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Academic Resource Preferences for Medical Students Pursuing Orthopaedic Surgery

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This protocol is exempt from the requirements for Institutional Review Board review, ethics approval, and informed consent per the exemption at 45 CFR 46.104(d)(2), as indicated by the Lake Erie College of Osteopathic Medicine Institutional Review Board in Protocol #30-030 on 9/29/22.

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ABSTRACT

Purpose: This study explores the preferences of academic materials favored by medical students pursuing orthopaedic surgery. It assesses how these resources are perceived in terms of their utility in both pre-clinical education and clinical rotations.

Methods: Deidentified electronic surveys, using SurveyMonkey's web-based platform, were distributed via national medical student orthopedic societies and medical student orthopedic interest groups. The surveys included multiple choice questions prompting respondents to rate their perceived usefulness of various educational resources.

Results: A consistent consensus was held that board reviews, question banks, and flashcards are more useful than textbooks and lectures for pre-clinical subjects. A similar pattern emerged for clinical rotation resources with direct patient care, review resources, question banks, and flashcards being favored over conventional instructional methods. Visual mnemonics demonstrated efficacy in subjects demanding memorization-intensive efforts and most respondents believed that visual mnemonics would be helpful in their orthopaedic studies.

Conclusion: Transitioning from conventional lecture-based instruction to dynamic, interactive learning approaches is a hallmark of modern medical education. This research provides strong evidence that medical students aspiring to become orthopaedic surgeons have a pronounced preference for active learning resources.

Introduction

Medical students are tasked to learn a considerable amount of information within a relatively short amount of time. As new discoveries continue to become implemented into the already substantial medical curriculum, educators must devise innovative ways to ensure that students retain this information, as the traditional method of instructing through lectures is becoming obsolete (Russell et al., 1984). Technological advancements have helped introduce a variety of alternative educational resources, including recorded lectures, virtual cadavers, podcasts, video games, simulations, and online question banks (Bridge et al., 2009; Emanuel, 2020; Guarino et al., 2014; Guze, 2015; Vallée et al., 2020), and the COVID-19 pandemic helped spur on the transition to and optimization of online training modules (Giordano et al., 2021). Review resources that utilize visual mnemonics are of particular interest; these use cleverly chosen pictures and symbols to represent specific concepts or facts, allowing students to recall this information more easily (Monzon & Samara, 2021; Rummel et al., 2003). Such visual mnemonic aids have become ingrained within the ritual for preparing for medical boards; Finn et al. (2022) surveyed 108 first-year and 119 third-year medical students and found that the majority in each class used SketchyMedical, a cartoon visual mnemonic review resource, in preparation for medical school exams and USMLE Step 1.

Unfortunately, the number of such available resources significantly dwindles for medical students preparing for clinical clerkships, internship, residency, and beyond. This is especially true for those pursuing careers in orthopaedic surgery, as there is currently no centralized course for aspiring orthopaedic surgeons (Wadhwa et al., 2022). In American medical schools, education in musculoskeletal medicine is underrepresented despite the high prevalence of musculoskeletal pathologies in the general population (DiGiovanni et al., 2016; Monrad et al., 2011; Skelley et al., 2012; Weiss et al., 2015). This educational discrepancy inadequately prepares students for orthopaedic surgery clinical rotations, as there is little overlap between medical school curricula and orthopaedic surgery topics, and students often feel underprepared for these rotations (Sabesan et al., 2018). This especially holds true for the types of questions that students are often asked during orthopaedic surgery audition rotations, such as relevant anatomy, eponyms, classifications, and operative indications for specific fracture patterns (Campbell et al., 2019; Somford et al., 2017). Given how competitive the field of

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orthopaedic surgery is, performing well during one's subinternships is paramount to increase the chances of matching into the field for residency (Baldwin et al., 2009; O'Donnell et al., 2017).

The purpose of this study was to investigate the types of academic resources that orthopaedic surgery applicants used during medical school, with the intention of utilizing this information to assess the preferred methods of preparing for medical boards exams, non-orthopaedic rotations, and orthopaedic rotations in this population and seeing if there is any room for improvement. Additionally, as visual mnemonics are becoming more popular, this study serves to preliminarily examine how useful such a resource would be for those applying to orthopaedic surgery.

Methods

Using SurveyMonkey (surveymonkey.com), a questionnaire was created that asked recipients to rate their preferences of academic resources used in preparation for pre-clinical, non-orthopaedic clinical, and orthopaedic clinical endeavors. This survey was distributed electronically to medical students interested in pursuing orthopaedic surgery via medical school interest groups and national student orthopaedic surgery interest groups, including the Student American Osteopathic Academy of Orthopedics, as well as to resident physicians currently in orthopaedic surgery residency programs by contacting them directly. For various pre-clinical subjects (Gross Anatomy, Physiology, Pathology, Pharmacology, Microbiology, Biochemistry, and Behavioral Sciences), respondents were asked to select their perceived usefulness of the resources listed in Table 1. They were asked similar questions regarding the resources used for clinical non-orthopaedic rotations and exams, for clinical orthopaedic rotations, and for learning orthopaedic classification systems, also listed in Table 1. These questions were posed as self-ratings for usefulness as a 5-point Likert scale, with the options and converted scores listed in Table 2. Finally, respondents were asked how beneficial they think visual mnemonics would be for them when preparing for orthopaedic surgery audition rotations, interviews, and internship.

Pre-Clinical Resources	**Clinical Non-Orthopaedic Resources**	**Clinical Orthopaedic Resources and Orthopaedic Classifications**
Textbooks	Direct patient care	Direct patient care
School lectures	Textbooks	Textbooks
Visual mnemonics (Sketchy, Pixorize, Picmonic, etc.)	School lectures / Grand rounds	School lectures / Grand rounds
Boards review sources (Boards&Beyond, Pathoma, First Aid, Step-Up, etc.)	Visual mnemonics (Sketchy, Pixorize, Picmonic, etc.)	Visual mnemonics (Sketchy, Pixorize, Picmonic, etc.)
Interactive events (Cadaver Lab, Workshops, etc.)	Boards review sources (OnlineMedEd, First Aid, Step-Up, etc.)	Review sources (PocketPimped, White Coat Coaching, etc.)
Question Banks	Question Banks	Questions Banks
Flashcards	Flashcards	Orthobullets
		Flashcards

Table 1: Academic resources listed in electronic survey.

Usefulness	**Score**
Minimally useful	1
Somewhat useful	2
Useful	3
Very useful	4
Essential	5
Not applicable	-

Table 2: Likert-scale options and corresponding scores for electronic survey.

For the scored survey questions, the responses were tested for normality using the Shapiro-Wilk test. Given that the responses were not normally distributed, non-parametric analyses were performed. For each of these questions, Kruskal-Wallis analyses with Dunn's post-hoc tests were performed to compare the mean ranks of each resource to each other, with the intent of determining which academic resources were perceived to be more useful than others for individuals pursuing orthopaedic surgery.

Results

A total of 60 responses were collected for this electronic survey. Seven respondents were current orthopaedic surgery residents, and 53 were current medical students pursuing orthopaedic surgery.

Using Kruskal-Wallis analyses, significant differences were revealed across academic resources for all subjects: Anatomy ($H(6) = 68.40$, $p < 0.0001$), Physiology ($H(6) = 89.96$, $p < 0.0001$), Pathology ($H(6) = 103.2$, $p < 0.0001$), Pharmacology ($H(6) = 146.5$, $p < 0.0001$), Microbiology ($H(6) = 169.0$, $p < 0.0001$), Biochemistry ($H(6) = 113.0$, $p < 0.0001$), Behavioral Sciences ($H(6) = 133.0$, $p < 0.0001$), Non-Orthopaedic Clinical Rotations ($H(6) = 131.6$, $p < 0.0001$), Orthopaedic Clinical Rotations ($H(7) = 105.1$, $p < 0.0001$), and Orthopaedic Classification Systems ($H(7) = 123.9$, $p < 0.0001$). Thus, Dunn's post-hoc tests were performed to compare the means ranks of each resource to each other. Figures 1A-D, 2A-C, and 3A-C display the averaged survey results for perceived usefulness of various academic resources in descending order for each subject, with brackets indicating which resources were more useful than others.

For pre-clinical subjects, interactive events were only considered more useful than other resources for Gross Anatomy, in which case it was deemed the most important resource. Board review resources, question banks, and flashcards were consistently regarded as more useful than textbooks and lectures, and visual mnemonics were useful for Microbiology and Pharmacology but not Physiology, Pathology, Biochemistry, or Behavioral Sciences.

For both Non-Orthopaedic and Orthopaedic Clinical Rotations, direct patient care, review resources, questions banks, and flashcards were more useful than textbooks, lectures, and visual mnemonics. Orthobullets was deemed important for Orthopaedic Rotations and Classification Systems.

Finally, the majority of respondents indicated that visual mnemonics, when preparing for Orthopaedic Surgery rotations, interviews, and internship, would be essential (19.61%) or very useful (47.06%). Visual mnemonics would be deemed only useful by 11.76%, somewhat useful by 17.65%, and minimally useful by 3.92%.

Discussion

Medical education is constantly evolving to reflect the needs of students. Previously, the conventional methodology of didactics was through lectures and textbooks, as these media can be standardized to teach a large volume of students (Golden, 1989). However, with the advent of alternative and on-demand resources, students often abandon in-person lectures, as they find recorded lectures and online courses more convenient, efficient, and effective (Ikonne et al., 2018). Traditional lectures may be deemed as obsolete because healthcare students are often at the age range where pedagogical teaching methods can no longer hold their attention, and they instead desire to take more control over their learning process (Chacko, 2021). Instead of a single pass-through of the information that traditional lectures offer, on-demand resources provide the opportunity to slow down, speed up, and replay the videos as necessary depending on the student's grasp of the information (Emanuel, 2020). Additionally, given that students often have varying learning style preferences (Bokhari & Zafar, 2019), they are now able to branch out and explore the alternative resources that fit their needs the best. The current study is consistent with these notions, as lectures were almost universally considered inferior to more engaging resources such as flashcards and question banks.

Visual mnemonics play an interesting role in medical education. In general, learning devices such as mnemonics, metaphors, analogies, similes, and mental imagery training help teach information by bridging one's prior knowledge and personal experiences to new

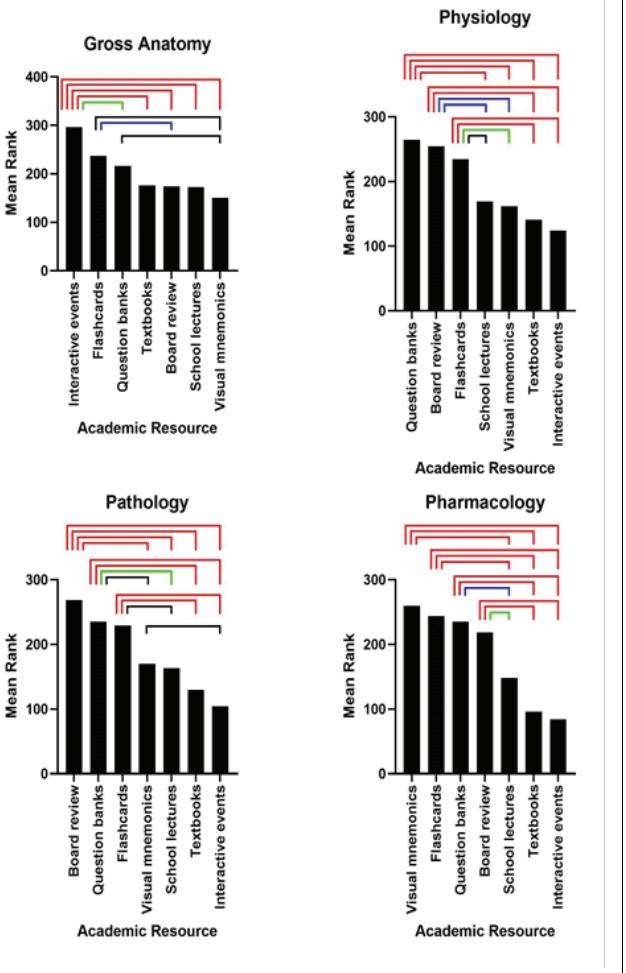

Figure 1A-D: Mean rank survey responses for Gross Anatomy, Physiology, Pathology, and Pharmacology. Black bracket: $p < 0.05$; Green bracket: $p < 0.01$; Blue bracket: $p < 0.001$; Red bracket: $p < 0.0001$.

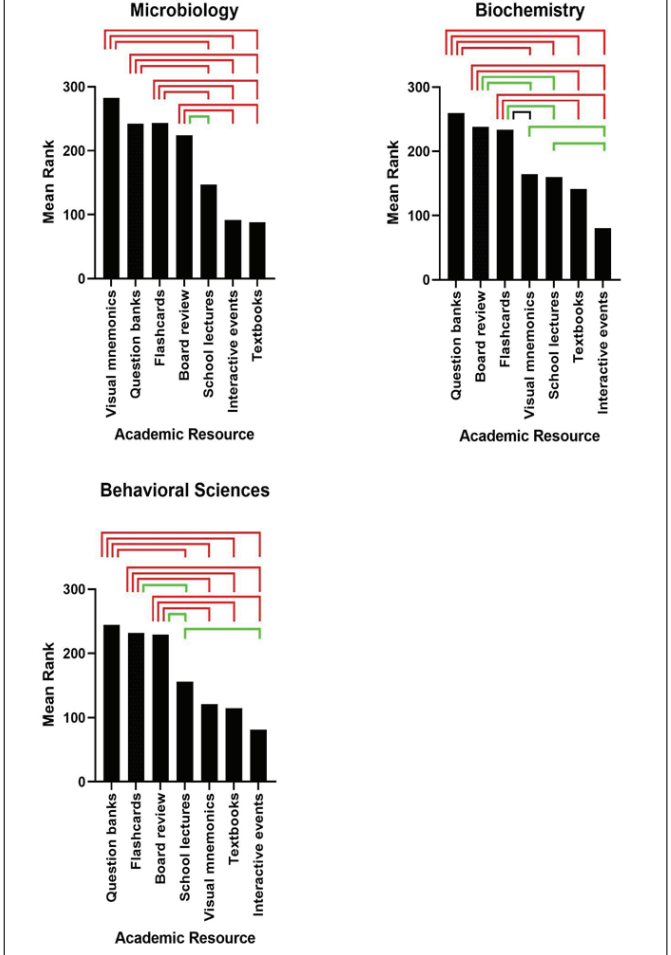

Figure 2A-C: Mean rank survey responses for Microbiology, Biochemistry, and Behavioral Sciences. Black bracket: $p < 0.05$; Green bracket: $p < 0.01$; Blue bracket: $p < 0.001$; Red bracket: $p < 0.0001$.

information (Dresler et al., 2017; Sutherland, 2013). These devices facilitate the transition of one's working memory into long-term memory by processing the information simultaneously in multiple neural processing centers (Paivio, 1990; Smith & Border, 2018), and they have been shown to improve learning, recall, and communication of simple and abstract concepts in the medical field (Fernandes & Speer, 2002; Hurst et al., 2022; Kanthan & Mills, 2015a, 2015b; Qureshi et al., 2014; Seto & Zayat, 2022; Sutherland, 2013). Visual mnemonics, which often include audio and even story-based components as well, especially utilize the dual coding process to improve learning and retention rates compared to traditional text-based material (Abdalla et al., 2021; Weinstein, 2018; Yang et al., 2014). When combined with flashcards, visual mnemonics can lead to long-term retention of complicated subjects (Monzon & Samara, 2021). Unsurprisingly, in the current study, respondents deemed visual mnemonics the most useful for microbiology and pharmacology, which are infamous for requiring large amounts of raw memorization to learn facts such as antibiotic choices for specific bacteria, side effects of drugs, and drug-drug interactions. These cartoons summarize a vast amount of information into a small amount of memory space, allowing the students to learn and retain information efficiently. Though visual mnemonics were not regarded as significantly useful for several other subjects, their prevalence and usage will likely increase as more visual mnemonic resources become commercially available.

Interestingly, for pre-clinical subjects, interactive events such as cadaver labs and workshops were only perceived as useful for Gross Anatomy, in which they were deemed the most useful resource. Especially in the post-COVID-19 setting, medical education seems to be shifting away from traditional cadaver lab-based methods for Gross Anatomy and instead moving towards virtual resources, such as virtual dissections and atlases (Onigbinde et al., 2021). Though these virtual resources may be cheaper and more accessible, cadaver-based dissections are important for aspiring surgeons given their hands-on interaction with the anatomy (Memon, 2018). This preference was reinforced in the current study, as the survey respondents, who were all aspiring orthopaedic surgeons, demonstrated their appreciation for cadaver-based dissections.

Regarding the acquisition of general orthopaedic knowledge, the current study demonstrated that students utilized a wide variety of resources, including websites, review resources, flashcards, question banks, and direct patient care. Adequate preparation for one's away rotations increases their chances of matching into orthopaedic surgery (Baldwin et al., 2009; Campbell et al., 2019; O'Donnell et al., 2017), yet medical schools often do not prepare their students well for these rotations (DiGiovanni et al., 2016; Sabesan et al., 2018; Skelley et al., 2012; Weiss et al., 2015; Yu et al., 2022). Additionally, program directors and applicants primarily perceive these away rotations as chances to see if the applicants fit the culture of the program well and can make good impressions rather than chances to educate the students on orthopaedic knowledge (O'Donnell et al., 2017), meaning that students really do not have consistent ways to learn orthopaedics beyond their own self-directed learning. Thus, there is much room for the improvement of orthopaedic surgery education for medical students as a whole. Some schools have implemented "Boot Camp" curricula to help establish foundational skills and knowledge for their orthopaedics applicants (Yu et al., 2022), which have helped performance on away rotations, increased match rates, and improved evaluations from program directors.

Regarding Orthopaedic Classification Systems, the most useful resources were again, unsurprisingly, review sources, question banks,

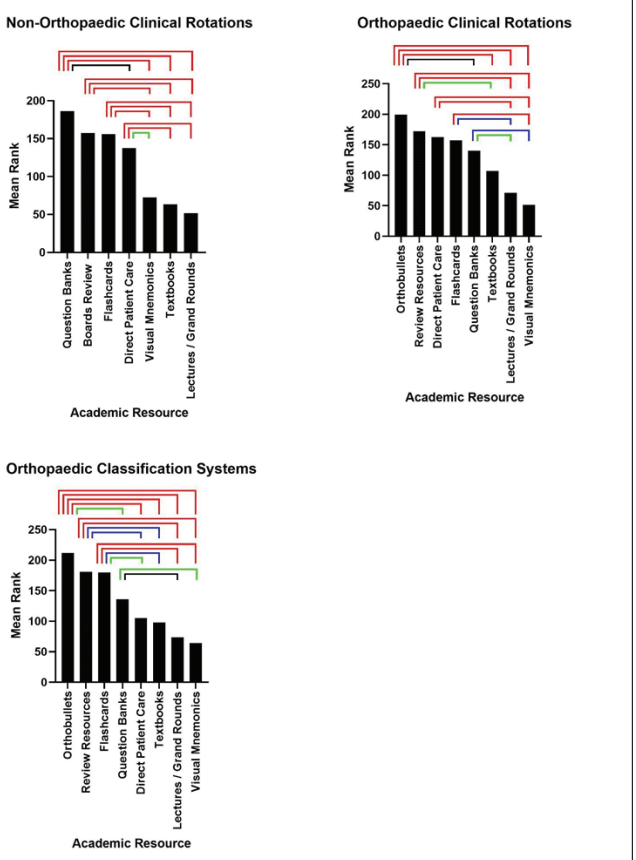

Figure 3A-C: Mean rank survey responses for Non-Orthopaedic Clinical Rotations, Orthopaedic Clinical Rotations, and Orthopaedic Classification Systems. Black bracket: $p < 0.05$; Green bracket: $p < 0.01$; Blue bracket: $p < 0.001$; Red bracket: $p < 0.0001$..

flashcards, and Orthobullets. Given that learning information for both classification systems as well as microbiology and pharmacology, they all shared similar profiles of useful academic resources. The main difference was that visual mnemonics were not deemed useful or applicable for Orthopaedic Classification Systems, as there are currently no such resources commonly available. Hence, the majority of respondents agreed that visual mnemonics would be useful for learning these systems.

This study served as a preliminary investigation into the learning styles of medical students and resident physicians pursuing orthopaedic surgery. One advantage of this study was that only those pursuing orthopaedic surgery were surveyed; given that learning styles are likely different in populations of students pursuing various specialties, only the styles of those pursuing orthopaedic surgery were investigated here. Thus, the responses reflect the general learning styles of those pursuing orthopaedic surgery. This study also expanded pre-clinical education by subject, as each academic subject requires different amounts of understanding versus raw memorization. Thus, conclusions were drawn based on the similarities and differences between the subjects. One weakness of this study was its retrospective nature, as responses likely suffered from recall bias. Additionally, though this study separated educational preferences between pre-clinical and clinical subjects, the pre-clinical era could also be further divided into learning new material versus revision learning, which may depend on different types of resources (Wynter et al., 2019).

Future studies may further investigate the disparities in resources of orthopaedic education with controlled trials of students learning information through different resources and comparing the understanding and retention of the information over time. Exploring the role of visual mnemonics, especially with orthopaedic classification systems, could potentially give rise to a new and innovative method of orthopaedic surgery education. The shift away from cadaver-based dissections during Gross Anatomy education could also be further investigated in the context of aspiring orthopaedic surgeons, as removing the tactile-based facet of anatomy education could be detrimental to the development of surgical skills.

Overall, this study demonstrated that medical students and resident physicians benefit from a diverse arsenal of academic resource types, depending on the subject. With subjects such as microbiology and pharmacology that require a lot of raw memorization, visual mnemonics were deemed very useful. With this in mind, visual mnemonics would likely aid students pursuing orthopaedic surgery, specifically in learning classification systems, eponyms, and other commonly asked information, to help them with their audition rotations and ultimately match into an orthopaedic surgery program.

Conclusion

Overall, this study demonstrated that medical students and resident physicians benefit from a diverse arsenal of academic resource types, depending on the subject. With subjects such as microbiology and pharmacology that require a lot of raw memorization, visual mnemonics were deemed very useful. With this in mind, visual mnemonics would likely aid students pursuing orthopaedic surgery, specifically in learning classification systems, eponyms, and other commonly asked information, to help them with their audition rotations and ultimately match into an orthopaedic surgery program.

Data Availability Statement: Survey results from respondents are available on request.

Declarations

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Authors' contributions: Arjun Malhotra – responsible for conceptualization, methodology, data analysis, writing, and reviewing.

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