respectively. The proportion of females in cohorts 1, and 2 were 90.91% (n=40) and 90.91% (n=36) respectively. There was no significant difference (p=0.071) in the demographic characteristics of students in the two cohorts. The students in cohorts 1 were not provided with PLAs, and constituted the control group, while students in cohort 2 were required to complete PLAs.

At week five, only 36.59% (n=15) of students in cohort 2 had completed the PLAs assigned to the cadaveric dissection. The completion of PLAs by students increased to 75.61% (n=31) at week ten, and by the conclusion of the course (week 15) 92.68% (n=38) of students had completed the relevant PLAs.

Learning outcomes of students

All the MCQs and practical examinations were valid and reliable indicators of student learning. There were no significant differences ($p>0.050$) in any psychometric values among the examinations administered to cohorts 1 and 2. The mean p-value of item difficulty, PBI, and the KR-20 values for the MCQ and practical examinations have been deemed acceptable for examiner generated assessments in anatomy.[22,29]

Overall, there were no differences in the scores for the MCQ examinations between the two cohorts. However, the scores for the practical examinations were higher in cohort 2 as compared to cohort 1 (Figure 1).

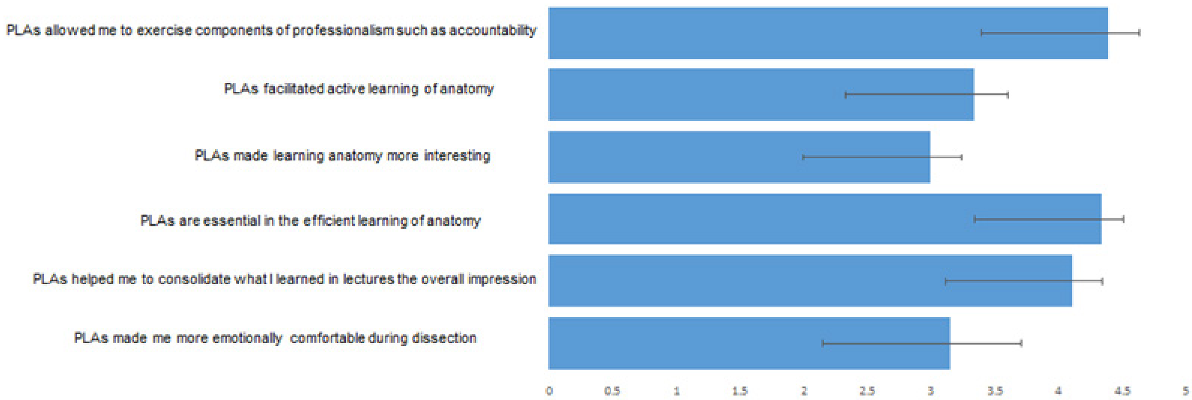

Figure 1 The perceptions of students in Cohort 2 (n=41) of the utility of PLAs in the learning of anatomy. A Likert scale of 1-5, on a continuum from strongly agree / agree / do not know / disagree / strongly disagree was used.

At week 6, there was no significant difference (p=0.078) in MCQ scores between the two cohorts of students. The MCQ scores in week 6 in cohorts 1 and 2 were 81.53±3.73 and 81.99±4.01 respectively. However, there was a significant difference (p=0.033; effect size: 0.815) in the concurrent practical examination scores in cohorts 1 and 2. The scores were 78.58±5.19 and 82.17±4.18 in cohorts 1 and 2 respectively.

At week 11, there was no significant difference (p=0.084) in MCQ scores between the two cohorts of students. The MCQ scores in cohorts 1 and 2 were 85.01±3.32 and 84.25±3.56 respectively. There was, however, a significant difference in the practical examination scores between the two cohorts (p=0.018; effect size: 0.801). The scores in in cohorts 1 and 2 were 82.95±4.21 and 86.29±4.99.

At week 16 also, there was no significant difference (p=0.069) in MCQ scores between the two cohorts of students. The MCQ scores in week 16 in cohorts 1 and 2 were 85.84±3.32 and 86.01±3.56 respectively. There was still a significant difference in the practical examination scores between the two cohorts (p=0.038; effect size: 0.796). The practical examination scores in week 16 in cohorts 1 and 2 were 87.13±4.89 and 90.09±4.05. (p=0.031; effect size: 0.803)

Intrinsic motivation of students

The students in cohort 2, who had completed the PLAs were more intrinsically motivated than their counterparts in cohort 1 (Figure 2).

On week 5, the scores for IM were significantly higher (p=0.036; effect size: 0.792) in students in cohort 2 than in cohorts 1. The scores for IM in cohorts 1 and 2 were 2.34±0.11 and 3.08±0.13 respectively. On week 11, the scores for IM continued to be significantly higher (p=0.038; effect size: 0.713) in students in cohort 2 as compared to those in cohort 1. The scores for cohorts 1, and 2 were, 2.99±0.24 and 3.56±0.19 respectively. On week 15, the scores remained significantly higher (p=0.041; effect size: 0.741) in cohort 2 as compared to cohort 1. The scores for IM for cohorts 1 and 2 were 3.12±0.26 and 3.77±0.26 were respectively.

Perception of students about prelaboratory assignments

The results of questions included in the questionnaire are presented in Figure 3 as mean ± standard deviation for each statement based on a Likert scale of 1-5, on a continuum from strongly agree / agree / do not know / disagree / strongly disagree. The majority of students in cohort 2 agreed that PLAs facilitated active learning, helped to consolidate the knowledge acquired through lectures and significantly mitigated the time-consuming nature of cadaveric dissection. Students also stated that PLAs allowed them to exercise components of professionalism such as accountability (4.39±0.24), and facilitated active learning of anatomy (3.33±0.27). In addition, PLAs made learning anatomy more interesting (2.99±0.25), were essential in the efficient learning of anatomy (4.34±0.17) and helped to consolidate what they learned in lectures (4.11±0.23). Finally, PLAs made them more emotionally comfortable during dissection (3.15±0.55).

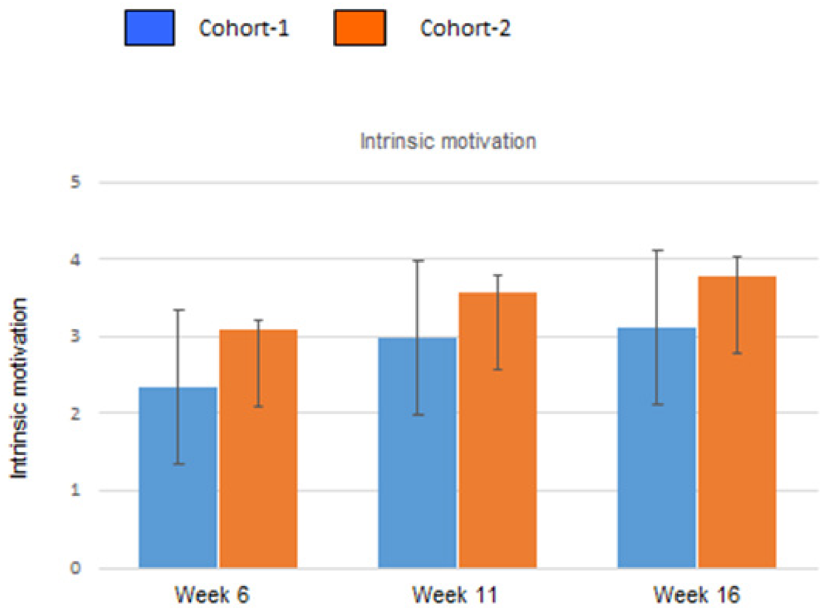

Figure 2 Academic outcome of students.

Footnote: Percentage scores in the MCQ and practical (bellringer) examinations held at weeks 6, 11 and 16 of students in cohort 1 (n=43) and cohort 2 (n=41). Results are presented as percentage mean values ± standard deviation (error bars). Each color represents a different cohort of students.

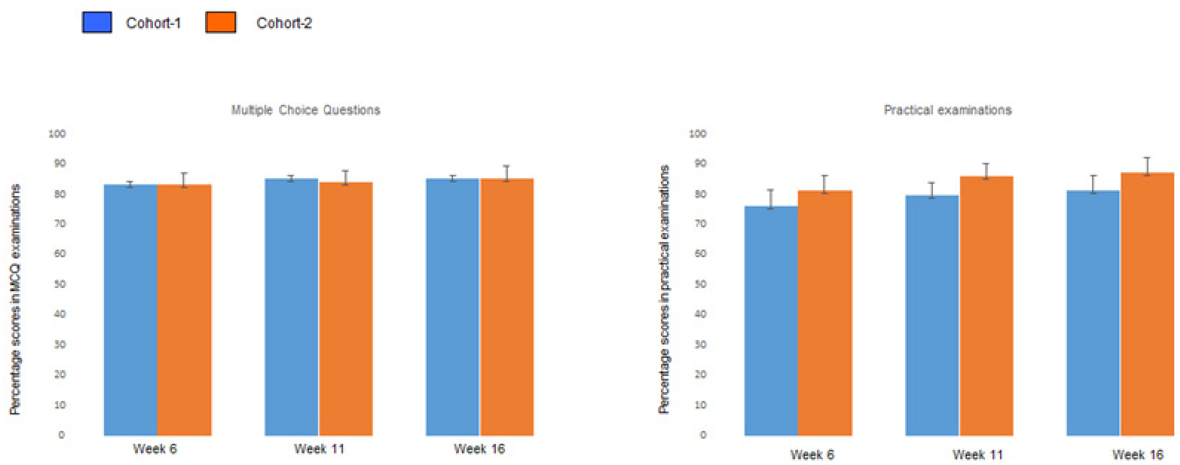

Figure 3 Intrinsic motivation of students

Footnote: The intrinsic motivation for cadaveric dissection in students in in cohort 1 (n=43) and cohort 2 (n=41) on weeks 6, 11, and 16. The intrinsic motivation was evaluated on a five-point Likert scale, where 1=strongly disagree, 2=disagree, 3=undecided, 4=agree, 5=strongly agree. All values are expressed as mean values ± standard deviation (error bar).

A total of 31 open-ended comments from students were analyzed, and organized into the following themes and subthemes. The major themes which emerged were that PLAs provided useful instructions in preparation for cadaveric dissection, and assisted in learning anatomy.

Theme 1: PLAs provided succinct goals and instructions for cadaveric dissection.

i. **Subtheme 1:** students reported that PLAs were extremely useful in providing accurate directions for cadaveric dissection. A few sample comments are included.
   - "It gave me a better idea of what to do during dissection"
   - "PLAs helped me to locate the structures during cadaveric dissection"

ii. **Subtheme 2:** students recognized the value of the goals and learning outcomes that were provided through the PLAs. A few comments include:
   - "By completing the PLAs I knew what I should learn from cadaveric dissection
   - "The PLAs helped me to complete the learning objective for cadaveric session"

Theme 2: PLAs assisted in learning anatomy.

i. **Subtheme 1:** majority of the students felt that PLAs helped in the memorization of anatomical information that was necessary to succeed in anatomy. A few exemplars are included.
   - "The origins and insertions of muscles were easy to remember after completing the PLAs"
   - "It helped me to memorize the structures on a cadaver"

ii. **Subtheme 2:** students also highlighted that PLAs provided the motivation to acquire and apply anatomical knowledge. A few comments of students included:
   - "The PLAs helped me to understand how anatomical structures are located and how they function"
   - "They were useful study aids for understanding the functions of a particular part and relate it to clinical cases"

iii. **Subtheme 3:** students felt that the provision of PLAs reduced the insecurity related to preparation for anatomy exams. A few comments include:
   - "Completing PLAs helped me study the muscles, arteries, veins and nerves for examinations.
   - "The PLAs definitely reduced my stress about taking the anatomy exams,"

In summary, students who were advised to complete PLAs had a higher score on the bellringer examination, and enhanced IM as compared to students who were not required to complete the PLAs. However, no changes in scores in the MCQ examination were observed in this cohort of students. The open-ended responses indicated that students found PLAs to be useful in learning anatomy through cadaveric dissection.

Discussion

Based on the results of this study, students who completed their PLAs demonstrated better academic performance and higher IM. Thus, PLAs can address one of the pedagogical challenges of meaningful engagement in this learning experience. Therefore, PLAs can assist in overcoming the major barriers of the time-consuming nature and lack of specific objectives of cadaveric dissection.

Extent of use of prelaboratory assignments (PLAs) by students

Despite the early uncertainties, a majority of students completed their PLAs on schedule, and their participation increased through the progression of the course. This is relevant since the completion of PLAs was not mandatory and there were no assigned grades. This rebuts previous studies which have contended that students will consider completing PLAs only if they are associated activities that contribute to their grades.[41,42] Therefore, the propensity of students to complete PLAs attests to the fact that students were able to recognize the inherent value of PLAs in the learning of anatomy.

In the context of completion of PLAs, there is universal consensus that the provision of choice to students in learning methods is a strong motivator of IM.[43] Hence, considering the preferences of current generation of healthcare students[7,41] it is suggested that the completion of PLAs should be voluntary, though students should be encouraged to complete PLAs on schedule. Therefore, PLAs can provide an autonomy-supportive environment of students that can enhance their intellectual meta-levels of thinking.

Role of prelaboratory assignments (PLAs) in the improvement of academic performance and intrinsic motivation of students. The results of this study indicated that students who had completed PLAs demonstrated positive changes in their academic performance and IM. Further, the performance in the MCQs and practical examination improved as the course progressed and was associated with the increasing participation of PLAs.

This is relevant since cadaveric sessions may not be synchronous with the corresponding lectures.[44,45] Therefore, considering the constraints of resources and the cognitive load on students,[46,47] PLAs should be actively considered as a teaching tool in human anatomy. Therefore, PLAs can assist in maximizing the preparation that can be feasibly achieved by students before cadaveric dissection.

However, while the completion of PLAs improved performance in the practical examination, it did not significantly impact the results of the MCQ examination. It is speculated that since success in the MCQ examination is dependent on textual information,[23,48] it does not require extensive visual or spatial[23,29] abilities. Therefore, it is possible that the beneficial effects of PLAs could have been undermined, due to the greater reliance on factual information,[49,50] and guessing strategies[11,32] of MCQ examinations.

It is encouraging that the improvement in academic grades paralleled the enhanced IM in students who were encouraged to complete the PLAs. This is relevant as the key aim of any teaching endeavor is the augmentation of the IM of students.[51] Therefore, the development of IM is often considered a popular proxy for the assessment of teaching strategies in students.[23,25,52] Further, the development of IM in healthcare students has been reported to persist beyond the learning of anatomy[12] and extend into their professional career.[12,26]

Designing of prelaboratory assignments (PLAs)

The results of this study have demonstrated the utility of PLAs in assisting students in learning anatomy. However, their success is heavily dependent on effective design, and requires careful consideration of prior knowledge[1,26] and experience[53] of students. Thus, PLAs need to be designed as carefully as lectures (since one is naturally reliant on the other.[27] Therefore, PLAs should clearly delineate the learning objectives that are supported by an achievement plan to attain that goal.[7,21] An elaborate discussion regarding the designing of PLAs is beyond the scope of this article, and hence a few suggestions have been presented in the succeeding sections.

The primary aim of PLAs should be to provide procedural information during cadaveric dissection since students acquire knowledge more productively through guided instruction, rather than discovery-based learning.[23,54] Therefore, PLAs should aim to reduce the incompatibility between lectures and the expected learning outcomes of cadaveric dissection. Consequently, PLAs should include the simplest possible representation of anatomical information and demonstrate how it fits within the context of cadaveric dissection.

While paper based PLAs were used in this study, considering the preferences of current students,[3,33,41] PLAs can also be completed using computer aided instructions. These technological tools can offer more pragmatic alternatives for diverse learning modalities.[5,55] The aim should be to present complex information in a simplified manner and should not be counterproductive to learning. In this context, reports suggest that static images are preferable to moving images because they allow greater attention to detail,[27] and are particularly useful in the elucidation of the complex anatomical relationships.[31] Consequently, PLAs should incorporate a sequence of annotated illustrations that depict the steps of dissection with a minimal amount of text,[22,54] and limited technological gimmicks. The ultimate aim of computer based PLAs should be to address the cognitive, affective and psychomotor domains of learning in a self-directed manner.

Prelaboratory assignments (PLAs) need to demonstrate their inherent benefits

In addition, PLAs should focus on providing scalable[26] and sustainable skills in students.[13] They should utilize active learning techniques that provide milestones that students can use to measure their performance[31] and competence.[55] The utility of PLAs, is dependent on appropriate assessments that provide students the opportunity to demonstrate their understanding of the course content.[19,29] Thus, assessments are considered as important determinants of the efficacy of teaching methods.[5,31] In addition, PLAs should be supported by positive attributions associated with attaining the learning goal.[56] The details of various designs of assessments in anatomy are beyond the scope of this article. However, an ideal assessment should ostensibly approximate performance in the real world while remaining within the limitations of standardized test-taking conditions.

Prelaboratory assignments (PLAs) in the curriculum

Considering the utility of PLAs, it is essential to coordinate the placements of lectures and PLAs in the curriculum to blur the distinction between them and explicitly demonstrate their connections.[17,22,29] This will enable students to recognize the inherent value of PLAs and not consider it as another adjunct to their learning.[11] This will also encourage students to devote more time towards the completion of PLAs in preparation for cadaveric dissection and ensure that novice dissectors are equipped with adequate skills.[23,57]

Prelaboratory assignments (PLAs) with more supportive information

Research has established that students learn anatomy by a combination of memorization[17,19] and visualization[31,39] of information. Thus, PLAs need to be supplemented by appropriate information towards the creation a mental image of anatomical structures.[37] The aim should be to support the concept of a spiral curriculum where knowledge is presented from simple to complex in a logical sequence. Thus, there should an iterative revisiting of topics, subjects or themes throughout the anatomy course so that each successive cadaveric session builds on the previous one.[17,40] This opportunity is available through repositories of digital representations for the deconstruction and contextualization[35] of anatomical structures. These computer aided instructions can support individualized learning and provide accessible information at the point-of-need,[58] and at a pace[19] and timing[20,38,40] that is preferable to students. Thus, the integration and effectiveness of computer aided instructions will allay the cost[2,7] and improve access[11,13] to anatomical information.

In summary, human cadaveric dissection must adapt to retain its position as the cornerstone of the anatomy curriculum. Thus, PLAs need to extend beyond an encouragement for students to prepare cadaveric dissection, to drawing the attention of students develop strategies for the study of anatomy. Therefore, PLAs should address the ultimate pedagogical aims of the enhancement of cognitive,[59] psychomotor[53] and affective[51] domains of learning.

Future directions

Since the study only included students from a single healthcare program, a larger and more diverse cohort of students from different institutions will yield greater representative data. Further since the vast majority of the students in this study were female, gender differences in in academic performance and could not be analyzed. This is relevant since gender differences in the academic performance[1,11,21,60] have been reported in healthcare students. Hence, more targeted multi-institutional research is warranted to assess the impact of anatomy pedagogies in preparing students for clinical practice.

Moreover, due to the design of the study it could not be determined if students had utilized other methods of preparation for cadaveric dissection. In addition, enough time has not elapsed to empirically evaluate the impact of PLAs on the long-term retention of anatomical knowledge and motivation. Hence, it cannot be conclusively establish if the incorporation of PLAs can yield the intended long-term effects on healthcare education. Therefore, protracted research is necessary to address some of these identified gaps in knowledge. However, while the results of the study cannot be generalized beyond their specific study setting, they nevertheless provide in-depth perspectives of the role of PLAs in anatomy education.

Conclusion

The results have demonstrated that PLAs are an active exploratory learning approach in anatomy. Consequently, they should be considered as an opportunity to augment academic performance and nurture the development of IM by addressing the needs of purpose, autonomy, relatedness, and competence. They should be based on the cybernetic cycle of behavior that is modulated by the available educational resources. Hence, it needs to be recognized that the role of the educator has shifted from a gatekeeper to a facilitator and arbiter of knowledge.[21,26] Therefore, educators should explore options to incorporate various forms of preparation for cadaveric dissection since the evaluation of instructional innovations must be an integral part of research in healthcare education.

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Conflicts of interest

The authors declare there are no conflicts of interest.

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