The Impact of the Images in Multiple-choice Questions on Anatomy Examination Scores of Nursing Students

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Abstract

Visualizing effects of images on improved anatomical knowledge are evident in medical and allied health students, but this phenomenon has rarely been assessed in nursing students. To assess the visualizing effect of images on improving anatomical knowledge and to use images as one of the methods of gross anatomical knowledge assessment in nursing students, the present study was repeated over two semesters. The results show that the percent class average (%) was significantly ($P<0.006$) increased with the inclusion of more anatomical images in a multiple-choice anatomy exam compared to a similar exam with fewer images and was significantly ($P<0.002$) decreased by reducing the number of images by 50% compared to image-rich exams. However, examinations with an equal number of images did not alter the class average. The percent score of individual questions from the examinations with images plus text was significantly ($P<0.001$) higher than the same questions with text only in both semesters. The findings of this study indicate that image inclusion in anatomy examinations can improve learning and knowledge, may help reduce cognitive load, recall anatomical knowledge, and provide a hint to an exam question.

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Key words: anatomy, physiology, images, visualization, nursing, knowledge retention, technology

Introduction

Human anatomy and physiology are considered foundational courses for medical, allied health, and nursing disciplines and serve as a prerequisite for clinical and subsequent years of these disciplines (Estai & Bunt, 2016; McVicar et al., 2014; Young et al., 2016). A variety of assessment methods are available to determine the learning outcomes of anatomical knowledge. These include but are not limited to, multiple choice questions (MCQ), matching questions, written essay questions, short answer questions (Pandey & Zimitat, 2007), labelling and identifying tagged structures (spotting) in specimens in practical examinations, and objective structured clinical examinations (Vorstenbosch et al., 2013; Sagoo et al., 2021). Included are also process questionnaires, the Structure of Observed Learning Outcomes Taxonomy (Pandey & Zimitat, 2007), and the use of various visual aids (Butcher 2006; Vorsteinbosch et al., 2013; Pickering 2015; Notebaert 2017). Images have been used as one of the most common methods of anatomical knowledge assessment by anatomy educators (Vorstenbosch et al., 2013; Notebaert et al., 2016; Sagoo et al., 2021) in the evaluation of students' academic performance, knowledge, competence, and clinical and problem-solving skills (Charlin et al., 2010; Pelgrim et al., 2011).

For the last two decades, due to the explosion in teaching technologies, many anatomy programs have shifted away from cadaveric dissections and prosections (Parker 2002; Bianchi et al., 2020). This may be due in part to changes in anatomy curricula such as increasing costs of cadavers, fewer hours for cadaveric dissection, strict ethics approval processes, and unwanted hazardous side effects (Parker 2002; McMenamin et al., 2014; Mutalik & Belsare, 2016) and emotional trauma associated with cadaveric dissection (Parker 2002; McMenamin et al., 2014; Mutalik & Belsare, 2016). While there has been a continuous increase in student enrollment in anatomy classes, the instructor-to-student interaction hours continue to decrease (McLachlan & Pattern, 2006; Drake et al., 2009; Drake 2014; Vogl 2017). There has been a shift from practical and oral examinations toward written assessment methods and the inclusion of many visual aids (Rowland et al., 2011). As a result, anatomy programs rely on alternate methods to support the teaching and learning of human anatomy (McLachlan 2004; Saxena et al., 2008; Drake et al., 2009; Attardi et al., 2016; Estai & Bunt, 2016; Narnaware & Neumeier, 2021a; Narnaware 2021b).

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The use of images in teaching and learning of anatomy by educators and students in the form of Microsoft PowerPoint® presentations and examinations is routine practice (Pandey & Zimitat, 2009; Vorstenbosch et al., 2013; Notebaert et al., 2016; Sagoo et al., 2021). Similarly, anatomy textbooks mainly consist of a myriad of images, line diagrams, color drawings, photographs, radiographs or animations (Wieslow et al., 2010; Inuwa et al., 2011), and the use of computers, the internet, and various teaching technologies have added a vast and varied number of images to be used by anatomy educators and students (Park et al., 2011; Attardi et al., 2016; Bianchi et al., 2020).

In addition, recent advances in multimedia representations with a plethora of body images provide an additional advantage of visualization to anatomy educators and students (Butcher 2006; Brazina et al., 2014; Estai & Bunt, 2016; Afsharpour et al., 2018). According to many research studies, these multimedia representations include verbal and visual information (Shaffer 2016). The visual representations include cadaveric dissection and prosections (Anyanwu & Ugochukwu, 2010; Souza et al., 2016; Montayre & Sparks, 2017), histological slides (Holland et al., 2015), preserved specimens, simulated laboratories, skeletons and mannequins (Fujieda & Okubo, 2016), anatomic models (Nowinski et al., 2009), plastination (Estai & Bunt, 2016), clay models (Oh et al., 2009), computer-generated three-dimensional (3D) images and 3D printing (McMenamin et al., 2014; Attardi et al., 2016; Backhouse et al., 2017; Zilverschoon et al., 2017; Rutty et al., 2019). Some anatomy educators also display images through educational videos and YouTube® videos (Saxena et al., 2008; Barry et al., 2016), interactive live digital imaging (Preim & Saalfield 2018; So et al., 2018; Rutty et al., 2019), mobile media devices (e.g. smartphones and tablets) (McNally et al., 2017; Raman 2015), while others use social media such as Facebook® (Pickering 2015; Pickering & Bickerdike 2017), Google® (Phelan et al., 2017), Twitter® (Hennesey et al., 2016) and iTunes® or podcasts and screencasts (Pickering 2015; Estai & Bunt, 2016). Others have been incorporating advanced teaching technologies such as virtual reality and 3D visualization goggles (Marta et al., 2017; Phelan et al., 2017), a virtual human cadaver (Anatomage Table; Bianchi et al., 2020; Narnaware & Neumeier 2021), while others have incorporated visual aids such as "living anatomy" that includes ultrasound, body painting (Reeves et al., 2004; So et al., 2017), and use imaging techniques (e.g. X-rays, CT-scans and MRIs) to explain anatomical structures and to familiarize the students with images (So et al., 2017; Rutty, et al., 2019). However, most of the studies enumerated above have evaluated the impact of visual aids on the study of a limited number of organ systems or anatomical regions, such as the cardiovascular system (Butcher 2006), or the head, neck, and trunk anatomy (Pandey & Zimitat, 2007; Vorstenbosch et al., 2013). Therefore, the impact of using images in studying systemic gross anatomy remains to be assessed.

Numerous studies have shown that visualization with images can lead to improved factual learning (Butcher, 2006), knowledge retention (Balemans et al., 2016; Narnaware & Neumeier, 2020a), spatial ability, and recall of anatomical knowledge, as well as reduction of examination anxiety and stress, and alteration of cognitive load; it may provide hints to answering questions in anatomy examinations (Mayer & Moreno, 2003; Mayer 2005; Butcher 2006; Crips & Sweiry, 2006; Barhtolomme & Bromme, 2009; Pickering 2015; Notebaert 2017). These visual aids studies, however, mainly focused on students' cognitive load, exam stress, and anxiety, but little is known on their impact on the students' academic performance.

In Canada, many nursing programs use didactic, passive teaching and learning of anatomy; a few exceptional programs incorporate laboratories without cadaveric dissections (Barton et al., 2016; Alfaro et al., 2018). The impact of the use of images on improving anatomical knowledge has only been investigated in a limited number of studies (Alfaro et al., 2018). Previous studies on the use of visual aids were mainly focused on medical and allied health programs (Pickering 2015; Notebaert 2017), particularly in relation to exam anxiety and stress (Mayer & Anderson, 1992; Sweller 1998; Mayer & Moreno, 2003), memorization, knowledge retention, and cognitive load (Butcher 2006; Crisp & Sweiry, 2006; Bartholomme & Bromme, 2009). These aspects, however, have rarely been assessed in nursing students.

The Department of Health and Science, Faculty of Nursing at MacEwan University in Western Canada has a student-centered nursing curriculum. However, teaching and learning of gross human anatomy in this program is impacted by the low number of instructional hours compared with other nursing programs without a laboratory component in anatomy and physiology in Canada, the United States, and Europe (Diaz-Mancha et al., 2016; Narnaware & Neumeier, 2020; 2021b). Recently, we reported that nursing students retained 71.0% of their first-year anatomical knowledge in their second year (Narnaware & Neumeier, 2019, 2020b) and 51.6% in third-year studies (Narnaware & Neumeier, 2021c). We have initiated many interventional strategies to improve students' long-term retention of anatomical and physiological knowledge, including the use of modern teaching technology (Narnaware & Neumeier, 2021a), content reinforcement (Narnaware & Chahal, 2019), and online and in- class activities (Narnaware et al., 2019). Despite human anatomy being considered a 'visual science' and an image-reliant subject, the impact of images on anatomy exam scores in nursing students has not yet been assessed. The objectives of the present study are: 1) to use images as one of the methods of gross anatomical knowledge assessment, 2) to determine the impact of images on gross anatomy examination scores, and 3) to evaluate the use of images as interventional strategies to improve learning and knowledge of the human body in first-year nursing students.

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Materials and Methods

Design and participants

This study was conducted in Fall 2017 and Winter 2018. The participants were enrolled in the first year of the Bachelor of Science in Nursing program at MacEwan University. Two sections of gross human anatomy, comprising 70-80 students each, were taught by conventional didactic teaching using Microsoft PowerPoint® presentations and a three-dimensional (3D) virtual human cadaver- the Anatomage Table (Anatomage, Inc., California, USA) that the Faculty of Nursing purchased in 2015 (Narnaware & Neumeier, 2021b). This course was taught in a lecture format for 80 minutes two days a week for 13 weeks in each semester; there was no laboratory. The majority of the participants were females (85.4%) with an average age of 21.4 ± 5.38 (means ± SD); the male participants (14.6%) had an average age of 21.8 ± 4.73.

Examinations

This study consisted of three midterms and a final examination with MCQs. The first mid-term (Exam #1) for both cohorts consisted of 66 MCQs and covered the introduction to anatomy, tissues, the integumentary system, bone tissues, articulations (joints), muscular tissue, and the appendicular skeleton (pectoral girdle - bones, muscles, nerves, and blood vessels). The second mid-term (Exam #2) consisted of 62 MCQs and covered the appendicular skeleton (upper limb: bones, muscles, nerves, and blood vessels) and axial skeleton (skull bones and muscle and blood vessels), the cardiovascular system (the heart and blood vessels) and the lymphatic system. The third mid-term (Exam #3) consisted of 65- 66 MCQs and covered the axial skeleton (vertebral column and rib cage - bones, muscles, nerves, and blood vessels) and the respiratory system, nervous system (nervous tissues, spinal cord, spinal nerves, brain and cranial nerves), autonomic nervous system (ANS) and the special senses. The final examination was cumulative, with an emphasis of a few chapters from the third midterm examination, i.e., the brain and the cranial nerves, ANS, special senses, and respiratory system, and covered the appendicular skeleton (pelvic girdle and lower limb - bones, muscles, nerves, and blood vessels), and the digestive, urinary and reproductive systems. The final exam consisted of 120 MCQs. Anatomy Exam #1 in section BN01 included 13 images (more images), whereas section BN02 included 5 images (fewer images). This order was reversed in Exam #2. In this exam, the section BN02 quiz included 11 images (more images), whereas section BN01 included 4 images (fewer images). Exam #3 included 5 images and the final exam consisted of 9 images in both sections (same number of images) (Table 1). The images were taken from lecture material with identification text and labelling removed and numbering adjusted for test items (see Figure 2). The exact order of images in both anatomy cohorts was repeated in Winter 2018, except in that semester, Exam #1, section BN03 consisted of 10 images in one section and 5 images in section BN04. This order was reversed in Exam #2. Exam #3 and the final examination included 4 and 9 images in both sections (BN03 & BN04).

Data analyses

All examinations were given to the students in both cohorts in both semesters in paper format. The MCQ answer sheets were collected at each examination's end and sent to the university's scanning center for optical scoring. The results were returned to the Principal Investigator (PI) in a pdf file with students' answers, score data, statistics such as average mean percent score with standard deviation (SD), confidence interval, and test reliability that included Kuder- Richardson Formula 20, coefficient (Cronbach) alpha and confidence intervals. The data from three midterms and finals exams from Fall 2017 and Winter 2018 with more, less or the same number of images were subjected to statistical evaluation using R 4.2.1 (R Statistical Software, R Core Team, Vienna, Austria), and results were expressed as a class mean with standard deviation (± SD). Individual percent scores of questions with images plus text versus text only, simplified image versus detailed image, and an individual tissue/organ with image plus text versus text only were also subjected to statistical evaluation. Because Exam #3 and the final exam consisted of equal images in both sections, the data were pooled and expressed as Exam #3 (Figures 1 and 2, A & B) for both semesters. Two sample t-test was performed to compare class averages with more versus less images within each semester, whereas two-way ANOVA with no interaction and a randomized block design was used to compare class averages with more versus less images between two semesters for exam #1 and Exam #2 (Fall-2017 vs. Winter-2018). A one-way ANOVA was conducted for exams #3 and final with the same number of images for both semesters (Fall- 2017 vs. Winter-2018). The Chi-square was used to evaluate correct versus incorrect answer data, and Fisher's Z-test was performed to compare the percent rating of individual questions with text plus images versus text only. The differences were considered to be significant at $P<0.05$ for all the exams and percent scores of individual questions. Graphs were prepared with Microsoft Excel® spreadsheet software for Microsoft Windows® (Microsoft Corp., Redmond, WA). Bar graphs were generated showing means (± SD). The differences were considered to be significant at $P<0.05$ for all the exams and percent scores of individual questions. Graphs were prepared with Microsoft Excel® spreadsheet software for Windows® (Microsoft Corp., Redmond, WA). Bar graphs were generated showing means (± SD).

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Results

Impact of the More Images versus Less on the Mean Class Score

The inclusion of images in anatomy examinations resulted in significant changes in the mean class average and percent rating of individual questions based on images. Results from the Fall 2017 study show that the inclusion of more anatomical images in a multiple-choice anatomy exam (Exam #1, section BN01 significantly ($P<0.006$) increased the percent class average compared to a similar exam with fewer images (Exam #1, section BN02, Table 1). Reducing the number of images to less than 50% in anatomy Exam #2, section BN01 resulted in a significant decrease ($P<0.002$) in the percent class average compared to an image-rich exam #2, section BN01. However, for Exam #3 and the final exam, which contained an equal number of images in both sections (BN01 & BN02), the percent class average did not differ (Table 1).

Exams	Sections	Number of Students (n)	Number of Images	Number of Questions	% Class Average (± SD)	P-value
Fall - 2017						
Exam #1	BN01	79	13	66	75.9 ± 6.2	
Exam #1	BN02	76	05	66	73.3 ± 6.6*	0.006
Exam #2	BN02	76	11	62	74.4 ± 7.3	
Exam #2	BN01	74	04	62	71.1 ± 9.0*	0.002
Exam #3	BN01	77	5	65	69.1 ± 7.2	
Exam #3	BN02	72	5	66	71.9 ± 7.8	0.43
Final Exam	BN01	75	9	120	70.9 ± 11.5	
Final Exam	BN02	72	9	120	70.8 ± 13.0	0.48

Table 1. *The impact of more versus fewer images on the percent class average in the Fall 2017. Results are expressed as mean ± SD and converted into percent class average. *P<0.006 section BN01 and BN02.*

In Winter 2018, yielded similar but slightly different results were obtained. The percent class average was highly significant ($P<0.001$) in anatomy Exam #1, section BN03, with more images compared to a similar exam with fewer images (Exam #1, section BN04, Table 2). However, reducing the number of images by 50% in anatomy Exam #2, section BN03 resulted in a significant decrease ($P<0.0005$) in the percent class average compared to an image-rich Exam #2 in section BN04 (Table 2). For Exam #3 and the final exam, which contained an equal number of images in both sections (BN03 & BN04), the percent class average did not differ (Table 2). However, percent class average was significantly lower ($P<0.006$) for the final exam in Winter 2018 compared to the final exam in Fall-2017.

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Exams	Sections	Number of Students (n)	Number of Images	Number of Questions	% Class Average (± SD)	P-value
Winter - 2018						
Exam #1	BN03	69	10	66	76.3 ± 6.5	
Exam #1	BN04	59	05	66	70.6 ± 6.3**	0.001
Exam #2	BN04	59	10	62	72.2 ± 7.3	
Exam #2	BN03	69	05	62	64.6 ± 10.0**	0.0005
Exam #3	BN03	69	04	65	72.4 ± 6.0	
Exam #3	BN04	59	04	66	69.3 ± 7.4	0.96
Final Exam	BN03	65	13	120	69.5 ± 11.3	
Final Exam	BN04	57	13	120	67.3 ± 14.8†	0.003

Table 2. *The impact of more versus fewer images on the percent class average in the Winter 2018. Results are expressed as mean ± SD and converted into percent class average. **P<0.001 compared to section BN03 and BN04. † P<0.003 compared to Fall-2017.*

Percent Scores of Individual Questions with Images Plus Text Versus Text Only

The percent score of an individual question based on images significantly increased by 23.4% in Exam #1 (P<0.001). Similarly, the percent score of an individual question based on images in Exam #2 was significant and increased by 10.5% (P<0.001; Figure 1A) in Fall 2017 compared to the overall mean score of exams with text only. However, the percent score of individual questions based on images was only increased by 0.7% in Exam #3 with the same number of images with text only.

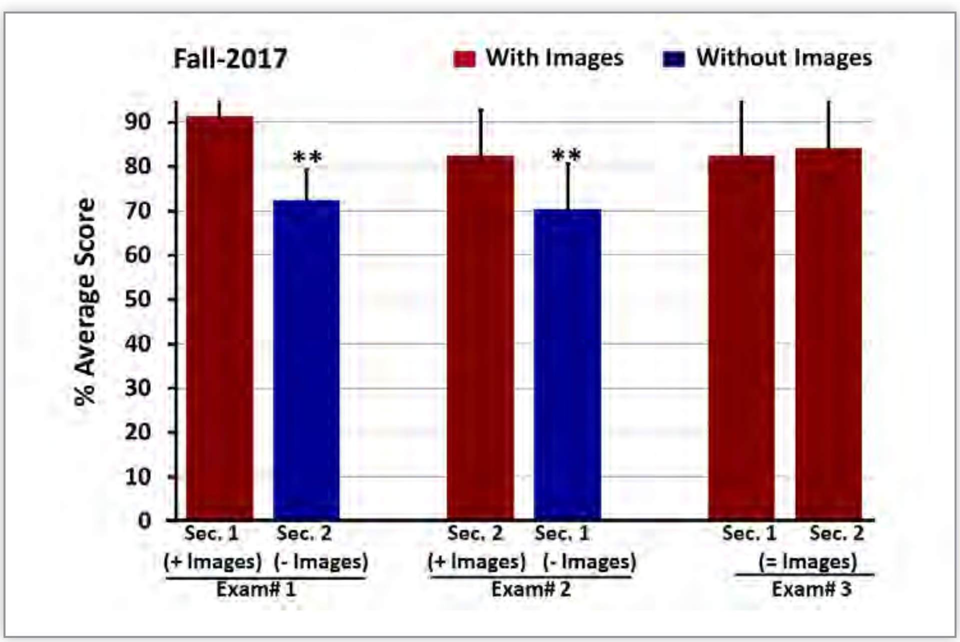

Figure 1A. *The percent scores of all questions with text plus images versus the same questions with text only in Fall 2017. Results are expressed as mean ± SD and converted into percent class average. **P<0.01 section 1 compared to section 2.*

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In Winter 2018, the percent scores of individual questions based on images plus text increased by 13.5% in Exam #1 and 10.2% in Exam #2 compared to an overall mean score with text only (Figure 1B). This score was increased by 5.4% in Exam #3 compared to the same number of images with text only.

Percent Scores of Selected Tissues/Organs with Images Plus Text Versus Text Only

The percent scores of the selected tissues with images plus text were increased by 30% compared to the same tissues with text only (86.8 ± 12.1 (± SD) % vs. 65.5 ± 28.0 (± SD) (Table 3).

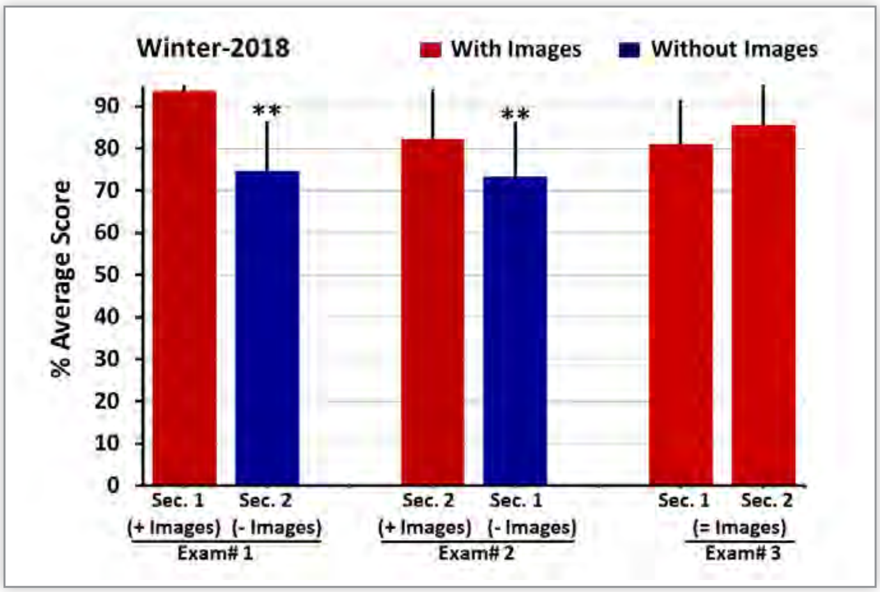

Figure 1B. *The percent scores of all questions with text plus images versus the same questions with text only in Winter 2018. Results are expressed as mean ± SD and converted into percent class average. **P<0.01 section 1 compared to section 2.*

Image description	Text + Images (%)	Text Only (%)
Directional terms	92.4	82.4
Directional terms	91.1	76.3
Planes and Sections	97.4	17.1
Intercellular Junctions	96.2	73.6
Section through Skin	91.1	65.8
Skeletal Muscle Layers	70.8	15.7
Structure of Scapula	68.3	64.4

Table 3. *An Example of the Percent Score of Individual Questions with Images + Text or Text Only on Selected Topics.*

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Percent Scores of an Individual Image Plus Text Versus Text Only

The overall mean score of individual questions with reference images plus text was significantly higher (P<0.05) compared to the same questions with text only (Figure 2).

Percent Scores of Simplified Images Versus Detailed Images

The percent score of simplified images plus text was significantly (P<0.05) higher than detailed images plus text (93.6 ± 4.0 (± SD) vs. 81.9 ± 3.0 (± SD) (Figure 3).

Questions	% Score with Text + Image	% Score with Text only
1. Which structure serves as the attachment site for the 'facet for the head of the rib'?	56.9%	25.9%
2. Which structure serves as a passage for the spinal cord?	79.2%	68.8%
3. Which structure separates the transverse process from the spinous process?	68.0%	59.7%

Figure 2. *An example of the inclusion of images of human thoracic vertebrae as a reference image for one anatomy examination. The percent score of three pooled questions was calculated using this figure with image plus text compared to the same questions with text only. *0.05 compared to text only.*

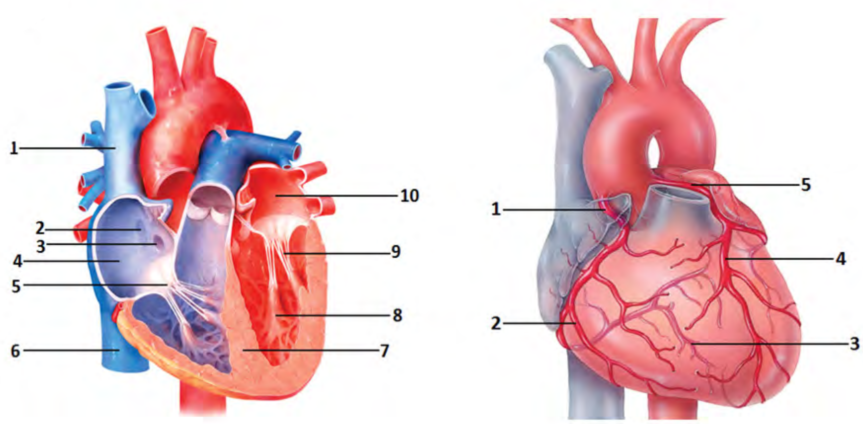

Figure 3. *Percent scores of simplified images versus detailed images of selected anatomical structures*

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Discussion

Anatomy educators routinely use myriad images to explain anatomy to students to stimulate visual learning (Bartholomme & Bromme, 2009; Vorstenbosch et al., 2013; Notebaert 2017). The present study shows that anatomy students had an advantage when images were included in their MCQ anatomy exams. This was tested in several ways: more images versus fewer images, images plus text vs. text only, and simplified images vs. detailed images. Moreover, the percent score of individual questions based on images plus text or scores of questions on tissues/organs or a single reference image with text significantly increased the class mean average compared with questions with text only. This indicates that images can provide a visualizing effect (Butcher 2006; Vorstenbosch et al., 2013). Image-linked visualizing effects have been shown to support the cognitive processes necessary for deep understanding (Butcher, 2006), effective memorization (Pandey & Zimitat, 2007), and learning and improved knowledge of the human body and academic performance (Notebaert et al., 2013; Pickering 2015).

The literature on the effect of the use of images on anatomy learning outcomes is varied and inconclusive. For example, a pilot study conducted on medical students by Holland et al., (2015) using 195 histology images showed no significant differences in item difficulty (proportion of students answering correctly), item discrimination (a correlation between answering a specific exam item correctly and performing well on the exam), and item point biserial correlation between question items containing images plus text versus text only. The opposite results were reported by Peeck (1993) for participants reading from a text without a picture; they were found to be more motivated and interested in continuing reading compared with those who read the same text accompanied by a poor diagram. Berends & van Lieshout (2009) pointed out that despite taking longer to answer questions, poor-performing students in their study reported that images were helpful. This contrasts with other studies where students found images unnecessary (Crips & Sweiry, 2006). The poor examination performance, lower accuracy, and slower response time on exam items were found to be associated with increasing working memory load, cognitive load, and students' inability to answer items in examinations (Mayer & Moreno, 2003; Sweller 1994).

On the other hand, a study by Vorstenbosch et al. (2013) on medical students reported lower item difficulty, item discrimination, and item point biserial in test items on fetal circulation containing images compared to images with an answer list. While using cross-sectional images of the abdominal organs and vessels around the heart, the same authors reported greater item difficulty and item discrimination. In a most recent study by Sagoo et al. (2021) using anatomical and radiological images of the bones and soft tissues the second- year medical students scored significantly higher on questions with images compared to questions without images. Similarly, in pre-nursing students, Notebaert (2017) reported that even though examination item discrimination and difficulty were not altered for MCQs with text containing reference images compared to MCQs with text only, students with text and reference images achieved higher academic performance compared to those with text only. This indicates that including reference images in MCQ exams had no influence on item difficulty and item discrimination. In a review of 55 experiments, however, Levie & Lentz (1982) reported that 85% of studies showed improved knowledge retention with an illustrated text (with the inclusion of images) compared with text alone, while Hunt (1978) demonstrated that 85% of students correctly answered a question with an image of a barium swallow versus students given the same question accompanied by a written X-ray report. The addition of appropriate illustrated images in anatomy exams by others has shown similar outcomes to those enumerated above in terms of improving and increasing academic performance (Carney & Levine, 2002; Mayer & Moreno, 2003; Mayer, 2015; Sagoo et al., 2021). The visualizing effects of images in exams also improved students' spatial ability; students with high spatial ability better understood exam items (drawings, photographs, specimens, and radiographs) and performed better overall in the exam (Vorstenbosch et al., 2013). These discrepancies and inconclusive results from the studies cited above could stem from many causes. These include the number of questions and images used to assess the students in these studies, the types and quality of images used, the degree of details in the images, the analytical methods used, and whether or not the students found these images relevant, helpful and essential to answer the questions (Butcher, 2006; Crisp & Sweiry, 2006; Berends & van Lieshout, 2009; Holland et al., 2013; Vorstenbosch et al., 2013; Pickering 2015; Notebaert 2017).

The present study shows that including images with accompanying text in anatomy exams containing MCQs improved the class performance compared to MCQs with text only. This is consistent with the use of anatomical images in pre- nursing students (Notebaert et al., 2017), anatomy drawing screencasts (Pickering, 2015), and histological images (Vorstenbosch et al., 2013; Holland et al., 2015; Pickering 2015), anatomical and radiological images of bones and soft tissues in medical (Sagoo et al., 2021) and allied-health students (Skinder- Meredith 2010). Improved class performance of anatomy students in exams containing more images and images plus text compared to text only in the present study may be attributed partly to visualizing effects of the Anatomage Table used in the present study (Biachi et al., 2020; Narnaware & Neumeier, 2021a). Thus, the present study indicates that image inclusion in anatomy exams increased exam test scores, improved knowledge and learning of the human body, and promoted active learning, similar to the findings by others in medicine (Pickering 2014;

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Notebaert 2017; Sagoo et al., 2021) and allied-health (Skinder-Meredith 2010) students. A variation in number of images and class averages between nursing students enrolled in the Fall 2017 and Winter 2018 semesters may have contributed to a number of factors such as a semester (fall vs winter), student cohorts, number of students, questions in the exams and images, whether reference images being simple vs. detailed and perceptiveness of visualizing effects of images by an individual student (Hunt 1978; McVicar et al., 2014; Notebaert 2017; Vorstenbosch et al., 2013). However, due to the large amount of data collected from three mid-terms and a final exam in both the fall and winter semesters, item difficulty, item discrimination, and biserial point were not determined in the present study and will form the basis of a separate future communication.

The notion that overly excessive details can reduce learners' ability to process essential information (Mayer & Moreno, 2003) was supported in the present study. We compared the simplified images (fewer details) versus detailed images (more information) over two semesters (see Figure 3).

The percent scores of individual questions with simplified images (e.g. heart markings) with five numerical labels were significantly higher than those for detailed images (e.g. heart's internal anatomy) with ten numerical labels. Extraneous information such as extra lines and labels, was eliminated in the simplified images. This helped students avoid spending too much time and attention on the images (Crips & Sweiry, 2006). Increased exam scores with more images or simplified images indicate that the students may have had a greater motivation to study when images were accompanied by a text (Peeck 1993; Ainsworth & Loizou, 2003). Simplified images have been shown to promote factual learning, and students learned more from simplified images than from illustrated images and made fewer comprehension errors than detailed images (Levie & Lentz, 1982; Butcher 2006). This can be explained in two ways: firstly, reducing diagrammatic details such as irrelevant words and only highlighting important information in a question with images can promote students' learning (Mayer et al., 2001; Bartholomme & Bromme, 2009; Vorstenbosch secondly, as images provide visual cues, visual information is processed much faster than verbal information (Bartholome & Bromme, 2009). In addition, learning from text and pictures supports mapping (numerical labels versus highlighting), reduces the student's cognitive load and visual search from images (Carlson et al., 2003; Bartholome & Bromme, 2009), their working memory load, and improves understanding and coherence (Mayer & Gallini, 1990; Mayer & Anderson, 1992; Mayer et al., 2001). It also supports students' comprehension and enhances integration between visual images and text during their learning (Butcher 2006). Others have also reported that simplified images reduce comprehension error and support information integration during learning (Butcher 2006); they also decrease item difficulty and item discrimination (Vorstenbosch et al., 2013), improve visualization and memorization (Pandey & Zimitat, 2007) and promote active learning (Pickering 2014).

Several theories have emerged concerning the visualizing effects of images. The improved learning outcome of the anatomy examinations with images with text compared to those with text-only observed in the present study could be attributed to the coherence and mental model development theory proposed by Bartholome & Bromme (2009) and Mayer et al. (2001). These authors stated that learning from pictures and text may stem from the fact that learners are required to select the relevant verbal and pictorial information from working memory that can then be organized in the central nervous system for processing to form a verbal and a pictorial/visual mental model. Then, the next step involves the comprehension process that integrates the information from both text and pictures. Finally, text and image information complement each other, thus fostering learning (Schnotz 2002). According to Mayer et al. (2001), words and pictures are processed in two different processing systems. Visual cues provide greater prompting (to labeled anatomical structures) than text only, encouraging students to use their free capacity for conceptual integration and processing (Batholome & Bromme, 2009).

On the other hand, cognitive load theory (CLT) proposed by Mayer & Moreno (2003) and the Multimedia Learning Theory by Mayer (2010) describes words and pictures from examination questions that enter the sensory memory via 'dual channel' (verbal and pictorial), then being organized within the working memory during the examination. Here, it can be integrated with the schemata from the long-term memory created when the student engages with the images during studying. Improved class performance with the inclusion of a greater number of images or more simplified images observed in the present study may be partly because visual resources were more likely to be 'read' and processed faster than text only (Winn 1987).

Limitations of this study

There were two key limitations throughout this study. The use of images in the assessment of anatomical knowledge is diverse, implying that the type of image used is an important factor interacting with the test item's content. Secondly, due to the large number of students involved and the vast number of images used in the exams, results on item difficulty, item discrimination, and point biserial points are not included in the current data interpretation. As supported by others, image inclusion can reduce exam anxiety, improve confidence, and spatial ability, alter the cognitive load, and help long-term knowledge retention was not assessed. In addition, students' opinions on whether images were helpful remain to be clarified in the present study. This study also did not evaluate the individual questions using images vs texts only in the previous exams, and therefore, long-term knowledge retention and learning could not be assessed.

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Conclusions

The present study highlights the significant impact of anatomical images on improving the understanding of gross human anatomy in nursing students. It also shows that they may reduce the cognitive load, increase spatial ability, help recall knowledge, and provide cues to exam question answers. Therefore, the inclusion of images in anatomy exams in a nursing curriculum that does not include a lab or cadaveric dissection should be considered an assessment method of learning outcomes of gross anatomy. The images can be used as an interventional strategy to improve long-term knowledge retention in nursing students. Therefore, when designing a curriculum to improve the learning outcomes in gross anatomy, emphasis should be placed on the inclusion of simplified structural diagrams of the body. The present study, conducted the first time on nursing students in Canada, indicates that visual representation appears to be the most effective when designed to support nursing students' cognitive processes integral for their enhanced understanding (Butcher 2006). This adds to available evidence that a "multimodal" approach using simplified body images should be incorporated into teaching and learning gross human anatomy to nursing students. Moreover, the inclusion of visual aids should be considered one of the active learning pedagogies to improve learning outcomes of human anatomy.

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