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Understanding the Current Anatomical Competence Landscape: Comparing Perceptions of Program Directors, Residents, and Fourth Year Medical Students

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11 **Understanding the Current Anatomical Competence Landscape:**
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14 **Comparing Perceptions of Program Directors, Residents, and Fourth**
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17 **Year Medical Students**
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3 ABSTRACT
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8 A mixed methods survey of fourth year medical students, resident physicians, and residency
9 program directors at the Indiana University School of Medicine gathered perceptions of
10 anatomical competence—defined as the anatomical education necessary for effective clinical
11 practice. The survey items explored numerous aspects of anatomical competence, including the
12 most effective modes of instruction, perceptions of readiness for clinical practice, and specific
13 suggestions for improving anatomical education during medical school and residency. The
14 response rate was 46% for fourth year medical students, 47% for residents (as graduates from
15 137 medical schools), and 71% for program directors. A majority of students and residents
16 reported the following: that their course in Gross Anatomy prepared them well for clinical
17 practice; that cadaveric dissection was important in the early development of their anatomical
18 competence; and that placing a greater emphasis on clinical relevance in medical school would
19 have improved their anatomical competence even further. However, in terms of anatomical
20 preparedness upon entering residency, the program directors rated their residents less prepared
21 than the residents rated themselves. All three groups agreed there is need for additional
22 opportunities for anatomical educational during medical school and residency. Suggestions for
23 improving anatomical education included: provide more opportunities for cadaveric dissection
24 during medical school and residency; more consistent teaching of anatomy for clinical practice;
25 more workshops that review anatomy; and better integration of anatomy with the teaching of
26 other subjects during medical school.
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Key words: gross anatomy education, medical education, anatomical competence; perception of anatomy knowledge, residency education, residency directors, adequate preparation; clinical practice

For Peer Review

INTRODUCTION

Gross anatomy has long served as one of the cornerstones of medical education (Pabst et al., 2001; Sugand et al., 2010). Anatomy is a learned art of observation, dissection, movement, and application, all on a canvas of skin, connective tissue, muscle, bone, and nerve. A majority of physicians consider gross anatomy to have been highly relevant in their medical training (Pabst and Rothkotter, 1997), training that aims to produce physicians possessing the knowledge, skills, and attitudes to care for health needs of the populations they serve. Yet, in recent decades, the teaching of gross anatomy in medical schools has undergone major transformative changes; changes that some believe are having an adverse effect on the level of anatomical knowledge of medical graduates (Collins et al., 1994; Cottam, 1999; Older, 2004; Pandey and Zimitat, 2007; Yammine, 2014).

These changes include: (1) a decline in the number of qualified anatomy teachers (Cahill and Leonard, 1999; Cahill et al., 2000; Older, 2004), (2) the absence of a core anatomy curriculum (Halasz, 1999; Older, 2004; Raftery, 2006), (3) a decreased use of dissection as a teaching tool (Cahill et al., 2000; Reidenberg and Laitman, 2002; Raftery, 2006), (4) a lack of anatomy taught in a broader medical context (Reidenberg and Laitman, 2002; Raftery, 2006; Norman, 2007), (5) the rise of integrated curricula (Monkhouse and Farrell, 1999; Williams and Lau, 2004), (6) an inadequate assessment of anatomical knowledge (Ellis 2002; Raftery, 2006; Turney, 2007), (7) a decrease in anatomy teaching time (Carmichael et al., 2002; Drake, 2007), and (8) a failure to vertically integrate anatomical teaching (McCrorie, 2000; Older, 2004; Norman, 2007; Bergman et al., 2014; Yammine, 2014). Some have even argued that these factors are contributing to the “devolution of anatomic curricula,” and the loss of anatomy’s

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3 identity within the field of medical education (Dangerfield et al., 1996; Dyer and Thorndike,
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6 2000; Yammine, 2014).

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8 However, a recent review of the eight aforementioned factors by Bergman and colleagues
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10 (2014) found no empirical evidence in the literature to support the claims that these changes
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12 were responsible for a decline in the anatomical knowledge of our medical students. Yet, the
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14 authors fully acknowledge that behind these claims are genuine concerns and stories, based on
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16 specific perceptions and experiences (Bergman et al., 2014). In this context, we sought to better
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18 understand some of these 'stories', particularly the story of the current state of anatomical
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20 competence, and perceptions thereof, of our fourth year medical students, residents, and program
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22 directors. We propose the term 'anatomical competence' to encompass both a practitioner's
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24 foundational knowledge of anatomy relevant to a given specialty, and well as his or her ability to
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26 effectively utilize that knowledge in the care of patients. We believe this term captures the
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28 essence of what anatomical education is all about, and why it's important to solicit the opinions
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30 of multiple stakeholders at the interface of training and practice.
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37 The last attempt in the United States to broadly assess the importance of gross anatomy,
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39 the adequacy of anatomical preparation, and the anatomical areas of deficiency was in 1999, and
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41 was limited to the perceptions of residency program directors and anatomy course directors
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43 (Cottam, 1999). Since then, important work by Lazarus et al. (2012) has formally assessed
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45 medical students, clinicians, and academic anatomists' perceptions of the perceived role of
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47 clinical anatomy, and evaluated the perceptions of medical students' ability to apply anatomical
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49 knowledge in the clinic. In addition, Orsbon et al. (2014) formally assessed physicians to
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51 determine the importance of specific anatomical topics they felt were essential to their practice of
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53 medicine, and assessed what should compose the common core of anatomical knowledge for the
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3 practicing physician. While important, the literature could be strengthened by further
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5 understanding. Specifically, understanding how fourth year medical students, residents, and
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7 residency program directors agree, and conversely disagree, regarding their perceptions
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9 concerning the current state of anatomical competence. This study aimed to do this by
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11 systematically evaluating and comparing the opinions of these three groups regarding the
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13 anatomical education necessary for effective clinical practice.
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17 To assess the current state of anatomical competence from the perspectives of fourth year
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19 medical students, residents, and residency program directors (all of whom are at various levels of
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21 learning, using, teaching, and monitoring their anatomical knowledge) this study complements
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23 the existing literature. However, it goes further in uniquely quantifying and comparing the
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25 perceptions of these groups, looking for key areas of convergence and divergence, illuminating
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27 recommendations each group perceives are necessary educational changes based upon how they
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29 believe anatomical competence could be best improved.
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36 MATERIALS AND METHODS

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38 In 2013, three mixed methods surveys were designed and administered to all fourth year
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40 medical students at Indiana University School of Medicine (IUSM), and to all residents and
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42 residency program directors of fifteen residency programs at IUSM. A panel of five anatomical
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44 educators and practicing physicians ranked all medical specialties on a scale of one to five;
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46 where five represented a specialty anatomy was exceptionally relevant to, and one represented a
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48 specialty anatomy was not relevant to at all. Any specialties that earned an average ranking of
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50 three or above, after scores from all five panel members were considered, were included in the
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52 study. These residency programs include: Anesthesia, Dentistry, Diagnostic Radiology,
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3 Emergency Medicine, Internal Medicine, Neurology, Neurological Surgery, OB/GYN,
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5 Ophthalmology, Orthopedic Surgery, Otolaryngology, Pathology, Radiation Oncology, Surgery,
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7 and Urology. The survey instruments sent to fourth year medical students and residents
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9 consisted of eighteen and nineteen questions respectively, and included both quantitative and
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11 qualitative elements. The survey instrument sent to residency program directors consisted of
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13 seven questions, and included both quantitative and qualitative elements.
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17 The survey sent to fourth year medical students and residents sought to examine their
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19 perceptions of their anatomical competence. Questions addressed the following: (1) their
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21 anatomical education during medical school; (2) how their anatomical education prepared them
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23 for clinical practice; (3) the current progression and development of their anatomical knowledge
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25 within their respective programs; and (4) ways they suggest their anatomical competence could
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27 be improved. Similarly, the survey sent to program directors sought to examine their perceptions
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29 of their residents' anatomical competence. Questions addressed the following: (1) how well they
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31 felt their residents were anatomically prepared for clinical practice upon entering residency; (2)
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33 the specific areas in which they felt their respective residents were either well-prepared or
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35 underprepared; (3) how well their residents' anatomical knowledge was progressing and
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37 developing; and (4) ways they suggest the anatomical competence of their residents could be
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39 improved. Prior to administration of the survey, the questions were vetted by an expert panel
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41 consisting of the associate dean for graduate medical education, the assistant dean for curriculum
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43 in the clinical sciences, the vice chair of education for the surgery department, and the course
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45 director for medical gross anatomy.
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53 The names and e-mail addresses of all fourth year medical students ($n = 301$), residents (n
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55 = 846), and residency program directors ($n = 86$) were obtained from the Office of the Registrar
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3 (students) or from the Office of Graduate Medical Education (residents and residency program
4 directors). Surveys were electronically administered through Research Electronic Data Capture
5 (REDCap) web application (REDCap Consortium, Vanderbilt University, Nashville, TN) ,which
6 is a secure data management platform used for building and managing online surveys and
7 databases. It was originally developed at Vanderbilt University, and is available for academic
8 use at Indiana University. The survey was active for a period of four months, during which six
9 invitations were sent via e-mail to elicit responses. The University’s Institutional Review Board
10 granted exempt status to this research.
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15 Quantitative data was analyzed using SAS 9.3 statistical software (SAS Institute Inc.,
16 Cary, NC), and qualitative data from open-ended questions was analyzed using NVivo
17 qualitative analysis software (QSR International, Victoria, Australia), as well as using a process
18 called inductive analysis. Inductive analysis is a process in which categories related to the
19 findings emerge as the analysis proceeds. Categories of meaning, with relationships between
20 categories derived from the data itself, are then used to build patterns and themes from data
21 collected in the study (Patton, 2002; Creswell, 2009). Specifically, data from key statements in
22 this study were highlighted and categorized into general themes, and using principles of an
23 inductive constant comparative analysis, the researchers coded and simultaneously compared the
24 data, reflected upon it, reduced it, and then repeated this process until saturation was achieved
25 (Glaser and Strauss, 1967). For the purposes of this study, coding is defined as a process where
26 “incidents or issues with similarities are grouped together into themes or categories, which are
27 named according to meaning,” an ongoing process that occurs throughout the study that
28 examines connections both within and between individual cases (Kennedy and Lingard, 2006).
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Reliability

In order to assess the internal reliability of items in the survey, a Cronbach Alpha test was used. Cronbach Alpha is a measure that seeks to assess the average degree of interterm correlation or covariance, and in context of a survey instrument can be used to determine the degree to which questions are consistent with each other in measuring the intended construct. A value greater than 0.8 suggests reliability is excellent. The Cronbach Alpha for this survey instrument was 0.738, which denotes an acceptable reliability, and is a first step in demonstrating validity.

RESULTS

Response Rate

Of all surveys administered, fourth year medical students returned 46 percent of the surveys (138/301). Residents returned 47 percent of the surveys (398/846), which provided a resident sample that included individuals from 137 different medical schools and 14 different countries. Residency program directors returned 71 percent of the surveys (61/86). Specific resident and residency program director returns by program are seen in Table 1. Results from the medical students' and residents' survey are presented first. This will be followed by a presentation of results from the residency program directors' survey. Finally, the study will conclude with a comparison of findings among fourth year medical students, residents, and residency program directors.

Fourth Year Medical Students and Residents

Current Trends in Educational Methods

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4 The survey listed eight types of teaching methodologies used in gross anatomy and asked
5 participants which method(s) were used in their anatomy course in medical school; participants
6 could mark all that applied. The options were: lectures, problem-based learning (PBL) team-
7 based learning (TBL), laboratory sessions, case studies, peer-teaching (where courses required
8 specific peer-teaching activities), online self-study modules, or other. Most of the fourth year
9 medical students (90%) and residents (94%) reported that lectures were used in their gross
10 anatomy course, and the use of laboratory sessions with medical students (97%) and residents
11 (94%) also emerged as a very common teaching methodology. The remaining teaching
12 methodologies for fourth year medical students and residents were far less commonly used. For
13 medical students, 38% reported peer-teaching being used; 30% reported TBL; 26% reported
14 PBL; 25% reported case studies; and 9% reported the use of online self-study modules during
15 medical school. It is important to note that the variety seen in teaching modalities among the
16 fourth year medical students was in part due to the fact that IUSM students are distributed among
17 nine separate, geographically isolated campuses for their preclinical training. Each campus has
18 its own complement of anatomy courses taught by local faculty, and there is variation in
19 instructional methodology among the nine campuses. As for residents, 43% reported PBL being
20 used; 43% reported TBL; 40% reported peer-teaching; 34% reported case studies; and 28%
21 reported the use of online self-study modules in their anatomy course during medical school (See
22 Figure 1 for full details).

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48 Participants were then asked to report the predominant mode of laboratory instruction
49 used in their gross anatomy course. Both medical students (95%) and residents (89%) reported
50 that dissection of cadavers was the predominant mode of instruction used in the laboratory, while
51 only 4% of medical students and 3% of residents reported that prosections were the predominant
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3 mode of instruction used in the laboratory. The use of plastic models, radiographs, digital
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5 technology, or other methodologies each emerged with fewer than 3% of participants identifying
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7 them as predominant modes of instruction used in their laboratory.
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10 *Course-Specific Preparation for Anatomical Competence*

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12 Fourth year medical students and residents were asked to report how they felt their
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14 various anatomy courses, including gross anatomy, neuroanatomy, histology, and embryology
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16 prepared them to be anatomically competent in their future or current residency program. When
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18 asked how well they thought their gross anatomy education prepared them to be anatomically
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20 competent in their future/current residency, 57% of fourth year medical students and 57% of
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22 residents felt either 'well' or 'very well prepared'. When asked how well they thought their
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24 neuroanatomy education prepared them to be anatomically competent in their future/current
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26 residency, a similar breakdown was found. With 61% of fourth year medical students and 49%
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28 of residents feeling either 'well' or 'very well prepared'. When asked how well they thought
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30 their histology education prepared them to be anatomically competent in their future/current
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32 residency, fewer felt 'well' or 'very well prepared', with 42% of fourth year medical students
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34 and 48% of residents feeling either 'well' or 'very well prepared'. Finally, when asked how well
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36 they thought their embryology education prepared them to be anatomically competent in their
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38 future/current residency, a much bleaker picture of preparation emerged. Fifty-one percent of
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40 fourth year medical students and 29% of residents felt either 'poorly' or 'very poorly prepared';
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42 38% of fourth year medical students and 47% of residents felt 'adequately prepared'; while only
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44 12% of fourth year medical students and 25% of residents felt either 'well' or 'very well
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46 prepared'. All course-specific preparation results can be found in Table 2.
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53 *Adequacy of Anatomical Preparation and Anatomical Development*

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4 Participants were asked to rank how they agreed or disagreed with the following
5 statement: "*Learning gross anatomy in medical school was critical in preparing me for clinical*
6 *practice in my future/current residency.*" The options were: strongly agree, agree, neutral,
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8 disagree, or strongly disagree. Overall, 90% of fourth year medical students and 86% of
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10 residents either agreed or strongly agreed, while only 9% of fourth year medical students and
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12 12% of residents responded that they disagreed, or strongly disagreed.
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18 When fourth year medical students and residents were given eleven options (participants
19 could indicate all that applied) to describe those aspects of their anatomical education they felt
20 were most important to their early development of anatomical competence, there were two
21 responses for both fourth year medical students and residents that emerged as predominant. First
22 was cadaveric dissection, with 78% of medical students and 79% of residents naming this as an
23 important factor in the early development of their anatomical competence (there was no
24 statistically significant difference in the ways the two groups responded). Second, reading
25 textbooks and lecture notes had 71% of medical students and 51% of residents naming this as an
26 important factor in the early development of their anatomical competence. In this case,
27 significantly more medical students than residents thought that reading textbooks and lecture
28 notes was important ($X^2 = 16.27$, 1 d.f., $P < 0.0001$). For both fourth year medical students and
29 residents, the reviewing of anatomy during required rotations, opportunities to self-test
30 knowledge, having anatomy taught in an integrated curriculum, and having the involvement of
31 clinicians in the teaching of anatomy all emerged as being important factors in the early
32 development of their anatomical competence, with about one-fourth or more of the respondents
33 from each group identifying these factors (See Table 3).
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Next, fourth year medical students and residents were given 12 options, based on previously published literature, to describe the ways they felt their anatomical education could have been improved in medical school to strengthen their anatomical competence; participants could indicate all that applied. Both groups felt strongly that placing a greater emphasis on the clinical relevance of anatomy in medical school could have strengthened their anatomical competence (68% of fourth year medical students and 71% of residents). When compared to residents, significantly more fourth year medical students felt that integrating anatomy with other basic science disciplines ($X^2 = 8.70$, 1 d.f., $P = 0.032$), having 3rd or 4th year advanced anatomy electives ($X^2 = 4.87$, 1 d.f., $P = 0.027$), having more patient contact ($X^2 = 6.47$, 1 d.f., $P = 0.011$), and increasing the time spent peer-teaching ($X^2 = 8.21$, 1 d.f., $P = 0.004$) could have strengthened their anatomical competence in medical school. In addition, significantly more residents than fourth year medical students felt a greater emphasis on lectures ($X^2 = 15.49$, 1 d.f., $P < 0.0001$) could have strengthened their anatomical competence, however this viewpoint represented a very small number of resident respondents (< 10%).

Continuing Development/Progression of Anatomical Competence

The respondents were provided with nine options and asked which activities during their medical school training (for fourth year medical students) or residency training (for residents) had been most important to their continuing development and progression of anatomical competence (participants could indicate all that applied). The majority of fourth year medical students (60%) and residents (57%) indicated that reviewing textbooks or online learning resources was the most important activity in their continuing development of anatomical competence. The teaching of other medical students/residents emerged as another very important activity that contributed to the continuing development of anatomical competence,

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3 with significantly more medical students (56%) than residents (44%) indicating the importance
4 of this activity ($X^2 = 5.52$, 1 d.f., $P = 0.0189$). Table 4 shows the remaining ways in which
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8 fourth year medical students and residents responded to this question.
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10 It is important to point out that practicing in the clinical skills lab and discussing cases
11 with colleagues were also important to both groups, with each of these activities having well
12 over a third of the respondents agreeing to their importance in the continuing development of
13 anatomical competence. For fourth year medical students, studying for clerkship exams emerged
14 as an important activity, and had significantly more medical students rank it as important as
15 compared to residents ($X^2 = 27.96$, 1 d.f., $P < 0.001$). For residents' responses specifically,
16 attending seminars ($X^2 = 5.65$, 1 d.f., $P = 0.0174$) and reading journal articles ($X^2 = 9.37$, 1 d.f.,
17 $P = 0.0022$) did not emerge with the highest percentage of respondents, however both emerged
18 as activities that had significantly more residents rank them as important as compared to the
19 fourth year medical students.
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38 **Residency Program Directors**

39 The survey administered to the residency program directors was comprised of seven
40 questions, of which three were qualitative in nature and were asked only of residency program
41 directors. The first qualitative question asked of program directors was: "*In the past five years,*
42 *were there any areas of anatomical knowledge that you felt your residents were particularly well*
43 *prepared in?*" While the majority of program directors simply replied 'no' to this question, 14
44 program directors (16%) did mention specific qualitative examples of strong anatomical
45 competence. Of these responses, the following themes represented the most common areas that
46 program directors felt their residents were particularly 'well prepared' in: cardiovascular
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3 anatomy (36%; 5/14 respondents), skeletal anatomy (36%; 5/14 respondents). The remainder of
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5 the responses failed to amount to a major thematic finding. With respect to being ‘well
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7 prepared’ in the area of cardiovascular anatomy, one program director remarked, “*Residents*
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9 *seem to be able to use their cardiovascular anatomy knowledge to read echocardiograms,*
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11 *ultrasounds and evaluate CTs.*” Although not a major theme, with respect to being prepared in
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13 neuroanatomy, one program director stated that, “*Most of our residents are adequately-well*
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15 *prepared in their knowledge of basic neuroanatomy and demonstrate this in the OR and on their*
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17 *annual written board exams.*”

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22 Program directors were then asked: “*In the past five years, were there any areas of*
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24 *anatomical knowledge that you felt your residents were particularly underprepared in?*” This
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26 question garnered a much higher response, with nearly 60% of program directors (n=51) citing
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28 specific areas of concern. Of these, the following major themes emerged as areas that program
29
30 directors felt their residents were particularly underprepared in: general anatomical knowledge
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32 (41% of responses; n=21), central nervous system anatomy (19% of responses; n=10), head and
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34 neck anatomy (17% of responses; n=9), pelvic anatomy (16% of responses; n=8), and finally the
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36 remaining 7% of responses fell into a miscellaneous category that included vascular anatomy,
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38 musculoskeletal anatomy, and anatomy needed for common patient exams (e.g., knee
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40 examination, testicular examination). The predominant finding that general anatomical
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42 knowledge was the area that most program directors felt their residents were underprepared in
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44 was highlighted by the comments, “*Functional anatomical knowledge is lacking, but really all*
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46 *aspects of anatomy are weak*”; and “*PGY-1’s are less prepared than in the past.*” Program
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48 directors also mentioned that, “*Residents have to learn their clinically-relevant anatomy for each*
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50 *clinical problem and the importance of the relevant anatomy has to be explained to them*”; and
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“*Very basic things like naming structures*” is also an area of concern. Furthermore, one program director pointed out that, “*Since anatomy is taught in the first year of medical school...most have very little recollection of the anatomy they learned.*”

Finally, program directors were asked: “*For your residents who are not progressing adequately in their clinically-relevant anatomical knowledge, how do you facilitate improvement?*” The most common theme that emerged, with nearly one-fourth of the program directors identifying this as an improvement method, was to encourage residents to increase their independent study; this could be a recommendation to read textbooks, journal articles, search online databases, or simply study more. Purposefully and intentionally discussing/teaching pertinent anatomy with struggling residents, particularly as it was being used with patients; encouraging time spent doing cadaveric dissections; and conducting lectures on relevant material were also popular responses.

Fourth Year Medical Students, Residents, and Residency Program Directors

Four common questions were included on all three surveys and asked of all participant groups (fourth year medical students, residents, and residency program directors). Data were analyzed using the Kruskal-Wallis test for non-parametric data; the non-parametric data reflected the Likert based response scale offered for each question. The first question asked about anatomical preparedness upon entering residency. Specifically, it asked fourth year medical students how well prepared they felt in their anatomical knowledge prior to beginning a residency; it asked residents how well prepared they felt in their anatomical knowledge when they first entered their residency; and finally, it asked program directors how well they felt their residents entering their program had been prepared in their anatomical knowledge relevant to the

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3 specialty. Participants could respond with one of the following answers based on a five-point
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5 Likert scale: 5 = very well prepared, 4 = well prepared, 3 = adequately prepared, 2 = poorly
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7 prepared, or 1 = very poorly prepared. Significant differences were noted ($p < 0.0001$) in how
8
9 the three groups responded to this question. Residents felt the most anatomically prepared
10
11 (average rating: 3.7), followed by fourth year students (average rating: 3.6), and lastly by
12
13 program directors (average rating: 3.1) who felt on an average that their residents were only
14
15 'adequately' prepared. It is important to note, however, that 18.1% of program directors felt that
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17 their residents were either 'poorly' or 'very poorly' prepared in their anatomical knowledge upon
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19 entering residency; and only 6.6% felt their residents were 'very well' prepared upon entering
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21 residency. See Figure 2 for results.
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27 The second question asked of all three participant groups pertained to the current
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29 progression and/or development of anatomical knowledge. Specifically, it asked fourth year
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31 medical students and residents how they would rate their development of anatomical competence
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33 in their current stage of training; and it asked residency program directors how well, on average,
34
35 they felt their residents were progressing in their clinically-relevant anatomical knowledge.
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37 Participants could respond with one of the following answers based on a Likert scale: 5 =Very
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39 good progress, 4 = Good progress, 3 = No progress, 2 = Poor progress, or 1 = Very poor
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41 progress. Again, responses indicated a significant difference ($p < 0.0001$) in how the groups
42
43 responded to this question. Residents once again felt best about their current development of
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45 anatomical knowledge (average rating: 4.1), followed by fourth year students (average rating:
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47 3.9), and lastly by program directors (average rating: 3.4). The program directors average rating
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49 was again the lowest in terms of how they felt the anatomical knowledge of their residents was
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51 progressing. See Figure 2 for results.
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The third question asked of all three participant groups pertained to the need for more anatomical education. Specifically, it asked the fourth year medical students how much they agreed with the statement, *“I feel there is a need for more formal anatomy educational opportunities during medical school”*; it asked residents how much they agreed with the statement, *“I feel there is a need for more formal anatomy educational opportunities during residency”*; and it asked residency program directors how much they agreed with the statement, *“I feel there is a need for more formal anatomy educational opportunities for the residents in my program.”* Participants could respond with one of the following answers based on a Likert scale: 5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, or 1 = strongly disagree. Data showed no significant difference in how the three groups responded to this question, with the average response being a 3.6 on the aforementioned scale, indicating that all three groups felt the need for additional anatomical education. See Figure 2 for results.

Finally, the last question asked of all three participant groups was qualitative in nature. Specifically, it asked, *“What are your top three suggestions for improving anatomical competence?”* From this, four major themes emerged from the data that reflected the participants’ top suggestions for improving competence. First, there is a need to have more opportunities for cadaveric dissection—in medical school and residency; second, there is a need to more consciously and consistently teach anatomy when it is being used—whether this is with a patient, in the operating room, or in the clinic; third, there is a need to hold more workshops that specifically focus on the review of anatomy; and finally, there is a need to more fully integrate anatomy with the teaching of other subjects during medical school.

DISCUSSION

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3 The primary aim of this study was to assess, quantify, and compare the perceptions
4 concerning the current state of anatomical competence from the perspectives of fourth year
5 medical students, residents, and residency program directors at IUSM. This study gives an
6 interesting insight into the areas where there is agreement, as well as demonstrates that there are
7 areas of substantial and significant disagreement among the three groups.
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17 **Fourth Year Medical Students and Residents**

18 *Early Development of Anatomical Competence*

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20 Whereas all of the fourth year medical student data represents only one medical school
21 (IUSM), resident data includes students from multiple medical schools (137), and multiple
22 countries (14). This may be one factor that explains the different views and findings between the
23 two groups. For example, while fourth year medical students and residents both cited lectures
24 and laboratory sessions as the most common teaching methods used in their anatomy course
25 during medical school, further analysis revealed that PBL, TBL, case studies, and online learning
26 modules emerged as methods that were used significantly more in the case of residents as
27 compared to the fourth year medical students, representing the diversity through which anatomy
28 is currently being taught. At IUSM, medical students are distributed among nine separate
29 campuses for their preclinical training. Each campus has its own complement of anatomy
30 courses taught by local faculty. Although there is some variation in instructional methodology
31 among the nine campuses, with some emphasizing PBL and TBL over traditional methods, we
32 believe it is fair to say that the most common mode of anatomy instruction for medical students
33 and residents is lectures and laboratory sessions. However, this in turn is one of the limitations
34 of this study, and future studies would examine a more diverse group of participants, particularly
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3 participants who have had exposure to anatomical teaching/learning outside of the traditional
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5 lecture and laboratory sessions.
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8 When asked about the aspects of their anatomy education that were most important to
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10 their early development of anatomical competence, both groups responded that cadaveric
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12 dissection and reading of textbooks and lecture notes were most important. The importance of
13
14 cadaveric dissection is consistent with previous research. Saltarelli and colleagues (2014) have
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16 shown that human cadaveric dissection offers a significant advantage over multimedia
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18 simulation programs on measures of identification and explanatory knowledge. In addition,
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20 there are unique advantages in keeping traditional dissection in the medical curriculum,
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22 advantages that arguably still outweigh other learning technologies. Our findings also agree with
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24 Dinsmore and colleagues (2001), who found that the vast majority of medical students expressed
25
26 a positive attitude toward the dissection experience, while Aziz and colleagues (2002) added that
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28 dissection is still necessary, in part, to establish the primacy of the patient. In addition, Gregory
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30 and Cole (2002) argue that dissection in American medical education combines the ideals of the
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32 profession, which include the acquisition of scientific knowledge and the development of
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34 humanistic attitudes and behavior. Lemmp (2005) showed that dissection offers a platform to
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36 impart tangible anatomical knowledge, gives students an important three-dimensional view of
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38 human anatomy, provides the opportunity to appreciate the range of variability present in real
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40 human material, while Patel and Moxham (2006) found there was a preference for the use of
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42 human cadaveric dissection among anatomists. However, Winkelmann (2007) pointed toward
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44 the need for additional educational research in anatomy in order to counterbalance emotional
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46 arguments about dissection with evidence, which in the context of this study, it is necessary to
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48 point out that emotionality may have influenced opinions concerning dissection and its worth.
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3 Additional research points towards dissection being the platform that introduces the student to
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5 their ‘first patient,’ helps students learn how lifestyle might have contributed to disease,
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7 increases appreciation of the contribution made to their education by the donors, and introduces
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9 students to self-directed learning and teamwork (Ferguson et al., 2008). Cadaveric dissection is
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11 clearly perceived to be of significant value to both fourth year medical students and residents.
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14 This should be borne in mind when medical schools consider curricular reforms.
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18 Fourth year medical students and residents also showed fairly consistent agreement over
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20 the importance of reading textbooks and lecture notes, having opportunities to self-test, having
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22 anatomy taught in an integrated curriculum, and having clinicians involved in the teaching of
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24 anatomy as being essential elements in their early development of anatomical competence.
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27 While an integrated curriculum has been shown to be as, if not more effective, when it comes to
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29 student performance and course evaluations in a foundational anatomy course (Halliday,
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31 O’Donoghue, Klump, and Thompson, 2014), our findings suggest that even with the variety of
32
33 novel teaching methods used in the undergraduate medical education of our participants, some of
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35 the more traditional and time-tested methods continue to rank as highly important in learning
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37 anatomy. These preferences should be seriously considered when designing a curriculum,
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39 especially in light of recent research that points towards the importance of collecting and valuing
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41 student preferences to optimize teaching methods and delivery (Davis et al., 2014).
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48 *Continuing Development of Anatomical Competence*

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51 When fourth year medical students and residents were asked what activities during their
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53 current training have been most important to their continuing development of their anatomical
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55 competence, the top two responses were the reviewing of textbooks/online resources, and
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3 teaching others. Educational research suggests that once a learner has established a foundation
4 of basic principles in a discipline, the learner can more fully explore other self-directed learning
5 methods to add to their knowledge base (Philip et al., 2008). Teaching one's peers has long been
6 shown to be an effective model used to refine knowledge and skills in medical education (Tang
7 et al., 2004). Our data suggests that the reviewing of textbooks/online resources, and the
8 teaching of others (which included formal peer-teaching learning activities), are likely the most
9 convenient and accessible ways in which medical students and residents are currently continuing
10 to develop their competence in anatomy after formal coursework has concluded. We suggest
11 that consistent and supported access to printed text, online resources, and opportunities to teach
12 others should be provided to medical students and residents as a cost-effective way to develop
13 and sustain anatomical competence.
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29 Finally, it is important to note that practicing in the clinical skills lab and discussing cases
30 with colleagues were also important to both groups—with each of these activities having well
31 over a third of the respondents agreeing to their importance in the continuing development of
32 anatomical competence. Discussing cases with colleagues likely includes the physician-to-
33 physician communication that occurs during patient handoffs. It has been documented that
34 handoffs in medicine require a solid foundation in communication skills, however they are often
35 variable in their quality and content (Solet et al., 2005). Therefore, these handoff interactions
36 present unique opportunities for clinical faculty to review case-specific relevant anatomy with
37 the learners on the team while conveying other important information about patient care.
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53 *Areas of Anatomical Education Needing Improvement*
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3 Nearly 70% of fourth year medical students and residents in this study indicated that
4 placing a greater emphasis on the clinical relevance of anatomy during medical school would
5 have helped them to improve their anatomical competence overall. This finding is in agreement
6 with previous research that emphasizes the importance of integrating basic sciences with clinical
7 medicine, as this allows learning to take place in an authentic context, reinforces reasons for
8 learning, is central to solving future clinical problems, and is important for undertaking safe
9 clinical practice (Drake, 2007; Fitzgerald et al., 2008). In addition, research has shown that
10 when the learning of anatomy is done in a setting that is clinically meaningful and relevant to the
11 academic and career goals of the learner, it facilitates the later retrieval of useful information and
12 fosters the efficient acquisition of knowledge (Stanford et al., 1994; Nnodim, 1997; McLachlan
13 et al., 2004; Drake, 2007).

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29 Similarly, the majority of fourth year medical students and residents felt that there was a
30 need to integrate anatomy with other disciplines/subjects in medical school, and considered this
31 to be an important educational area needing improvement. This is not surprising, as the
32 advantages of integrating anatomy with other disciplines throughout the medical school
33 curriculum have been addressed previously, showing that integration reinforces core anatomical
34 principles by fostering appreciation of its context with other subjects and its clinical relevance
35 (Turney, 2007). Indeed, Drake et al. reported in 2009 that only 30% of medical schools in the
36 United States taught anatomy as part of an integrated curriculum. However, as of 2014, Drake et
37 al. reported that more gross anatomy courses were part of an integrated curriculum, with 45% of
38 surveyed schools reporting an integrated curriculum. Therefore, the predominant preference of
39 the learners in this study to be taught in an integrated fashion may in part reflect the fact that
40 participants learned part of, or all of their anatomy within an integrated curriculum and prefer
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3 this approach. Therefore, our study's findings are of particular interest, because they go beyond
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5 affirming the educational soundness of integrating anatomy with other disciplines, and in
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7 addition show that the predominant preference of our learners mirrors trends in curricular
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9 evolution, namely to have anatomy taught in an integrated fashion.
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13 Finally, having been told how anatomical competence was defined in the context of this
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15 study, nearly one-half of the fourth year medical students and residents in our study felt that
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17 having a greater involvement of clinicians in the teaching of anatomy in medical school would
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19 have improved their anatomical competence. Research has shown that clinical teachers are
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21 central to the successful education of medical graduates, and students appreciate their knowledge
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23 and skillset (Dahlstrom et al., 2005). When Dahlstrom et al. (2005) surveyed clinicians, they
24
25 found that the main factors influencing clinician motivation to teach medical students were
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27 intrinsic issues such as altruism, intellectual satisfaction, and truth seeking; teaching that at its
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29 core was done with the desire to help students become good doctors. In particular, the students
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31 appreciate the knowledge of medicine that clinicians bring to the teaching endeavor, and the
32
33 ability of their clinical teachers to draw upon experiences they have built up through direct
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35 interactions with patients (Parsell and Bligh, 2001). Therefore, our findings support the notion
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37 that students have a clear appreciation for, and a desire for, greater clinician involvement in the
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39 teaching of anatomy.
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48 **Program Directors**

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50 The program directors in this study were particularly opinionated concerning the areas
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52 they felt their entering residents were underprepared in. However, it is important to note that the
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54 residency directors surveyed in this study came from medical specialties where anatomy was
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3 exceptionally relevant, and as such may have allowed their specialty-focused biases to
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5 differentiate their patterns of responses. Even so, one of the reasons for such opinionated
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7 responses may be due to the specific area that was cited as needing the most help, which was
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9 general anatomical knowledge—a broad sweeping, impactful area with the highest percentage of
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11 program directors indicating it was a problem (41%). Comments centered around the fact that
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13 many residents lacked the ability to name structures, needed relevant anatomy to be explained to
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15 them, were perceived to be less prepared entering residency than in past years, and that as a
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17 whole, their anatomical knowledge was weak. Findings suggest that a general anatomical review
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19 course early on in residency, specific to specialty, could be beneficial to address the general
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21 areas of deficiency resident directors feel their residents possess.
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27 Interestingly, our data supports and reaffirms research from over a decade ago, which
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29 found that even then, program directors in the United States felt residents needed to be more
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31 proficient in their general anatomical knowledge (Cottam, 1999). Similarly, Barden et al.,
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33 (2002) reported that both residents and program directors felt that residents' knowledge of basic
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35 science had not improved from the previous decade, as expected, and remained an area of
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37 weakness. In addition, it is possible that program directors hold their residents to
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39 disproportionately high standards upon entering residency, losing perspective of the fact that
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41 they are comparing incoming residents' knowledge to what they expect well-trained residents to
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43 have, this would also explain similar findings from previous research (Cottam, 1999; Barden et
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45 al., 2002). Finally, our data suggests a number of more specific areas where program directors
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47 felt their residents were particularly weak, such as central nervous system anatomy, head and
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49 neck anatomy, and pelvic anatomy, all important areas where additional educational resources
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51 could be directed.
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Importantly, when program directors were asked how they would facilitate improvement for those residents they felt were not progressing adequately in their clinically relevant anatomical knowledge, they were remarkably consistent in their responses, indicating that they would first suggest independent study. To some extent this may reflect the fact that even with a reduction in resident work hours, and a perceived overall improvement in the quality of resident life, time and resources available to residents and their program directors for remediation are still limited. This perhaps necessitates that independent study be the first course of action many program directors choose to facilitate improvement (Barden et al., 2002).

Overall Analysis: Fourth Year Medical Students, Residents, and Residency Program

Directors

When all three groups were asked their opinions about how prepared in their anatomical knowledge they felt (depending on their stage of training, and position), opinions differed significantly. Residents felt the most prepared, followed by fourth year medical students, and finally by program directors who felt on average that their residents were only 'adequately' prepared in their anatomical competence. The significant difference in perception of anatomical preparedness could be attributed to the fact that fourth year medical students lack the immersive clinical experience of residents, so their confidence in their preparation has yet to be fully formed and remains underestimated. Conversely, program directors have had years of clinical experience and can very accurately judge the anatomical preparedness of individuals, being more acutely aware of accomplishments and shortcomings. These findings support Lazarus and colleagues (2012) who also found that both clinical educators and medical students alike felt that medical students were ill prepared to transfer their anatomical knowledge to the clinic.

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3 It is important to note, however, that residents are not confident in all areas. Research
4 has shown that residents often lack confidence in their ability to care for critically ill patients as
5 specialty-specific team leaders (Hayes et al., 2011). Nevertheless, our data suggest that residents
6 are fairly confident in their anatomical preparedness in practice, while those who supervise the
7 residents are much less confident, with nearly a fifth of program directors feeling their residents
8 were either 'poorly' or 'very poorly' prepared in their anatomical preparedness upon entering
9 residency. This shows a very clear discordance between these two groups' perception of their
10 anatomical preparedness, and warrants further investigation to understand why, and to explore
11 ways to better align the expectations of residents and program directors.
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24 When asked about the current development/progression of their anatomical knowledge,
25 residents, once again, felt the best about how their knowledge was progressing, followed by
26 fourth year medical students, and lastly by program directors whose average rating of their
27 residents was lowest. While the differences were significant, the authors feel that the program
28 directors lower opinion reflects the fact that they are likely to have taken a longer-term view of
29 this question. While residents may be thinking that their knowledge is progressing both
30 efficiently and wholly at present, program directors have the advantage of experience and
31 personal knowledge, knowing precisely how much more a resident has to learn, and the time in
32 which they have to learn it. Thus, the perspective of the program directors is likely to be more
33 conservative in the long-term.
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48 Finally, this study carries an important lesson, in that even though there were many
49 differences of opinions among how the groups responded to questions throughout the surveys,
50 when all three study populations were asked if they felt that there was a need for additional
51 anatomical education, they all agreed. There is a need for additional anatomical education—in
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3 medical school and during residency training. These findings agree with the conclusions drawn
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5 from the study conducted by Lazarus and colleagues (2012), which found a need for advanced
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7 anatomy courses to be taught in conjunction with medical students' clinical education, courses
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9 that should be informed and developed through input from both clinicians and academic
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11 anatomists.
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15 In this study, the ways in which the three groups suggested how this need could be
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17 addressed, and anatomical knowledge improved, were fairly similar and straightforward. First,
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19 respondents suggested having more opportunities for cadaveric dissection, an idea supported by
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21 previous research which suggests that using cadaveric specimens to learn anatomy is
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23 advantageous (Ellis, 2001; Patel and Moxham, 2006; Raftery, 2007). This finding suggests that
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25 even though many participants indicated a preference for an integrated curriculum in medical
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27 school, participants desire increased access to some of the more traditional learning
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29 methodologies, specifically access to cadaveric dissection. Second, respondents suggested that
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31 there is a need to more consciously and consistently teach anatomy when it is being used,
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33 whether this is with a patient, in the operating room, or in the clinic. Again, this is supported by
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35 previous research that suggests that learning is progressive and developmental in nature. That
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37 due to the situated and distributed nature of learning, there needs to be a stronger connection
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39 between clinical learning in specific contexts and the formal knowledge basic to the practice of
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41 medicine, like anatomy (Cooke et al., 2010). Third, respondents suggested that there is a need to
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43 hold more workshops that specifically focus on the review of anatomy. Anatomically-focused
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45 workshops are feasible and beneficial to students and residents alike. Examples of effective
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47 workshops include ones that use ultrasound to teach anatomy (Miles, 2005; Brown et al., 2012;
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49 Dreher et al., 2014), dissection workshops in clinical anatomy for residents in various specialties
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3 (Macchi et al., 2003), and didactic radiologic imaging sessions that teach applied anatomy
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5 (Gunderman and Wilson, 2005).
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8 Finally, respondents suggested that there is a need to more fully integrate anatomy with
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10 the teaching of other subjects during medical school. This desire is supported by the literature,
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12 which suggests that teaching basic sciences in a manner that is more consistent with clinical
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14 practice is advantageous as an integrated approach. Learning this way emulates how a clinician
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16 must eventually think, and there is an overwhelming amount of information one needs to learn in
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18 medicine that cannot feasibly be taught in only two years (Brooks et al., 2015).
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24 **Limitations of this study**

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27 This study has several limitations. It was conducted at one Mid-Western public medical
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29 school (IUSM) in the United States, surveying fourth year medical students from only this
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31 institution, a factor that limits the generalizability of our findings. However, our resident sample
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33 population in this study represented individuals from a wide variety of medical schools and
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35 educational backgrounds in anatomy, resulting in a group that included residents from multiple
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37 medical schools across the country and the world. Another limitation was the low response rate
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39 from the fourth year medical students (46%) and residents (47%). Nevertheless, these response
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41 rates are comparable to those reported in similar studies of medical students and residents, which
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43 were in the 50% range (Dinsmore et al., 2001; Kerby et al., 2011; Olowo-Ofayoku and Moxham,
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45 2014). The authors also acknowledge that in order to fully understand this study's findings, and
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47 draw broader conclusions, there is a need to validate our survey instruments, and assess their
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49 reliability at additional institutions and medical schools—particularly medical schools with
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51 different curriculum than at the institution surveyed.
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6 CONCLUSION
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8 Our findings point to some interesting results that can be classified into the past, present,
9 and future. As for the past, upon entering residency, residents felt significantly more prepared
10 than fourth year medical students, or how their program directors felt they were prepared, in
11 terms of their anatomical competence. Presently, residents feel they are developing their
12 anatomical competence significantly better than fourth year medical students see themselves, or
13 how program directors see their residents progressing. Finally, for the future, all three groups
14 (fourth year medical students, residents, and program directors) feel there is a need for more
15 formal anatomical education. When asked what their suggestions were for improvement, they
16 responded that there need to be more opportunities for cadaveric dissection, more conscious and
17 consistent teaching of anatomy when it is used with patients, available workshops that focus on
18 the review of anatomy, and integrating the teaching of anatomy with other subjects during
19 medical school. In considering the perspectives of those individuals who are at the forefront of
20 learning, our findings can more fully inform our changing anatomical landscape in order to guide
21 and shape it in ways that are most effective and needed.
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For Peer Review

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For Peer Review

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For Peer Review

TABLE TITLES:

Table 1: Survey Returns by Residency Program Type

Table 2: Course Specific Self-Reported Perceptions of Preparation for Competence

Table 3: Self-Reported Perceptions Concerning the Early Development of Anatomical Competence

Table 4: Self-Reported Perceptions of Factors Contributing to the Continuing Development of Anatomical Competence

FIGURE LEGENDS:

Figure 1: Self-reported teaching methodologies students/residents experienced in their gross anatomy instruction.

Figure 2: Likert scale responses to three questions from the survey. Five-point Likert scale for Q1: 5 = very well prepared, 4 = well prepared, 3 = adequately prepared, 2 = poorly prepared (2), or 1 = very poorly prepared. Five-point Likert scale for Q2: 5 = Very good progress, 4 = Good progress, 3 = No progress, 2 = Poor progress, or 1 = Very poor progress. Five-point Likert scale for Q3: 5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, or 1 = strongly disagree. Mean, \pm standard deviation (SD) is indicated on the bars. *Denotes a statistically significant difference in how the groups responded at $P < 0.05$.

Table 1. Survey Returns by Residency Program Type

Residency Program	Residents			Program Directors		
	Number of surveys sent	Number of responses	Response rate (%)	Number of surveys sent	Number of responses	Response rate (%)
Anesthesia	88	50	56.8	4	4	100
Dentistry	20	6	30.0	3	2	66.7
Diagnostic Radiology	81	49	60.5	10	7	70.0
Emergency Medicine	75	27	36.0	5	4	80.0
Internal Medicine	270	136	50.4	22	19	86.4
Neurology	21	10	47.6	3	2	66.7
Neurological Surgery	13	8	61.5	2	2	100
OB/GYN, Obstetrics and Gynecology	44	18	40.9	4	3	75.0
Ophthalmology	18	5	27.8	2	1	50.0
Orthopedic Surgery	35	9	25.7	5	3	60.0
Otolaryngology	14	9	64.3	2	1	50.0
Pathology	34	12	35.3	10	4	40.0
Radiation Oncology	10	8	80.0	1	0	0.0
Surgery	102	44	43.1	9	5	55.6
Urology	21	7	33.3	4	4	100
Total	846	398	47.0	86	61	70.9

Table 2. Course Specific Self-Reported Perceptions of Preparation for Competence

Course	Very Well or Well Prepared		Adequately Prepared		Poor or Very Poorly Prepared	
	4 th Year Medical Students n, (%)	Residents n, (%)	4 th Year Medical Students n, (%)	Residents n, (%)	4 th Year Medical Students n, (%)	Residents n, (%)
Gross Anatomy	79 (57.3)	219 (57.0)	41 (29.7)	49 (35.5)	18 (13.0)	28 (7.2)
Neuroanatomy	85 (61.3)	190 (49.3)	41 (29.7)	156 (40.5)	12 (8.7)	38 (9.9)
Histology	58 (42.0)	185 (48.0)	63 (45.7)	168 (43.6)	18 (13.0)	32 (8.3)
Embryology	16 (11.7)	95 (24.7)	53 (38.4)	180 (46.7)	70 (50.7)	110 (28.6)

Table 3. Self-Reported Perceptions Concerning the Early Development of Anatomical Competence

Aspects of Your Anatomical Education Important for the Early Development of Your Anatomical Competence	Fourth Year Medical Students n, (% Agreed)	Residents n, (% Agreed)	P-value
Cadaveric dissection	108, (78.2)	315, (79.1)	0.7756
Reading textbooks and lecture notes	98, (71.0)	203, (51.0)	<0.0001 ^a
Review of anatomy during rotations	68, (49.3)	108, (27.1)	<0.0001 ^a
Opportunities to self-test knowledge	51, (37.0)	100, (25.1)	0.0058 ^a
Anatomy taught in integrated curriculum	35, (25.4)	108, (27.1)	0.7067
Involvement of clinicians in teaching anatomy	32, (23.2)	108, (27.1)	0.3514
Small group learning (e.g., PBL)	13, (9.4)	76, (19.1)	0.0080 ^a
Peer teaching	27, (19.6)	60, (15.1)	0.3005
Online learning	18, (13.0)	44, (11.1)	0.5565
Third or fourth year advanced anatomy electives	21, (15.2)	32, (8.0)	0.0162 ^a
Patient contact	2, (1.4)	28, (7.0)	0.2872

^aDenotes a statistically significant difference in how the two groups responded ($p < 0.05$).

Table 4. Self-Reported Perceptions of Factors Contributing to the Continuing Development of Anatomical Competence

Activities Most Important for the Continuing Development of Anatomical Competence	Fourth Year Medical Students n, (% Agreed)	Residents n, (% Agreed)	P-value
Reviewing textbooks or online resources	83, (60.1)	219, (56.9)	0.5061
Teaching other medical students/residents	77, (55.8)	170, (44.2)	0.0189 ^a
Practicing in the clinical skills lab	59, (42.8)	160, (41.6)	0.8073
Discussing cases with colleagues	48, (34.8)	146, (37.9)	0.5128
Studying for clerkship/in-service exams	74, (53.6)	110, (28.6)	<0.0001 ^a
Attending seminars that review anatomy	23, (16.7)	103, (26.8)	0.0174 ^a
Attending/presenting at grand rounds	22, (15.9)	82, (21.3)	0.1766
Reading journal articles	6, (4.4)	54, (14.0)	0.0022 ^a
Attending/presenting at conferences	3, (2.2)	18, (4.7)	0.1995

^aDenotes a statistically significant difference in how the two groups responded ($p < 0.05$).

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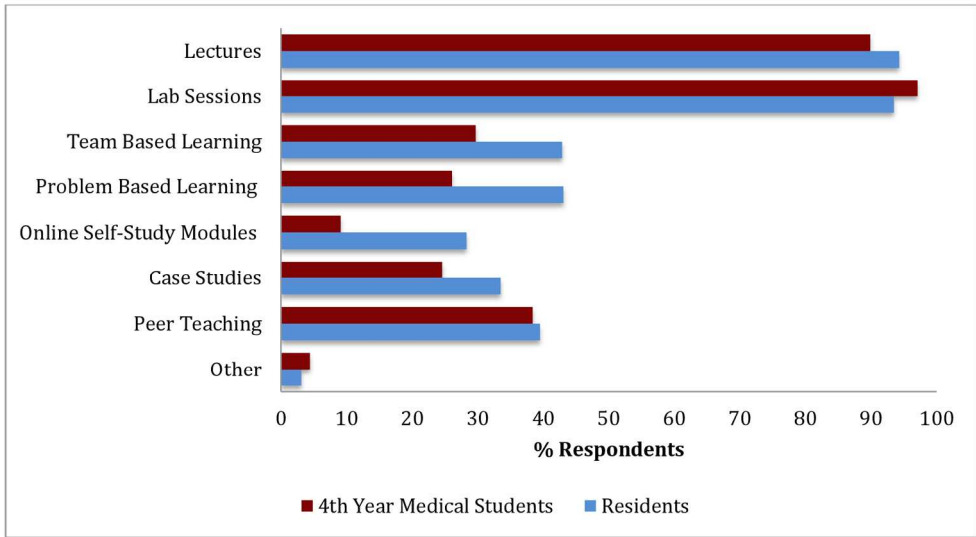


Figure 1: Self-reported teaching methodologies students/residents experienced in their gross anatomy instruction.
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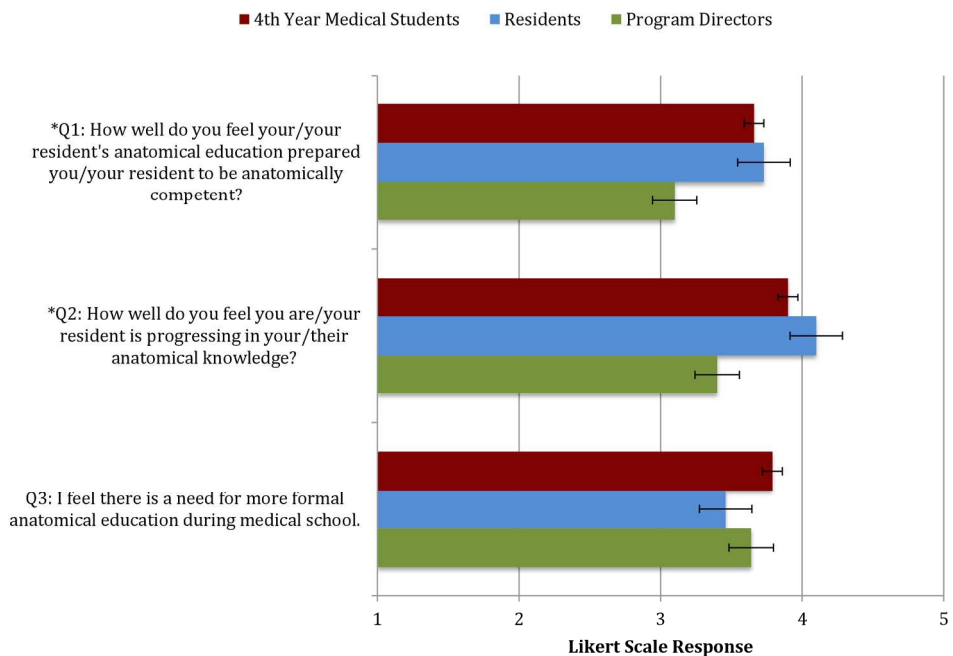


Figure 2: Likert scale responses to three questions from the survey. Five-point Likert scale for Q1: 5 = very well prepared, 4 = well prepared, 3 = adequately prepared, 2 = poorly prepared (2), or 1 = very poorly prepared. Five-point Likert scale for Q2: 5 =Very good progress, 4 = Good progress, 3 = No progress, 2 = Poor progress, or 1 = Very poor progress. Five-point Likert scale for Q3: 5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, or 1 = strongly disagree. Mean, ± standard deviation (SD) is indicated on the bars. *Denotes a statistically significant difference in how the groups responded at P < 0.05.
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view