HOW WE TEACH | Classroom and Laboratory Research Projects

An anatomy workshop for improving anatomy self-efficacy and competency when transitioning into a problem-based learning, Doctor of Physical Therapy program

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Bains M, Kaliski DZ. An anatomy workshop for improving anatomy self-efficacy and competency when transitioning into a problem-based learning, Doctor of Physical Therapy program. Adv Physiol Educ 44: 39–49, 2020; doi:10.1152/advan.00048.2019.—First-year Doctor of Physical Therapy (DPT) students entering a problem-based learning (PBL) program are faced with a number of pedagogical challenges, including the development of self-directed learning skills, resource unfamiliarity, and group dynamics. These challenges can make learning anatomy in a self-directed manner less efficient. Prematriculation introduction of strategies to improve anatomy learning may help prepare students for a rigorous DPT program and improve anatomy learning efficiency. The present study describes a 2-day anatomy workshop offered to incoming students before a DPT program was initiated. Knowledge acquired during both days of the workshop resulted in statistically significant improvements in anatomy postquiz scores for each corresponding prequiz (P < 0.001 for lower and upper limb quizzes). Workshop participants survey responses demonstrated that anatomy confidence and PBL preparedness increased at distinct intervals following the workshop and was significantly higher than controls after the first semester (P < 0.01 for anatomy confidence and PBL preparedness). Multivariate regression analyses demonstrated statistically significant relationships between semester anatomy practical scores and workshop participation (P = 0.03 for practical 1 and P = 0.049 for practical 2) and undergraduate grade point average (P < 0.001 for practical 1 and P = 0.03 for practical 2). First-year DPT students reported the anatomy workshop to be a valuable experience for learning strategies to improve anatomy self-efficacy. An introductory anatomy workshop is an effective strategy to improve self-directed anatomy learning efficiency before the start of a rigorous DPT program.

anatomy; learning efficiency; physical therapy education; problem-based learning

INTRODUCTION

Integral to a Doctor of Physical Therapy (DPT) curriculum is the integration of anatomy comprehension with the clinical reasoning process, to drive best clinical decision-making and patient practices. Anatomy can be a challenging subject to learn beyond the surface level memorization and mnemonic centered approach that has traditionally been the pedagogical standard of learning. Various forms of learner-centered, problem- and team-based graduate curricula design have recently been adopted for promoting higher order critical thinking and reasoning skills (16). Problem-based learning (PBL), for example, utilizes a self-directed learning approach that integrates core courses using clinical patient cases as problems and small-group-created learning objectives to facilitate self-directed learning (28). These changes in curricula design have also impacted the anatomical sciences with less anatomy lecture, increased independent study and access to virtual anatomy resources, and increased focused on application (8–10, 18, 31). Despite these modern advances, depth and retention of anatomical knowledge in health professional graduate programs, even with recent pedagogical changes remain a challenge (12, 29, 35).

PBL, which was founded at McMaster University in Hamilton, Ontario, Canada, is a pedagogy rooted in self-directed learning in which small-group analyses of clinical cases drives the curriculum (20). The model was first implemented in a medical curriculum and has since been reproduced across various disciplines beyond the professional health sciences (16). The University of the Incarnate Word (UIW), School of Physical Therapy, is a PBL DPT program modeled after the original McMaster University PBL paradigm. Using the PBL model, traditional lectures are replaced with large- and small-group discussions, student-led demonstrations, content-related class activities, preclass readiness assignments, online modules, and article discussions. The curriculum includes a mix of both self-regulated and self-directed learning, with the goal to produce self-directed lifelong learners. The foundational sciences, including anatomy, physiology, pathophysiology, radiology, and pharmacology, are integrated within the semester clinical cases, and the content is facilitated simultaneously as the learners work through each case. The theory follows that presentation of basic science through clinical cases facilitates the linkage of the foundational sciences with clinical application and at the same time promotes clinical reasoning that is reflective of clinical practice (3, 20, 21). Furthermore, connecting basic science with application may allow for the early development of problem-solving skills during the didactic curriculum, which are skills typically gained during clinical rotations (3).

From the standpoint of the facilitator, the self-regulated learning environment requires appropriate course structuring and integration to ensure the translation of the anatomical sciences to clinical application (3). To foster the development of self-directed learning, students in PBL-programs are pro-
vided access to numerous anatomical resources [virtual resources, interactive three-dimensional (3D) models, video atlases] and learning materials in various forms to meet their learning goals. However, students often do not take advantage of the available resources, relying solely on their required textbooks, either because they do not have the time to access additional aides, and/or they are not efficient in utilizing multiple resources (3). Some established challenges that constrain application of anatomy to clinical reasoning include the timing of anatomical instruction as well as anatomy resource familiarity to allow for content synthesis and mastery before clinical skills practice (3, 14). Taking into account the need for time to allow for anatomy synthesis with other previously reported distractions to student learning in a PBL program (overabundance of resources, content relevance, group dynamics), it becomes evident that the efficiency of anatomy learning may become easily constrained if not appropriately introduced (3, 14, 26, 28).

Transition programs, similarly referred to as bridging programs, boot camps, and/or workshops, are developed to help transition a student from one learning environment to another. The need for such programs exists for a variety of reasons, including improving self-efficacy, reducing stress, providing resource familiarity, reducing student turnover rates, etc. Although there is vast evidence demonstrating the impact of summer university bridging programs tailored to persons with disabilities, at-risk students, minorities, and first-generation students (15, 30, 36), evidence of pregraduate preparatory transition to rigorous physical therapy professional programs is lacking.

The available evidence indicates that pre- and postprofessional transition programs hold value in the areas of improving confidence and promoting academic success. Boelen and Kenny (4) evaluated the impact of a 5-day anatomy-physiology and chemistry bridging course aimed at developing learning strategies, providing resource familiarity, and reducing stress for individuals transitioning between nursing degrees. Exposure to learning strategies before initiating the nursing program gave students an opportunity to reflect on how they learn best, and postcourse surveys identified statistically significant increases in confidence in the areas of “return to study,” “anatomy,” “physiology,” and “chemistry” (4). Programs designed to improve student confidence when transitioning between academic careers also demonstrate increased confidence, as well as clinical skills performance. A 5-day medical student boot camp aimed at transitioning students to surgical internships was developed based on surgical attendee and surgeon feedback and included both didactic content review and skills application practice (23). Following the boot camp, student survey responses demonstrated increased confidence levels in 18 of 19 skills reviewed. When confidence levels were compared with the control group (students not enrolled in the boot camp course) at a 6-mo internship follow-up, boot camp participants demonstrated increased confidence levels in cricothyroidotomy and chest tube skills, with a trend of greater confidence in the majority of the remaining skills surveyed (23). Finally, similar results were reported in a 5-day anatomy course for senior medical students designed specifically to practice intern level surgical procedures on cadavers (32). Following the short course, self-reported skill confidence and skill competency, assessed by daily knowledge pre- and post-

tests, were significantly increased compared with baseline. Anxiety levels following the course were significantly decreased (32). Collectively, these programs demonstrated a resourceful method to increase confidence, reduce stress, and facilitate the development of learning strategies and/or improving skills competency (4, 23, 32).

As physical therapist education programs shift toward non-didactic methods, new expectations of self-directed anatomy learning may overwhelm students who have otherwise depended on traditional lecture methods for anatomy instruction. Furthermore, students are less likely to appropriately utilize multiple available resources without the opportunity to familiarize themselves with them before the start of a rigorous graduate program. Improving anatomy learning efficiency and self-efficacy may require restructuring of the timing of anatomy instruction as well as better methods to deliver and introduce the available anatomical resources to students. An introductory anatomy workshop, similar to a university transition program, offered to students before the start of the rigorous DPT curriculum, may be an effective method to address the challenges of time constraints, resource overburden, and early cognitive overload. The purpose of this study was to assess the impact of a 2-day, introductory anatomy workshop before the start of a DPT program on 1) student perceptions of anatomy confidence and anatomy learning preparedness in a PBL program; 2) anatomy knowledge acquisition during the workshop; and 3) anatomy competency during the first semester of a DPT program.

METHODS

Participants and Setting

This study was completed over the course of 2 consecutive yr at the UIW, School of Physical Therapy, DPT program. The 2-day anatomy workshop was offered in August of 2017 and 2018 to first-year DPT students. Incoming students were invited to participate via e-mail in a 2-day prematriculation anatomy workshop held the weekend before orientation week. The e-mail described both the study objectives and the objectives of the anatomy workshop and provided site investigators’ contact information. In 2017, 20 students participated in the workshop, and in 2018, 24 students participated, for a total of 44 in the intervention group. Three participants were removed from the study analyses for failure to complete at least 50% of the anatomy workshop (failure to complete online modules), leaving a total of 41 in the intervention group.

Following the completion of the 2-day workshop, the workshop participant group began the DPT program with their respective cohort. The remaining students from the two separate cohorts (n = 60), who did not attend the anatomy workshop and who consented (n = 59) to receiving two surveys and the use of their academic data, served as the control group. All students were enrolled in DPT5313 Foundational Sciences I during their first semester in the program, which is the course series that facilitates the anatomy and physiology content of the DPT program. Participation in the study was voluntary with no negative consequences for nonparticipation, and all data were collected in a deidentified manner. No incentives were provided for participation in the anatomy workshop. The study was approved by the UIW Institutional Review Board (protocol no. 17-05-015) as exempt research.

Procedures and Workshop Design

Educational framework. The theoretical framework for the anatomy workshop was to provide an opportunity for learners to be
exposed to the various online anatomy instruction tools and required anatomy texts utilized by UIW before the start of the rigorous DPT program, while also upholding the PBL method. Similar to the DPT program, participants were assigned to a small group of five to six learners and were provided a safe learning environment to explore different methods to learn and apply anatomy and engage in small-group discussions without direct faculty instruction. Learners, through the guidance of their senior DPT peer instructors (herein referred to as peer instructors) were provided approaches and activities to deepen their anatomy learning, while also reflecting on their preferred anatomy study methods. Although the workshop included the review of the lower and upper regions of the body, it was used to practice the process of learning anatomy rather than solely serving as an opportunity for learners to brush up on their anatomy. The goal was to provide structured time for learners to become acclimated to a non-traditional style of learning anatomy that was self-regulated. This period of acclimation was also utilized to set the expectations of learning anatomy at the graduate level.

Workshop design. Each day of the 2-day workshop was divided into a 4-h morning session of onsite interactive activities led by the peer instructors, followed by an online afternoon session of Blackboard modules created to reinforce the learned content from the day. Blackboard modules were designed to promote self-regulated learning and followed the DPT curricular courses in organization and appearance. Day 1 of the workshop focused on the lower limb, and day 2 followed a similar format, but focused on the upper limb.

Two faculty who teach the Foundational Sciences course series in the second (Dr. Bains) and third year (Dr. Kaliski) of the program developed the workshop with support from their capstone students, who served as peer instructors for the workshop. The 4-h onsite morning session on both days was mostly facilitated by peer instructors to reflect the peer-teaching aspect of PBL with supervision from the two faculty instructors. The faculty and peer instructors worked collaboratively to develop both the onsite and online anatomy workshop activities. Peer instructors were guided by the two faculty during the previous summer semester on the appropriate facilitation of the onsite sessions. Three of the four peer instructors for the second summer workshop in 2018 were previous workshop participants from the year before. Thus there was consistency in the onsite peer-led facilitation portions over the 2 yr. The instructor for the Foundational Sciences I course offered during the first semester of the program was listed on the study institutional review board, but intentionally did not help design the anatomy workshop to avoid any bias in developing the anatomy activities. The first semester Foundational Science I course covers lower quarter anatomy, whereas the second semester Foundational Science II course covers the upper quarter anatomy. The lower and upper limb anatomy content reviewed during the workshop was intentionally selected to not completely align with the anatomy content from the Foundational Science I course. A summary of the workshop schedule is provided in Table 1.

Onsite organization. Participants were instructed to prepare for day 1 and day 2 of the workshop by creating a list of all of muscles of the lower and upper limb, respectively. After brief introductions, students were randomly placed in four groups of five to six learners. Learners were oriented to the format of the workshop and were encouraged to participate in the various activities that were designed to introduce different ways to learn anatomy. The onsite activities comprised four anatomy stations, each led by a peer instructor, where groups rotated stations every 45-min until each group completed all four stations.

Each station focused on different learning approaches using different resources available to all DPT students and were divided into the following themes: 1) surface anatomy identification; 2) grouping anatomy; 3) illustrating anatomy; and 4) technology as a tool for learning anatomy. For the surface anatomy station, workshop participants used required anatomy texts and bone models to identify bony landmarks of the lower or upper limb and muscle attachment sites of select muscles. Peer instructors facilitated discussions on muscle function based on proximal and distal attachment sites, stressing the link between anatomy and functional movement. For the grouping anatomy station, workshop participants organized the lower or upper limb anatomy based on compartment, function, and innervation and learned how to group anatomy by structures that have similar functions. Participants were introduced to Visible Body, an online interactive 3D atlas (Newton, MA), and utilized von Hagen’s plastinated models (Guben, Germany) to organize their anatomy. For the illustrations station, workshop participants illustrated a cross section of the leg and compared their drawing to a plastic model to appreciate the depth of different muscles and compartmental organization. For the visualization station, workshop participants practiced using Cyber Anatomy virtual 3D software (Coraville, IA) and Visible Body, combined with von Hagen’s plastinated models, for muscle identification and labeling.

Workshop participants also created a brief PowerPoint presentation with their small groups on lower limb joint and ligament anatomy on day 1 of the workshop. Due to participant feedback, this activity was removed from the second 2018 workshop. There were no anatomy lectures included in the workshop design, and no printed slide sets or handouts containing anatomy content. All handouts used during the anatomy stations served as templates for workshop participants to organize their anatomy information during the activities. Students were also provided cross-sectional, lumbosacral, and brachial plexus labeling workshops, which were linked to both anatomy station activities and the online afternoon sessions. A listing of the onsite anatomy activities is provided in Table 2.

Online organization. For each day, the online Blackboard modules consisted of the following: 1) module objectives; 2) module checklist; 3) selected videos from Acland’s Video Atlas of Human Anatomy (Wolters Kluwer, U.S.), followed by brief self-assessment quizzes; 4) selected Netter’s anatomy plate and/or table readings from their required (UIW DPT program) anatomy texts paired with an activity (i.e., cross-sectional illustration or flashcard writing); and 5) introduction to Draw it to Know it (Indianapolis, IN) anatomy tutorials. Each module also included peer instructor-created videos that explained the assigned activities. The end of the first module also included preparation for day 2 of the workshop.

Table 1. Schedule of 2-day anatomy workshop

| Day/Time          | Location | Activities                                      |
|-------------------|----------|-------------------------------------------------|
| Saturday, 8 AM–12 PM | Onsite   | Pre-workshop baseline survey Day 1 prequiz, lower limb Day 2 anatomy workshop preparation |
| Saturday, 1–4 PM   | Online   | Self-directed learning module 1: lower limb      |
| Sunday, 8 AM–12 PM | Onsite   | Day 1 postquiz, lower limb Brachial plexus instructor-led tutorial Four anatomy station rotations Wrap-up: content overview, Q&A |
| Sunday, 1–4 PM     | Online   | Self-directed learning module 2: upper limb Post-workshop survey |

Q&A, questions and answers.

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Table 2. List of onsite anatomy station activities and online activities

Day 1: Onsite anatomy activities: lower limb
Station 1: Bone activity using bone bag, origin and insertion painted skeleton, and required texts
Participants will:
- List the muscles of the lower limb (gluteal, thigh, and leg) (completed during day 1 preparation)
- Identify bones of the lower limb (thigh and leg)
- Identify bony landmarks/surface anatomy on those bones and the muscle that attach to those landmarks

Station 2: Lower limb muscle identification and action using von Hagen’s leg plastinate, Visible Body, and required texts
Participants will:
- List the muscles of the lower limb (thigh and leg) (completed during day 1 preparation)
- Group the listed muscles by action
- Identify and pin the muscles on von Hagen’s plastinate. (worksheet provided to group the muscles by innervation and linked to afternoon modules)
- Identify the nerves that make up the lumbosacral plexus on the plastinate (worksheet provided and linked to afternoon module)

Station 3: Leg and thigh illustrations and cross sections using plastic leg model and required texts
Participants will:
- List the muscles of the lower limb (thigh and leg) (completed during day 1 preparation)
- Organize and group the muscles of the thigh and leg into compartments (worksheet provided)
- Identify and pin the thigh and leg muscles on the plastic model
- Draw and label a cross section of the leg and thigh (cross-section worksheets provided and linked to afternoon module)

Station 4: Visible Body on large touch screen and von Hagen’s torso plastinate
Participants will:
- List the muscles of the lower limb (thigh and leg) (completed during day 1 preparation)
- Identify and label the muscles using both Visible Body and the von Hagen’s plastinate
- Students will link anatomy to function as they are guided through peer instruction
- Use the Visible Body app to identify the action of each muscle

Day 1: Online self-directed learning module activities: lower limb
- Watch: Acland’s Video Atlas of Human Anatomy: The Hip (7 videos)
- Complete: Self-check quiz 1
- Read: F. H. Netter’s Atlas of Human Anatomy (5 plates)
- Complete: Cross-section activity. Draw the middle cross section of the thigh. Try it from memory first by recalling what was learned from anatomy station 3
- Read: F. H. Netter’s Atlas of Human Anatomy (7 plates, 7 muscle tables)
- Complete: Cross-section worksheet activity. Label the following muscles on the leg cross-section worksheet provided in class: soleus, tibialis posterior, gastrocnemius lateral head, fibularis longus
- Watch: Acland’s Video Atlas of Human Anatomy: The Knee (4 videos)
- Complete: Self-check quiz 2
- Watch: Acland’s Video Atlas of Human Anatomy: The Leg (2 videos)
- Complete: Self-check quiz 3
- Watch: Draw it to Know it tutorial on the lumbosacral plexus
- Complete: Worksheet activity, using the worksheet provided during anatomy station 2. Label the nerves that innervate the thigh, which make up the major terminal branches of the lumbosacral plexus
- Complete: Workshop day 2 preparation. Create a list of muscles of the upper limb (shoulder, arm, forearm); view the brachial plexus essentials tutorial on Draw it to Know it

Day 2: Onsite anatomy activities: upper limb
Station 1: Bone activity using bone bag, origin and insertion painted skeleton, and required texts
Participants will:
Continued
Table 3. Anatomy confidence and PBL preparedness survey questions

| Likert Scale Statements                                                                 | Confidence                                                                                  | Preparedness                                                                 |
|----------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|
| • I am comfortable using online anatomy resources to learn anatomy.                     | • I am well prepared to study anatomy content at the graduate level.                        | • I am well prepared to study anatomy content at the graduate level.          |
| • I am comfortable identifying bones of the lower and upper limb.                       | • I feel ready to learn anatomy in a PBL, DPT program in a self-directed manner.            | • I feel ready to learn anatomy in a PBL, DPT program in a self-directed manner.|
| • I am comfortable identifying muscles of the lower and upper limb.                     | • I feel comfortable using multiple anatomy resources to support my anatomy learning.        | • I feel comfortable using multiple anatomy resources to support my anatomy learning.|
| • I am comfortable handling plastinated human models.                                    | • A 2-day anatomy workshop is worthwhile.                                                   | • A 2-day anatomy workshop is worthwhile.                                     |

Results are based on a Likert scale, where 1 = strongly disagree and 5 = strongly agree. DPT, Doctor of Physical Therapy; PBL, problem-based learning.

A 2-day anatomy workshop is worthwhile.

was administered at three time points: before and after the workshop and on completion of the first semester in the program. The control group completed the same survey at two time points, before and after the first semester. Cronbach’s α reliability coefficient was calculated to assess the internal consistency of the Likert scale items.

A five-question Likert scale anatomy workshop questionnaire was distributed to participants of the 2017 anatomy workshop in the second semester of their first year in the program to gather feedback for preparation of the 2018 workshop. We did not make any significant changes to the 2018 workshop based on these results, other than to modify an activity.

To assess learning during the anatomy workshop, participants completed pre- and postquizzes for both days of the workshop (4 quizzes total). Quizzes were composed of 15 multiple-choice questions specific to anatomy structure and function identification and assessed the content learned during the onsite workshop and through the online modules. Quiz questions were modified from e-resources available through the Acland’s video atlas university subscription. *Prequiz 1* (lower limb) and *prequiz 2* (upper limb) were both disseminated at the start of the onsite workshop for each day. The postquiz for *quiz 1* was disseminated before *prequiz 2* on day 2 of the workshop, and *postquiz 2* was delivered at the end of the afternoon online Blackboard module on day 2. It must be noted that *postquiz 2*, which covered the upper limb, was not a proctored quiz, whereas the remaining three quizzes were all proctored onsite. The postquizzes were replicated versions of the respective prequiz content, meaning the quiz questions were similar but not identical. Thus, all four quizzes contained questions that were not previously seen by the workshop participants.

To evaluate anatomy-specific academic performance and potential workshop carryover, anatomy practical scores from the first two practical assessments in the DPT5313 Foundational Sciences I course were collected at the end of the semester. Practical scores were imported into Excel, placed in the appropriate study group (intervention versus control) and deidentified. The practical exams consisted of 10 questions of anatomy identification (origin, insertion, action, function) using the prosected anatomy models from the Foundational Science laboratory. The anatomy practical was the same exam for the 2 yr in which the data were collected, and the instructors (M.B and D.Z.K.) who developed the anatomy workshop had no involvement in the creation of the anatomy practicals for the course.

**Statistical Analysis**

Descriptive statistics were generated for all participants. Race/ethnicity was categorized as white/non-Hispanic, black/non-Hispanic, Asian/Pacific Islander, Latino/Hispanic, and other/unknown (i.e., self-identified as other, multiple races, or did not respond). The \( \chi^2 \) tests were used to compare sex and race/ethnicity of workshop participants and the control group. The incoming grade point average (GPA), specifically for the final 60 semester hours, of both intervention and control groups was compared using an independent-samples \( t \) test to determine potential baseline academic differences.

Differences in workshop participants pre- and postquiz assessment scores were determined by paired-samples \( t \) tests. A total confidence score (range from 6 to 30) and total PBL preparedness (range from 3 to 15) score was calculated from each of the six confidence and three PBL preparedness Likert questions. A single confidence and PBL preparedness score was then calculated for each individual survey respondent and expressed as a percentage. Anatomy confidence and PBL preparedness percentages and anatomy workshop enthusiasm between the workshop participant and control groups across the different semester time points were analyzed using a one-way analysis of variance (ANOVA), followed by Tukey’s multiple-comparisons post hoc analysis to assess for statistically significant changes in student levels of self-reported confidence and PBL preparedness. Levene’s test for homogeneity of variances was used to assess equality of variances across groups.

Multivariate linear regression models were conducted to characterize the predictive relationships between the dependent variables of first-semester anatomy practical grades and the independent variables (sex, ethnicity, GPA, and intervention group). Due to the nature of the participant selection process and to compensate for inherent differences between the intervention and control groups, demographic (sex, ethnicity) and academic (GPA) data were included as independent control variables in the linear regression analyses. For regression models, ethnicity was grouped into non-Hispanic and Hispanic. We started with the most complex model that included all independent variables. Nonsignificant independent variables were then removed one at a time to identify the most parsimonious models for the two anatomy practical outcome variables. The models presented in the **RESULTS** are the final best-fit and most parsimonious models.

Data are expressed as the mean standard deviation (SD), with a value of \( P < 0.05 \) considered statistically significant. All analyses were performed using Statistical Package for Social Sciences (SPSS) software (version 25, SPSS, Inc., Chicago, IL) and GraphPad Prism (version 7.0d, La Jolla, CA).

**RESULTS**

**Demographic Characteristics of Class Cohorts**

All \( n = 100 \) students from the two cohorts who consented to the study were analyzed regarding their demographic and academic characteristics. Forty-one percent of students participated in the anatomy workshop from 2017 and 2018. Anatomy workshop participants were compared with students who did not choose to participate in the workshop (control group, \( n = 59 \) (Table 4). There were statistically significant differences in sex, where 80% (\( n = 33/41 \)) of workshop participants were female compared with 49% (\( n = 29/59 \)) of the control group. No statistically significant differences were found for race/ethnicity and undergraduate GPA. See Table 4 for complete demographic data.
Workshop participants scored 3.66 points higher than the control group \( (P = 0.001) \), with a mean of 87 and 84, respectively. Participants in the workshop also demonstrated statistically significant increases in both post-semester anatomy confidence \( (P < 0.001) \) and PBL preparedness \( (P = 0.003) \), with a mean increase of 74 and 77\% for PBL preparedness, respectively. Levene’s statistic was not statistically significant \( (P = 0.09) \) for anatomy confidence and \( P = 0.84 \) for PBL preparedness, indicating that the groups had homogeneous variance.

Anatomy Competency During the First Semester

To assess whether the anatomy workshop intervention could predict first semester academic performance, two anatomy practical scores from the DPT5513 Foundational Sciences I course were compared between workshop participants and the control group using multivariate linear regression models. All potential predictors were incorporated into the regression and were sequentially removed until all remaining variables showed statistical significance. The overall regression model for the first anatomy practical was statistically significant, \( F(2,97) = 8.04, P < 0.001, R^2 = 0.14 \). Participants in the workshop scored 3.66 points higher than the control group \( (P = 0.03, \text{Table 5}) \), with a mean of 87 and 84, respectively. Sex and ethnicity were not selected to be included in the final model.

Table 4. Characteristics of 2020 and 2021 class cohorts

| Characteristic             | Workshop Participants | Control | \( P \) Value |
|----------------------------|-----------------------|---------|--------------|
| \( n \)                    | 41                    | 59      | <0.001*      |
| Sex, \( n \) (%), Female   | 33 (80)               | 29 (49) |             |
| Male                      | 8 (20)                | 30 (51) |             |
| Race/ethnicity, \( n \) (%)|                       |         | 0.48*        |
| White, non-Hispanic       | 18 (44)               | 25 (42) |             |
| Black, non-Hispanic       | 3 (7)                 | 2 (3)   |             |
| Hispanic                  | 14 (34)               | 18 (31) |             |
| Asian                     | 3 (7)                 | 9 (15)  |             |
| Other                     | 3 (7)                 | 3 (7)   |             |
| Not identified            | 0                     | 2 (3)   |             |
| GPA, mean (SD)            | 3.36 (0.28)           | 3.37 (0.30) | 0.86†       |

Values are \( n \), no. of participants, with percentage in parentheses; grade point average (GPA) values are means (SD). Statistical significance \( (P < 0.05) \) is indicated in bold. \( P \) values are based on a \(^*\) test and \(^{unpaired} t\) test.

Anatomy Workshop Knowledge Acquisition

Pre- and postquizzes reviewing the lower (pre- and postquiz 1) and upper limb (pre- and postquiz 2) anatomy assessed content covered during the onsite and online portions of the workshop. Comparisons made between pre- and postquizzes for each body region are shown in Fig. 1. Knowledge acquired on both days 1 and 2 of the workshop resulted in statistically significant improvements in the postquiz scores for each corresponding prequiz \( (P < 0.001 \) compared with prequiz 1; \( P < 0.001 \) compared with prequiz 2). These results indicate that the anatomy content reviewed during each day of the workshop resulted in learning and retention.

Survey Results of Anatomy Confidence and PBL Preparedness

Cronbach’s \( \alpha \) reliability coefficient for internal consistency of the survey was 0.77, which indicated acceptable internal consistency. The identical survey was completed at three distinct time points for the workshop participants: before the workshop (100% response rate), which served as the baseline, after the workshop (84% response rate), and after the first semester (77% response rate). The same survey was also distributed to the control group at two time points: before the semester (85% response rate), which served as the baseline, and after the first semester (64% response rate). Self-reported changes in anatomy confidence and PBL preparedness between the workshop participants and the control group over the course of the first semester is shown in Fig. 2. Percent confidence and percent PBL preparedness at baseline for both groups was roughly equivalent (66% for anatomy confidence; 74–77% for PBL preparedness), with no statistically significant differences between the groups. Workshop participants demonstrated statistically significant increases in both measured indexes compared with baseline on completion of the 2-day workshop \( (P < 0.001 \) compared with baseline workshop participants for anatomy confidence and PBL preparedness).

The control group also demonstrated statistically significant increases in both indexes after completing their first semester \( (P < 0.001 \) compared with baseline control for anatomy confidence and PBL preparedness). Workshop participants demonstrated a further significant increase in their anatomy confidence following their first semester in the program \( (P = 0.01 \) compared with post-workshop anatomy confidence). Although not statistically significant \( (P = 0.10) \), a 6% increase was observed for PBL preparedness in the workshop participant group after their first semester compared with their self-reported PBL preparedness after the workshop. Both percent anatomy confidence and PBL preparedness were significantly higher in the workshop participant group compared with controls after the first semester \( (P = 0.005 \) and \( P = 0.002 \) compared with the post-semester controls for anatomy confidence and PBL preparedness, respectively).

![Fig. 1. Anatomy workshop pre- and postquiz scores. Mean scores were significantly improved on both postquiz assessments of the lower (**P < 0.001 compared with prequiz lower limb, \( n = 41 \) participants; A) and upper limb (**P < 0.001 compared with prequiz upper limb, \( n = 38 \) participants; B). Three students did not complete the postquiz lower limb. Values are means \pm SD, as measured using a paired-sample \( t\) test.](advan.00048.2019.Fig.1)
model, as they were both found to have high $P$ values in the initial regression model. However, GPA was included in the final model and was also a statistically significant predictor of the first anatomy practical score of the semester ($P < 0.001$, Table 5). It should be noted that participation in the anatomy workshop also significantly predicted the first anatomy practical score of the semester, even when sex and ethnicity were included in the initial linear regression model ($P = 0.04$, data not shown).

The overall regression model for the second anatomy practical of the semester was also statistically significant, $F(3,96) = 4.70$, $P = 0.004$, $R^2 = 0.13$. Participants in the workshop scored 3.44 points higher than the control group ($P = 0.049$, Table 5) with a mean of 88 and 85, respectively. Sex was not selected to be included in the final regression model, as it was found to be nonsignificant in the initial regression model. Both GPA and ethnicity were included in the final best model and were both statistically significant predictors of the second anatomy practical score ($P = 0.03$ and $P = 0.02$, respectively; Table 5). While GPA was found again to have a positive relationship with the anatomy practical score, Hispanic ethnicity was found to have a negative relationship.

### Table 5. Parameter estimates of multivariate regression model for first-semester anatomy practical performance

| Variable                | Anatomy Practical 1 | Anatomy Practical 2 |
|-------------------------|---------------------|---------------------|
|                         | $\beta$ Coefficient | SE                  | $P$ Value | $\beta$ | SE | $P$ Value |
| Sex                     |                     |                     |           |         |     |           |
| Female                  | 0.656               | 1.783               | 0.71‡     | 0.037   | 1.903 | 0.99†     |
| Male                    | 0*                  | 0*                  |           |         |     |           |
| Ethnicity               |                     |                     |           |         |     |           |
| Hispanic                | $-$3.193            | 1.711               | 0.07†     | $-$4.432| 1.825 | 0.02‡     |
| Non-Hispanic            | 0*                  | 0*                  |           |         |     |           |
| GPA                     | 9.417               | 2.794               | $<$0.001‡ | 0.69    | 3.007 | 0.03‡     |
| Intervention            |                     |                     |           |         |     |           |
| Anatomy workshop        | 3.660               | 1.641               | 0.03‡     | 3.44    | 1.838 | 0.049‡    |
| Control                 | 0*                  | 0*                  |           |         |     |           |

$n = 100$ participants. GPA, grade point average. *Reference category set to zero; $P$ values are based on the initial regression model and the final regression model. Significance ($P < 0.05$) is indicated in bold.

Non-Hispanic students scored 4.43 points higher than Hispanic students ($P = 0.02$), as indicated by the negative $\beta$-coefficient (Table 5). It should be noted that participation in the anatomy workshop did not significantly predict the second anatomy practical score of the semester when sex was included in the initial linear regression model ($P = 0.06$, data not shown).

### Enthusiasm and Effectiveness of the Anatomy Workshop

The final question on the anatomy confidence and PBL preparedness survey (see Table 3) queried whether the utility of an anatomy workshop was worthwhile. Workshop participants responded with a score of 4.70 out of 5 on the Likert scale leaning toward “strongly agree” on the first baseline survey before the workshop and a 4.8 for the second post-workshop survey and third post-semester survey, indicating that their perceptions of the workshop and enthusiasm remained very positive (Fig. 3). The enthusiasm for the anatomy workshop for the control group was positive at baseline before the start of the semester and significantly declined toward the start of the semester and significantly declined toward...
“neutral” after the first semester (4.0 and 3.4 out of 5, respectively, \( P = 0.002 \) compared with baseline control). The interest of the control group toward the workshop was significantly lower than that of the workshop participant group at both the baseline and post-semester time points (\( P < 0.001 \) compared with baseline control and post-semester control).

Finally, an anatomy workshop questionnaire was distributed to participants of the 2017 anatomy workshop during the second semester of their first year in the program to gather feedback in preparation for the second anatomy workshop that was offered in 2018 to incoming students. The questionnaire included Likert-scale questions addressing workshop effectiveness, including questions that were specific to both the onsite and online portions of the workshop. The 2017 workshop participants agreed that the workshop helped introduce the PBL curriculum, exposure to various study strategies, provided anatomy resource familiarity, and both the onsite and online experience were beneficial. Questions and responses are shown in Fig. 4.

DISCUSSION

The objectives and goals for the workshop were threefold: 1) introduce and utilize the available anatomy resources used in the DPT program; 2) explore and utilize multiple study strategies during onsite and online activities; and 3) review anatomy of the lower and upper limb. All objectives were met as students were immersed and fully engaged in a combined onsite and online anatomy experience that incorporated self-regulated studying practices, hands-on activities with prosected anatomy models, and one-on-one interactions with faculty and peer instructors. Success of the workshop was further supported by tracking user participation of the online modules, which demonstrated 90% completion of the three self-check assessments for module 1 and 85% completion of the two self-check assessments for module 2. Post-semester feedback of the workshop remained positive, as students reported forming study habits and continued use of the multiple anatomy resources during the semester.

Data collected from the pre- and postquizzes during the workshop demonstrated that learning and short-term retention were achieved as participants significantly improved on their baseline anatomy knowledge. This improvement in anatomy knowledge was also reflected in the participant’s self-efficacy, as measured in the survey of self-reported anatomy confidence and preparedness to learn anatomy in a PBL program. Compared with baseline scores, both confidence and PBL preparedness were significantly increased immediately after the workshop. We hypothesized that improved anatomy knowledge and learning self-efficacy would translate to improved academic performance in the first semester compared with controls. Indeed, regression analyses indicated that participation in the anatomy workshop as well as GPA were statistically significant predictors of anatomy practical performance for the two semester practicals in their Foundational Sciences I course. It was not surprising that GPA was also a predictor of anatomy practical performance, as it has previously been established to predict academic success, early identification of students at risk, and performance on the National Physical Therapy Exam (7, 33).

Interestingly, the effect of Hispanic ethnicity on anatomy practical performance was varied, with no predictive significance on the first anatomy practical and predictive significance on the second practical. Although not significant, students who identified as Hispanic performed lower than non-Hispanic students by 3 points on the first practical, which supports a trend that this population of students may be at risk for an academic disadvantage in graduate level anatomy. Interestingly, Hispanic students who participated in the workshop performed better than Hispanic students in the control group by 4 points on the first practical and by 2 points on the second practical (data not shown). Because the population sample size was small and the independent variable for ethnicity for the first anatomy practical of the semester was not statistically significant, caution should be taken when interpreting these results. However, whether the anatomy workshop could be utilized to improve academic performance in Hispanic/Latino graduate students warrants further investigation.

Our results echo similar findings reported by other health science programs on the positive utility of workshops or other short-transition programs (4, 23, 32). Undergraduate initiatives have invested in workshops and curricula for improving confidence and assessment outcomes for students on health science tracks, with positive results on both self-confidence and academic performance (5, 22). Medical “boot camp”-like experi-

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**Fig. 4. Effectiveness of a 2-day anatomy workshop.** Post-semester workshop effectiveness survey questions and responses from (2017) workshop participants are shown as mean ± SD Likert scores; \( n = 13 \) participants. Results are based on a Likert scale, where 1 = strongly disagree and 5 = strongly agree. DPT, Doctor of Physical Therapy; PBL, problem-based learning.
ences delivered at the end of medical curricula have yielded statistically significant effects on self-confidence and clinical skills before internship initiation (11, 23, 27, 32). Herling et al. (13) assessed the impact of a premed school matriculation anatomy boot camp on study skills development, anatomy retention, and academic performance. In addition to significantly higher scores on the first two semester laboratory examinations compared with the control group, boot camp participants reported successful transition to medical school and positive peer social interactions (13). Similarly, this study focused on developing an experience before initiation of a DPT program to improve student anatomy confidence, PBL preparedness, and anatomy competency as a means to transition students to a rigorous didactic DPT graduate program.

Although participation in the anatomy workshop significantly predicted anatomy practical performance on both first-semester practicals, there was a drop in the significance on the second practical of the semester. We believe this is due to a washing out of the anatomy workshop effect by the second anatomy practical, where students who did not participate in the workshop would have had time to develop their self-directed learning methods and anatomy confidence. This washing out effect of the anatomy workshop is evident by the second semester in the program because the workshop no longer predicts practical scores after the first semester (data not shown). It is also possible that the potential for post-workshop academic outcome improvement was less for the high-performing students who participated in the workshop, resulting in a ceiling effect of the workshop on anatomy practical scores for this subgroup of participants. The 3- to 4-point increase in practical scores in the workshop participant group translated to a difference in a letter grade for the first practical compared with the control group. A review of the results revealed that participation in the anatomy workshop resulted in a leftward shift in the grade distribution (data not shown) among workshop participants, increasing the number of A’s and B’s earned and decreasing letter grades of C and below, compared with controls, for both practical assessments.

The anatomy workshop was strategically not modeled after the Foundational Science I course, and thus the musculoskeletal anatomy content facilitated in the first-semester course and tested on the semester anatomy practical was not directly aligned with the anatomy that was facilitated during the workshop. The core objective of the workshop was to improve anatomy learning efficiency by providing resource familiarity and strategies to support self-directed learning as a goal to improve anatomy outcomes overall. McNulty and colleagues (19) were able to demonstrate statistically significant anatomy learning carryover using a similar approach delivered in a 1-wk veterinary anatomy precourse aimed to support self-guided anatomy learning. In their model, the learning strategies developed during the precourse resulted in higher exam performances in the precourse group even on examinations in which both groups were exposed to the content for the first time during the semester (19).

Self-reported anatomy confidence and PBL preparedness levels continued to improve during the first semester for anatomy workshop participants and was significantly higher than that for the control group at the end of the semester. It could be argued that the initial increase in self-efficacy indexes after the workshop was misaligned because students had not yet experienced graduate level testing standards. However, self-reported confidence and PBL preparedness after the semester did not decline or plateau when compared with “post-workshop” levels: instead it continued to increase.

High academic self-efficacy has been shown to influence and promote academic success because it can contribute to motivation toward learning, managing emotions, embracing challenges, and goal-setting behaviors (1, 2, 25, 37). Burgoon et al. (6) reported relationships between medical student self-efficacy ratings and performance on laboratory practicums and written exams. In another pilot study on undergraduate premedical students, implementation of a self-monitoring workbook exercise designed to promote content self-awareness and self-assessment resulted in statistically significant increases in student self-efficacy, as well as performance, on a biomedical science module compared with controls (6, 17). Similarly, Opacic (24) reported that physician assistant student’s self-efficacy as well as exam performance were both predictors for clinical performance success (24). Workshop participants in this study were provided an opportunity to develop anatomy self-efficacy during the pre- and postquiz activities in the 2-day workshop. Improvements in anatomy knowledge as measured by the two postquizzes served as real-time evidence of the ability to succeed in learning anatomy, and this “enactive mastery experience” is one source of information that can develop students’ self-efficacy (34).

It is likely that the observed increase in anatomy self-efficacy after the workshop and first semester was attributed to the workshop participant group’s ability to establish best anatomy learning strategies earlier than the control group, as well as developing familiarity with the online resources, Blackboard course organization, laboratory facilities, PBL environment, and group dynamics. The continued increase in anatomy self-efficacy after the workshop may be a reflection of solidifying best anatomy learning methods that were developed during the anatomy workshop. Indeed, the level of enthusiasm for the workshop among the participants remained high (4.8 out of 5 on Likert scale) for all three survey responses over the course of the semester, indicating that the workshop was worthwhile to their learning.

The level of enthusiasm for the utility of an anatomy workshop varied between the groups. While the control group agreed that the workshop was worthwhile, their agreement on the utility of the workshop was significantly lower than that of the workshop participant group. Furthermore, this interest in the workshop among those in the control group declined toward “neutral” at the end of the semester. This can be explained by the timing at which the baseline survey was collected from each group. Participants completed the survey on day 1 of the workshop, whereas the control group completed the survey the following week during orientation. It is possible that regret of not participating in the anatomy workshop and orientation-related stress influenced the responses of the control group. Other explanations for the decline in interest from the control group include hitting neutral simply to complete the survey and being unaware of the benefits of the anatomy workshop since they were not invested in the workshop. It should be noted that, while baseline enthusiasm for the workshop differed significantly between groups, there was no statistically significant difference between confidence and PBL
preparedness at baseline between the two groups, as discussed above.

Study Limitations

Some of the limitations of the study include the potential for sharing the materials developed by the workshop participants with their assigned PBL group peers who were part of the control group, which may have weakened the predictability of the workshop on semester practical outcomes. However, we intentionally did not control for the sharing of content and encouraged workshop participants to engage with the control group, specifically with introducing the various anatomy resources that were available to them, as peer support is a pillar of the PBL process. Another limitation was the recruitment method via e-mail and self-selection, which may have resulted in immediate responses from goal-oriented, academically driven students. To account for this academic selection bias, the GPA from the last 60 undergraduate semester credit hours was compared between both groups, and no statistically significant differences were observed. Furthermore, the multivariate regression analyses factored in the inherent demographic differences between the two groups. Another limitation is that this workshop was offered at one institution, thus limiting the generalizability across other DPT programs. In addition, replication of such study would require access to similar anatomy resources (Visible Body, Acland’s Video Atlas of Human Anatomy, etc.).

Conclusions

A prematriculation anatomy workshop designed to transition students to an unfamiliar pedagogy is a constructive strategy to improve anatomy learning efficiency before the start of a rigorous DPT program. Transition programs can be specifically tailored to address established curricular challenges, utilize minimal resources to develop, and provide an effective means to improve graduate outcomes for entering students. Rather than focusing strictly on best pedagogical methods of teaching, an emphasis should be placed on better equipping students for the academic rigor of graduate programs and improving learner self-efficacy.

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DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the authors.

AUTHOR CONTRIBUTIONS

M.B. and D.Z.K. conceived and designed research; M.B. analyzed data; M.B. prepared figures; M.B. drafted manuscript; M.B. and D.Z.K. edited and revised manuscript; D.Z.K. approved final version of manuscript.

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