

1 **Title:** A Narrative Review on Quality Improvements for Radiology Clerkships from Medical Student Perspectives

2  
3 **Article type:** Review

4  
5 **Author names:**

- 6 1. Star Chen
- 7 2. Dr. Maruti Kumaran

8  
9 **Degrees and Affiliations:**

- 10 1. B.S. Fourth-year medical student, Lewis Katz School of Medicine at Temple University, Philadelphia,  
11 PA, USA.
- 12 2. MD, MBBS. Associate Professor, Department of Radiology. Lewis Katz School of Medicine,  
13 Philadelphia, PA, USA.

14  
15 **ORCID (Open Researcher and Contributor Identifier):**

- 16 1. <https://orcid.org/0000-0003-3841-0526>
- 17 2. <https://orcid.org/0000-0002-3263-3967>

18  
19 **About the author:** Star Chen is a fourth-year medical student at Lewis Katz School of Medicine at Temple  
20 University. Dr. Maruti Kumaran is an associate professor in the Department of Radiology at Temple University  
21 Hospital

22  
23 **Corresponding author email:** star.chen@temple.edu

24 **Acknowledgment:** none

25 **Financing:** none

26 **Conflict of interest statement by authors:** Authors have no conflicts of interest to disclose

27 **Compliance with ethical standards:** N/A, no human subjects were involved, all information and data was  
28 retrieved and synthesized from already published studies.

29  
30 **Authors Contribution Statement:** Conceptualization: S.C.. Methodology: S.C.. Validation: S.C., and M.K..  
31 Formal Analysis: S.C.. Data Curation: S.C.. Investigation: S.C.. Writing – Original Draft: S.C.. Writing – Review  
32 & Editing: S.C., and M.K.. Supervision: M.K..

33  
34 **Manuscript word count:** 4491 words.

35 **Abstract word count:** 200 words

36 **Number of Figures and Tables:** 2

37  
38 **Personal, Professional, and Institutional Social Network accounts.**

- 39 • **Facebook:** none
- 40 • **Twitter:** @StarKentChen
- 41 • **Instagram:** none

- 1 • **Linkedin:** none

2

3 **Discussion Points:**

- 4 • As amazing as the field of radiology is, the radiology clerkship in medical school has developed a  
5 reputation as being passive and unengaging.
- 6 • What are your thoughts on radiology electives in medical school? How can they be improved?
- 7 • #MedicalStudents, #Radiology, #MedTwitter, #MedicalEducation

8

9

10 **Dates**

11 Submission: 02/09/2023

12 Revisions: 03/08/2023, 08/05/2023

13 Responses: 03/10/2023, 08/06/2023

14 Acceptance: 09/10/2023

15 Publication: 09/14/2023

16

17 **Editors**

18 Associate Editor/Editor: Francisco J. Bonilla-Escobar

19 Student Editors: Leah Komer, Diego Carrion Alvarez

20 Copyeditor: Richard Christian Suteja

21 Proofreader:

22 Layout Editor:

23

24 **Publisher's Disclosure:** *This is a PDF file of an unedited manuscript that has been accepted for publication.*  
25 *As a service to our readers and authors we are providing this early version of the manuscript. The manuscript*  
26 *will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable*  
27 *form. Please note that during the production process errors may be discovered which could affect the content,*  
28 *and all legal disclaimers that apply to the journal pertain.*

29

30

31

32

33

34

35

36

37

38

39

40

41

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39

**ABSTRACT.**

Radiology clerkships have the potential to give medical students a better appreciation towards the responsibilities of radiologists towards patient care, while also raising interest and improving student confidence in diagnostic imaging skills. Unfortunately, many radiology clerkships across the US have developed a reputation for being unorganized, and unengaging. This narrative review is focused on summarizing various clerkship practices performed across the US that have been well received by students, as well as specific weaknesses with the traditional clerkship format from the student perspective, with the aim of effective approaches to revamping electives to showcase the realities of the specialty while also attracting bright and motivated students. This narrative review examined 28 studies that gathered survey responses from medical students that completed radiology clerkships to determine their perceptions towards the clerkship. Major findings to be discussed in detail include weaknesses with the traditional format related to passive learning through observing, and unclear expectations for medical students, as well as certain challenges that clerkship directors may face while attempting to implement changes to their clerkship. This narrative review will also discuss specific well-received practices involving more active learning, including interactive workstations, interactive simulators, flipped classrooms, and case banks and online learning modules.

**Key Words:** radiology, clerkship, elective, medical student, perception, education (Source: MeSH-NLM).

## 1 INTRODUCTION.

2  
3 Advancements in medical technology have made diagnostic imaging much more widely available than it once  
4 was. As a result, clinicians can rely more heavily on diagnostic imaging compared to years past to help guide patient  
5 management, and the need for radiologists who are both well-trained and dedicated to the field will continue to grow.  
6 Surprisingly, there is a deficit in the amount of required radiology clerkships across United States (US) medical schools.  
7 One study surveying multiple Canadian and US medical schools note that only about 20% of US medical schools and  
8 only 1 of 17 Canadian medical schools require their medical students to take a radiology clerkship, a number which has  
9 not changed between 2011-2018.<sup>1</sup> This deficit may be further demonstrated by a separate study that found that only 49%  
10 of medical schools taught radiology during the 3<sup>rd</sup> and 4<sup>th</sup> years, and that often these lessons were being taught by non-  
11 radiologists even though 98% of radiology department chairs do not believe these physicians are capable of adequately  
12 teach imaging concepts to medical students.<sup>2</sup>

13  
14 For the medical students who do choose to pursue elective radiology clerkships, they face additional challenges.  
15 Radiology clerkships have developed a reputation for being disorganized, having little hands-on learning, relying mostly  
16 on passive shadowing without enough structured teaching.<sup>3,4,5</sup> These practices will often fail to keep students engaged,<sup>4</sup>  
17 which could ultimately lead to decreased long-term learning retention, decreased interest from students that are  
18 undecided of which specialty to pursue, and also failure to dispel rumors and misconceptions about the specialty.<sup>6</sup> The  
19 effects of this education disparity compared to other clerkships may be seen bleeding into the newer generation of  
20 practitioners, as a recent study surveyed 175 post-graduate year-1 (PGY-1) residents across multiple specialties regarding  
21 their radiology education and their confidence and found a concerning mismatch between their radiology-related  
22 responsibilities, and perceived confidence in their diagnostic imaging skills.<sup>7</sup> Although 63.7% of the interns were  
23 frequently asked to preview radiology studies on their own, only 60.2% of interns reported having high confidence in  
24 their ability to recognize common/emergent pulmonary findings on chest imaging, and only approximately 33% had high  
25 confidence of when to order oral/IV contrast with a computer tomography (CT) study.

26  
27 In addition, with recent changes to US medical education and licensing exam practices, it is becoming  
28 increasingly difficult to predict how new residency criteria may impact undergraduate radiology education. In one study,  
29 the authors suggests that with the removal of a scored Step 1 exam, there will be a shift of emphasis towards applicants'  
30 numerically scored Step 2CK and likely more focus on other parts of the application including letters of  
31 recommendation, research, and extracurricular achievements.<sup>8</sup> These authors believe that with fewer schools offering any  
32 dedicated Step 2CK study time, many medical students may soon flood radiology electives due to the general reputation  
33 of them being easier and having decreased time commitments to maximize study time. They also suggest that more  
34 students may end up applying to radiology residencies due to the uncertainty of where they stand in terms of  
35 competitiveness without a scored Step 1 score. Both shifts may lead to significant increase in student load for radiology  
36 electives and thus increased teaching responsibilities for already extremely busy radiologists, which will require a drastic  
37 restructuring of radiology elective curriculums.<sup>8</sup>

38  
39 The utility of a well-structured and actively engaging radiology elective would be incredibly valuable for the  
40 next generation of physicians. To our knowledge, currently there does not seem to be an existing comprehensive review  
41 of medical student perspectives towards the curriculum and structure of radiology electives across the United States. The

1 purpose of this literature review is to summarize certain radiology clerkship practices that have been well-received from  
2 the medical student perspective. Specifically, the primary goal of this study is to identify many of the shared limitations  
3 of various radiology electives as described by medical students, while also identifying certain radiology clerkship  
4 practices that were viewed favorably by medical students. The secondary goal is to identify certain challenges that  
5 clerkship directors may face while attempting to implement favorable changes to the clerkship.  
6

Accepted, in-press

1 **METHODS**

2  
3 *Search strategy*

4 A literature search was conducted within PubMed and CINAHL databases. Search terms used included  
5 ‘radiology,’ ‘clerkship,’ ‘elective,’ ‘medical student,’ ‘perception,’ and ‘preference.’ Articles were then obtained from the  
6 databases using these search strings: radiology clerkship, radiology clerkship student, radiology elective, medical student  
7 preference radiology, medical student radiology education. Articles were obtained between 1990 up to 2023, and  
8 included article subtypes such as case reports, commentaries, educational perspectives, randomized clinical trials, meta-  
9 analyses, reviews, and systematic reviews.

10  
11 *Inclusion and exclusion criteria*

12 Articles were selected based on their relevancy towards formal radiology clerkships as opposed to longitudinal  
13 radiology education or preclinical radiology education. Articles that specifically discussed student perceptions towards  
14 the clerkship were preferentially chosen. In addition, articles that looked at mentorship practices or resident teaching  
15 methods during the radiology clerkship were also included if student perceptions to the practices were discussed. Articles  
16 that reviewed limitations or challenges that clerkship directors faced when attempting to build or modify their radiology  
17 elective courses were also included. To limit the scope of this review, articles that focused on integrated curriculums over  
18 four years as opposed to focused electives were excluded. Articles that proposed structural changes to radiology  
19 clerkships without data discussing student opinions or perceptions to said changes were excluded. Studies that looked  
20 solely at medical student radiological competence/knowledge after the elective without considering student attitudes or  
21 perceptions towards the elective were excluded to keep the article focused. Any articles that did not pertain to the specific  
22 specialty of diagnostic radiology, including solely interventional radiology or radiation oncology clerkships, were  
23 excluded. As one of the goals of this study is to examine clerkship practices that medical students viewed favorably or  
24 unfavorably, articles that only examined faculty or resident perspectives without discussing medical student perceptions  
25 were also excluded. Any articles that focused primarily on professionalism, academic dishonesty, or ethics as opposed to  
26 the educational structure of the elective were excluded as they did not seem relevant to the goals of this study. Lastly, any  
27 articles that primarily focused on evaluating match rates into radiology, applying to radiology residency, appealing to one  
28 gender over another to the field, or on training medical students in single modalities (ex. ultrasound) were excluded.

29  
30 *Data extraction*

31 All articles were independently reviewed by the primary investigator to ensure relevancy. 97 articles were found  
32 on PubMed and 126 articles found on CINAHL. These articles were screened with the inclusion and exclusion criteria  
33 and duplicates (**Figure 1**). Additional articles (n=3) were found from searching through references of the original articles  
34 found from the database search that met selection criteria (n=25), for a total of 28 articles.

## 1 RESULTS.

2 Of the 28 articles reviewed, there were 5 review articles, 1 editorial piece, 2 prospective cohort studies, 4  
3 observational studies, and 16 case studies (**Table 1**). By far the most common method used to assess student feedback  
4 and perceptions towards the clerkship was a 5- or 10-point Likert scale (eg. surveyors asked to rate how much they agree  
5 with a statement, 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree), which was implemented  
6 in 13 of the 28 articles. 9 articles used a mixed method approach to assess student perspective by including both a Likert  
7 scale and other questionnaire methodology (ranking, open response, multiple choice), and 4 articles used methodologies  
8 that did not include the Likert scale.

9  
10 Of the 16 case studies, 14 of them were conducted while researchers were implementing a new intervention to  
11 their radiology clerkship, allowing them to collect data on student perspectives toward said changes. Various new  
12 teaching methods were implemented, including switching to virtual options considering the COVID-19 pandemic,<sup>19,20</sup>  
13 flipped classroom teaching,<sup>14,15,16,29,31</sup> interactive workstations,<sup>18,26</sup> and interactive websites<sup>17,28</sup> and simulators<sup>27</sup>.

14  
15 The two prospective cohort studies both compared how students performed and responded to learning from an  
16 integrated or flipped classroom modality as compared to the traditional didactic format of radiology learning.<sup>14,16</sup> All four  
17 of the observational studies did not involve the implementation of any new interventions to their existing radiology  
18 elective by the researchers, and instead focused on assessing student's ongoing perceptions and suggestions for  
19 improvement of radiology electives via qualitative surveys.<sup>2,11,22,30</sup> One editorial was included as it provided additional  
20 perspective to some of the challenges and mindsets that students have during a radiology elective.<sup>4</sup> The 5 reviews  
21 provided summaries on various topics including recommendations on how to structure radiology electives in the context  
22 of student values,<sup>9,13,30</sup> current novel teaching methods that are well received by faculty,<sup>32</sup> and various challenges that are  
23 experienced by radiology educators.<sup>23</sup>

24  
25 Given the context of the study goals, the findings of the literature search are organized into sections: current  
26 state of radiology clerkships, the traditional format of many radiology electives, problems with the traditional format,  
27 barriers to improvement, and possible solutions to improving clerkships.

## 1 DISCUSSION.

### 3 *Current state*

4 In undergraduate medical education, imaging is taught in numerous ways. While many curriculums attempt to  
5 integrate diagnostic imaging lessons into preclinical courses, most notably anatomy, and other 3<sup>rd</sup> year core clerkships,  
6 such as internal medicine and surgery, most academic radiologists across the US rely on radiology or 4<sup>th</sup> year electives to  
7 teach diagnostic imaging concepts to medical students. In a recent survey conducted across US medical schools,  
8 approximately 48 of the 54 (89%) radiology department chairs stated they used radiology electives to teach medical  
9 imaging, with the second most common method being integration into other courses such as anatomy (44, 81%).<sup>9</sup>

11 Many medical students who end up enrolling in radiology electives will share specific educational goals they  
12 hope to achieve by the end. In a recent survey, researchers at a single institution conducted a needs assessment of medical  
13 students (n=36) that completed the radiology elective to determine the most common goals students had for the  
14 elective.<sup>10</sup> The top educational goals were to learn about the specialty (n=13, 37%), learn how to approach various CT  
15 scans (n=13, 37%), to improve on chest x-ray interpretation (n=10, 29%), and to understand indications for various  
16 imaging (n=11, 31%). Researchers also inquired students about what activities they would like to see incorporated into  
17 future electives. The most selected choices were participating in procedures and scanning (96%), interpreting cases and  
18 reviewing with residents or staff (93%), participating in exercises focused on imaging work-up/appropriate ordering of  
19 imaging (91%), and getting assigned a resident mentor during the elective (82%), which was of note more popularly  
20 selected than getting assigned a faculty mentor during the elective (77%). A separate study conducted a questionnaire to  
21 medical students that completed the radiology elective at their institution and found that these students were motivated to  
22 learn about appropriateness criteria for ordering imaging, improve their imaging interpretation skills, increase their  
23 confidence, and learn about the science behind technology with regards to protocol, contrast, and techniques.<sup>11</sup> These  
24 findings demonstrate that many medical students come into radiology electives with specific goals to learn about the field  
25 and improve their clinical skills and are highly motivated to become more involved during the elective.

### 27 *Traditional format of radiology electives*

28 Across US medical schools, many radiology electives have been structured similarly. Traditionally, radiology  
29 electives tend to occur in either 1-week, 2-week, or 4-week blocks occurring during the 3<sup>rd</sup> or 4<sup>th</sup> year of medical school.<sup>2</sup>  
30 Prior to starting the rotation, medical students are often given a set of learning objectives detailing their expectations and  
31 roles in the reading room.<sup>2,12,13</sup> Following this, the traditional radiology elective tends to involve many forms of passive  
32 learning via having students observe readouts,<sup>12,14</sup> attend didactic lectures,<sup>14,15,16</sup> and have students rotate through  
33 different radiology subspecialties.<sup>17,18</sup> Certain rotation directors have also began implementing newer practices, such as  
34 adding flipped classroom instruction,<sup>15,16</sup> or adding online learning modules during the pandemic.<sup>19,20</sup>

### 36 *Problems with the traditional format*

37 With the traditional structure of radiology electives, multiple issues have been commonly reported by medical  
38 students. Most commonly, the issues seem to relate to the extremely passive observer role students are given, the  
39 inaccurate representation of what radiologists do, and unclear communication between students and faculty.

1 The skillset required to be able to effectively and efficiently interpret and order diagnostic imaging is incredibly  
2 high and beyond the skills of medical students.<sup>13</sup> That in tandem with the job that students are often given in the reading  
3 room of simply observing results in many medical students feeling unengaged and unsure of what their expectations are.  
4 Researchers in a single institution surveyed 95 medical students who completed their radiology elective and found that  
5 the most common themes students had issues with were the lack of autonomy, lack of structured teaching, and lack of  
6 preceptor continuity.<sup>3</sup> In a different qualitative study at a separate institution, narrative feedback from students centered  
7 towards feelings of isolation, feeling like there was no accountability, and feeling of little value, with one student  
8 commenting he just felt “like a bother.”<sup>21</sup>

9  
10 Issues with the traditional format of radiology electives can also lead to failures in dissolving misconceptions  
11 medical students may have towards radiologist and their field. Currently many medical students view radiology electives  
12 as having the reputations of being easy and flexible, which does not accurately represent the daily practice of radiology.<sup>13</sup>  
13 A recent educational perspective helps to further highlight many of the ongoing misconceptions about radiology,<sup>6</sup> stating  
14 that radiologists may be seen as being socially inept, are only interested in financial incentives, that the reading room is a  
15 boring place, and that radiologists might soon be replaced by artificial intelligence.<sup>4</sup> Considering the passive observer  
16 role that most medical students have in the room, sitting in silence while watching radiologists dictate studies, it is not  
17 far-fetched to understand why several of these misconceptions are still very prevalent across US medical schools.

18  
19 Problems with communication between students and faculty are also prevalent. Researchers at one institution  
20 surveyed 31 radiologist faculty, and found that they themselves had issues with lack of clarity regarding learning  
21 objectives, and lack of understanding of what level of knowledge to expect of the medical students.<sup>3</sup> Suggestions for  
22 improvement have been made in the past, with researchers from one study surveying 28 medical students at their  
23 institution and finding proposals that medical students be treated like residents and thus being given responsibilities to  
24 review/dictate cases with faculty, and have more teaching time with faculty.<sup>21</sup> So with these suggestions, why not just  
25 give medical students more responsibility and have faculty spend more time with them across US medical schools?

### 26 27 *Challenges*

28 Many radiology clerkship coordinators will inevitably face similar issues while designing their courses, with  
29 most coming from similar themes: (1) faculty don't have time,<sup>9,13,22</sup> (2) no financial motivation to teach,<sup>22</sup> (3) no suitable  
30 entry-level tasks for students.<sup>13</sup> The daily responsibilities of an attending radiologist make it difficult to accommodate  
31 extra teaching roles. One review article notes how radiologists often have shift-like rotation and are often at the whims of  
32 their scheduling, which ultimately prevents faculty from taking ownership of supervising individual students.<sup>13</sup> Currently,  
33 majority of US radiologists are compensated on a fee-for-service model, with each study carrying an associated relative  
34 value unit (RVU) that determines their reimbursement, and thus their salaries are heavily reliant on their abilities to read  
35 high volumes of imaging studies per day. On top of their ever-increasing clinical responsibilities of reading images  
36 leading to less available time,<sup>9,22</sup> and the fact that there is simply less financial incentive to support education as it  
37 generates less income due to it lowering clinical productivity,<sup>22</sup> there is decreased motivation for faculty to focus more of  
38 their time on teaching medical students.

39  
40 As one study demonstrates, simply increasing clinical responsibilities for medical students on elective may not  
41 address issues of available time for faculty. One institution implemented a novel hands-on elective where 4<sup>th</sup> year

1 medical students were given resident-level responsibilities to dictate studies.<sup>23</sup> While this likely led to better learning for  
2 the students and was ultimately deemed a success by researchers, they acknowledged that the course was incredibly time-  
3 consuming for faculty since each student had to receive individualized education from faculty based on their own  
4 strengths/weaknesses. So, what are some ways to approach these limitations?

### 5 6 *Solutions*

7 Throughout the current literature, there are numerous teaching modalities that were implemented and were well-  
8 received by medical students. These modalities can be organized into common themes: (1) supplemental online modules  
9 and case banks, (2) interactive workstations or simulators, (3) consistent teaching and feedback from residents, and (4)  
10 flipped classroom learning.

11  
12 One well-received modality was with online learning modules, in particularly the use of case banks. In two  
13 separate institutions, researchers developed an interactive electronically available case bank that medical students  
14 enrolled in the radiology elective could access and use to supplement their learning.<sup>10,24</sup> At one of the institutions,  
15 students responded well to the case bank, giving a median Likert score (5 = excellent, 4 = very good, 3 = good, 2 = fair, 1  
16 = poor) of 4.5.<sup>24</sup> At the other institution, researchers implemented three changes to their clerkship, including the  
17 development of resident-led rounds, a new case bank, and a more structured schedule, before comparing survey results  
18 for students enrolled before the changes and after the changes.<sup>10</sup> The mean Likert score (ranging between 1=poor and  
19 5=excellent) given by medical students for overall elective experience was significantly higher after implementing their  
20 changes compared to before the changes ( $4.2 \pm 0.90$ ,  $3.3 \pm 1.28$ ,  $P=0.022$ ), with the case bank getting a mean score of  $4.7$   
21  $\pm 0.49$ .

22  
23 Other institutions employed active learning methods in the form of simulation-based learning. Medical students  
24 enrolled in radiology electives in two different medical schools were given the chance to work with a newly implemented  
25 interactive workstation simulator.<sup>18,25</sup> These workstations were composed of a desktop computer in the reading room that  
26 were preloaded with anonymized cases and vignettes deemed appropriate for students by faculty. In both studies, medical  
27 students were encouraged to use the workstation during times when faculty and residents were busy dictating. The  
28 responses from both groups of students were positive, with one surveyed group reporting that 91% of the medical  
29 students believed the station had at least “moderate” (Likert scale 4/5) positive impact on their experience, and 35%  
30 saying the station was the best experience of the entire elective.<sup>18</sup> For the other group, of the 25 students surveyed over  
31 half described the workstation as the best experience they encountered in radiology education, though the researchers  
32 noted the initial process of exporting anonymized imaging studies for the workstation was time intensive (however they  
33 predict maintenance time requirements to be substantially less), and there were also some hardware troubles.<sup>25</sup>

34  
35 In addition, one prospective cohort study performed by an institution found that employing active learning  
36 methods lead to both improvements in both student feedback scores as well as time benefits for faculty.<sup>14</sup> The group  
37 created an integrated radiology clerkship, which substituted hours of traditional didactics taught by faculty for self-  
38 directed simulation-sessions where students could interpret cases on image viewing software. Students (n=91) were  
39 assigned to either the traditional clerkship (n=42) or the integrated clerkship (n=49), and researchers found that not only  
40 was there a statistically significant improvement in student agreement scores from the integrated clerkship compared to  
41 the traditional for positive statements like “I have a better understanding of the role of the radiologist,” (mean Likert

1 score 4.6 vs. 4.3,  $P=0.031$ ) or “my perception of radiology has been improved,” (mean Likert score 4.7 vs. 4,  $P < 0.001$ ),  
2 a secondary effect they noticed was the integrated format actually freed up 7 hours of radiologist time over the course of  
3 the week compared with relying on their traditional clerkship.<sup>14</sup> Other methods of interactive learning employed that  
4 were ultimately well received by students was the use of the novel open-source ICARUS module,<sup>19,26</sup> an interactive web-  
5 based platform like a game where students are presented with a clinical scenario and can then simulate ordering studies,  
6 interpreting images, and making diagnostic decisions, or incorporating the use of audience response systems on students’  
7 smart phones to encourage anonymous interaction during traditional didactics.<sup>4</sup>

8  
9 To help remedy the issue of certain radiology electives being disorganized, two separate studies investigated  
10 developing a new website. One of the research groups claim that students of the technology-driven younger generation  
11 prefer self-directed learning and want autonomy, and that a well-developed website could help accommodate these  
12 needs.<sup>27</sup> The other group of researchers built the website hoping that it would help to consolidate resources, organize  
13 schedules, and improve communication between students and their faculty during the clerkship.<sup>17</sup> In both studies,  
14 surveyed students responded overall positively, with the results from one group showing that 82.5% found the website to  
15 be either “extremely informative,” or “very informative,” when asked to rate the website.<sup>27</sup> In the other group, survey  
16 results showed that 80% of students accessed the website at least once a day, and 17% a few times a week, and 90%  
17 agreed that having easy access to the schedule had a positive impact on their experience.<sup>17</sup> Researchers were able to  
18 identify pearls and pitfalls that were similar across both studies. Both found that the website helped to promote more  
19 autonomy and learner control by easing access to the material,<sup>17,27</sup> and one of the groups found that this increase in  
20 autonomy even helped to relieve radiology faculty of time constraints that would otherwise be required for teaching.<sup>27</sup>  
21 Potential pitfalls identified were technical failures,<sup>27</sup> and that a poorly designed website would have no benefits to  
22 improving student perceptions.<sup>17</sup>

23  
24 Compared to the traditional didactic approach, the flipped classroom method encourages independent self-paced  
25 learning, where students often study or perform assignments on their own outside the classroom and return to discuss  
26 what they learned and collaborate with faculty. Two studies employed this, with one group having students interpret and  
27 dictate an image independently prior to returning to faculty and helping to generate the final report,<sup>28</sup> and the other group  
28 completing an interactive workshop where faculty presented a clinical scenario and focused on facilitating discussion and  
29 engagement from students as opposed to lecturing.<sup>16</sup> Both studies compared student feedback for the flipped classroom  
30 method vs. didactic method, though one study was a prospective cohort that assigned students solely to flipped classroom  
31 vs. didactic,<sup>16</sup> while in the other students would experience alternate between both methods.<sup>28</sup> Results for both were  
32 similar in that students responded significantly more positively to the flipped classroom method, with one group of  
33 students stating they experienced more task value, had less boredom and greater enjoyment,<sup>16</sup> and the other stating they  
34 felt more engaged and had perceived more educational value.<sup>28</sup>

35  
36 Lastly, medical students seem to highly value regular teaching and feedback from residents or faculty. In their  
37 review, Visscher and Faden report that medical students interested in radiology highly value longitudinal mentorship,  
38 small group teaching, and often do not perceive a significant difference in teaching quality between residents and  
39 attendings.<sup>29</sup> One study developed a new “resident liaison for medical student education” role, where the selected  
40 resident would focus primarily on actively teaching medical students, recruiting other residents for teaching roles, and  
41 serving as course director for their 2-week radiology elective.<sup>5</sup> Following the program implementation, feedback from

1 both the teaching residents and students was excellent, with the 8 medical students surveyed giving an average rating of  
2 9.6 out of 10 and providing narrative feedback stating the teaching was excellent and they felt like the resident was  
3 invested in their learning. At a separate study, researchers implemented a new resident-led rounds where students would  
4 be given the chance to take and interpret cases and be given prompt feedback.<sup>10</sup> When surveyed, medical students rated  
5 the resident-led rounds very well (Likert score mean  $4.9 \pm 0.35$  out of 5), the highest of all the changes implemented  
6 (other changes including a case bank and more detailed schedule). These findings may suggest that not only are students  
7 receptive towards resident teaching, but these residents may also be extremely effective teachers, and possibly help  
8 alleviate some of the time constraints of teaching from attending radiologists.

### 9 10 **Limitations:**

11 This article is primarily flawed in that majority of the primary literature in this review are case studies, and thus  
12 did not incorporate control groups for comparison. As a result, there is no specific way to identify if specific  
13 interventions were the actual cause of any improved student feedback and perceptions. In addition, many of the studies  
14 included small sample sizes, so the results may not be generalizable across US medical schools. Majority of the studies  
15 also relied heavily on the Likert-scale to assess student attitudes, an inherently arbitrary metric which may not always  
16 properly represent how student's feel.

17 In addition, this article was written with the purpose of being an informative narrative literature review, and  
18 therefore did not follow the stringent guidelines of a true systematic review that followed PRISMA guidelines. This  
19 article focused on incorporating a collective of reviews, opinions, and recommendations as opposed to strict data  
20 extractions, structured appraisals, and meta-analyses expected of a systematic review. As a result the article does not  
21 specifically examine each primary article to assess for whether survey questions were validated, whether a statistician  
22 was involved, what the response rates were for each study, whether surveys were pilot tested, or whether sample sizes  
23 were calculated.

### 24 25 **Conclusions:**

26 With the current growth of reliance in imaging and projected manpower requirements to meet these demands, it  
27 is imperative that teaching institutions across the country look closely at how the specialty is perceived amongst the  
28 medical students, and that radiology electives be revamped to showcase the realities of the specialty and make it  
29 attractive. The aim should be to be able to attract bright and motivated students to take up this specialty, while also  
30 providing a rewarding environment to learn imaging skills for those students who will eventually choose to pursue other  
31 fields. Investigators addressed some of the problems of the traditional radiology elective, as well as some of the newly  
32 implemented strategies that have been well received by medical students for improving perceived radiology elective  
33 quality. Majority of the flaws of the traditional elective stem from the passive observer role that students have in the  
34 reading room, and unclear expectations for what medical students should do. Radiology clerkship directors may  
35 experience challenges with time constraints for faculty to teach, and not having tasks suitable for the skill level of  
36 medical students. Certain novel teaching methods have been implemented which have been well-received by students  
37 and could potentially offer an approach to help alleviate some of these challenges. New active learning methods in the  
38 form of case banks, interactive simulators, and websites, might help alleviate some of the teaching time constraints  
39 experienced by faculty while also keeping students actively engaged. In addition, increased resident teaching roles and  
40 responsibilities as well as flipped classroom teaching can also be viewed favorably by medical students while helping to  
41 decrease some of the teaching burden from faculty. While this is certainly not a fully comprehensive list of the various

1 novel teaching methods used across clerkships, the positive feedback given by students suggest they may be a step in the  
2 right direction towards making radiology clerkships more engaging and valuable for students while also being  
3 logistically feasible for faculty.

4  
5  
6  
7  
8  
9

Accepted, in-press

## 1 SUMMARY - ACCELERATING TRANSLATION

2

3 **Title:** A Narrative Literature Review on Quality Improvements for Radiology Clerkships from Medical Student  
4 Perspectives

5 **Main problem to solve:** Radiology clerkships have the potential to give medical students a better  
6 appreciation towards the responsibilities of radiologists towards patient care, while also raising interest and  
7 improving student confidence in diagnostic imaging skills. Unfortunately, many radiology clerkships across  
8 the US have developed a reputation for being unorganized, and unengaging.

9 **Aim of study:** This review is focused on summarizing some of the clerkship practices performed across the  
10 US that have been well received by students, as well as some weaknesses with the traditional clerkship  
11 format from the student perspective, with the aim of highlighting effective approaches to revamping electives  
12 to showcase the realities of the specialty while also attracting bright and motivated students.

13 **Methodology:** The investigators performed a literature search on the PubMed and CINAHL databases using  
14 specific search terms deemed relevant to the topic of this review. From the results of the initial research,  
15 investigators proceeded by individually selecting articles to be reviewed more in depth and for final analysis  
16 based on specific inclusion and exclusion criteria listed in the review. The end result was 28 studies that  
17 gathered survey responses from medical students that completed radiology clerkships to determine their  
18 perceptions towards the clerkship.

19 **Results:** Major findings discussed included weaknesses with the traditional format related to passive learning  
20 through observing, and unclear expectations for medical students, as well as certain challenges that clerkship  
21 directors may face while attempting to implement changes to their clerkship. This review also discussed  
22 specific well-received practices involving more active learning, including interactive workstations, interactive  
23 simulators, flipped classrooms, and case banks and online learning modules.

24 **Conclusions:** With the growing demands towards diagnostic imaging, it is imperative that teaching  
25 institutions across the country look closely at how the specialty is perceived amongst the medical students,  
26 and that radiology electives be revamped to showcase the realities of the specialty and make it attractive to  
27 bright and motivated students to take up this specialty. Investigators addressed some of the problems of the  
28 traditional radiology elective, as well as some of the newly implemented strategies that have been well  
29 received by medical students for improving perceived radiology elective quality. Majority of the flaws of the  
30 traditional elective stem from the passive observer role that students have in the reading room, and unclear  
31 expectations for what medical students should do. Radiology clerkship directors may experience challenges  
32 with time constraints for faculty to teach, and not having tasks suitable for the skill level of medical students.  
33 Certain novel teaching methods have been implemented which have been well-received by students and  
34 could potentially offer an approach to help alleviate some of these challenges. New active learning methods in  
35 the form of case banks, interactive simulators, and websites, might help alleviate some of the teaching time  
36 constraints experienced by faculty while also keeping students actively engaged. In addition, increased  
37 resident teaching roles and responsibilities as well as flipped classroom teaching can also be viewed  
38 favorably by medical students while helping to decrease some of the teaching burden from faculty. While this  
39 is certainly not a fully comprehensive list of the various novel teaching methods used across clerkships, the  
40 positive feedback given by students suggest they may be a step in the right direction towards making  
41 radiology clerkships more engaging and valuable for students while also being logistically feasible for faculty.

1 **REFERENCES.**

- 2
- 3 1. Lee H, Kim DH, Hong PP. Radiology Clerkship Requirements in Canada and the United States: Current State and  
4 Impact on Residency Application. *JACR*. 2020;17(4):515-522.
- 5
- 6 2. Poot JD, Hartman MS, Daffner RH. Understanding the US Medical School Requirements and Medical Students'  
7 Attitudes about Radiology Rotations. *Acad. Radiol*. 2012;19(3):369-373.
- 8
- 9 3. Darras KE, Spouge R, Kang H, et al. The Challenge with Clinical Radiology Electives: Student and Faculty  
10 Perspectives Identify Areas for Improvement. *Can Assoc Radiol J*. 2019;70(4):337-343.
- 11
- 12 4. Lo L, Awan OA. To Engage or Not to Engage: A New Era for Medical Student Education in Radiology.  
13 *RadioGraphics*. 2020;40(7):1830-1831.
- 14
- 15 5. Webb EM, Ahearn B, Naeger DM. A Designated "Teaching Resident": A Novel Leadership Position to Promote  
16 Educational Skills and an Academic Career. *JACR*. 2016;13(1):77-80.
- 17
- 18 6. Gunderman RB, Hill DV. Student Concerns and Misconceptions about A Career in Radiology. *Acad. Radiol*.  
19 2012;19(3):366-368.
- 20
- 21 7. Saha A, Roland RA, Hartman MS, Daffner RH. Radiology Medical Student Education: An Outcome-based Survey of  
22 PGY-1 Residents. *Acad. Radiol*. 2013;20(3):284-289.
- 23
- 24 8. Chan D, Sakya SM, Pfeifer CM. United States Medical Licensing Examination Step 1 Pass-or-Fail Reporting: Student  
25 Perspectives on Implications for Medical Student Education in Diagnostic Radiology. *JACR*. 2020;17(12):1670-1672.
- 26
- 27 9. Straus CM, Webb EM, Kondo KL, et al. Medical Student Radiology Education: Summary and Recommendations  
28 From a National Survey of Medical School and Radiology Department Leadership. *JACR*. 2014;11(6):606-610.
- 29
- 30 10. Larocque N, Lee SY, Monteiro S, Finlay K. Reform of a Senior Medical Student Radiology Elective Using a Needs  
31 Assessment. *Can Assoc Radiol J*. 2018;69(3):253-259.
- 32
- 33 11. Mullins ME, Lieberman G, Shaffer K, Novelline RA. Factors to consider in the revision of educational objectives for  
34 medical students in radiology clerkships. *JACR*. 2005;2(1):55-60.
- 35
- 36 12. Benedetti NJ, Naeger DM, Webb EM. Radiology Primer: A Novel Radiology Course for Undecided Medical  
37 Students. *JACR*. 2014;11(12, Part A):1182-1185.
- 38
- 39 13. Naeger DM, Phelps A, Kohi M, Elicker B, Ordovas K, Webb EM. Reading room electives: say goodbye to the "radi-  
40 holiday". *JACR*. 2013;10(6):442-448.
- 41

- 1 14. Redmond CE, Healy GM, Fleming H, McCann JW, Moran DE, Heffernan EJ. The Integration of Active Learning  
2 Teaching Strategies Into a Radiology Rotation for Medical Students Improves Radiological Interpretation Skills and  
3 Attitudes Toward Radiology. *Curr. Probl. Diagn. Radiol.* 2020;49(6):386-391.  
4
- 5 15. Belfi LM, Bartolotta RJ, Giambrone AE, Davi C, Min RJ. "Flipping" the Introductory Clerkship in Radiology:  
6 Impact on Medical Student Performance and Perceptions. *Acad. Radiol.* 2015;22(6):794-801.  
7
- 8 16. O'Connor EE, Fried J, McNulty N, et al. Flipping Radiology Education Right Side Up. *Acad. Radiol.*  
9 2016;23(7):810-822.  
10
- 11 17. Desai NS, Bunch PM, DiSalvo DN, et al. The Use of an Integrated Website to Enhance the Educational Experience  
12 in a Medical School Radiology Clerkship Course. *Curr. Probl. Diagn. Radiol.* 2016;45(1):17-22.  
13
- 14 18. Friedman MV, Demertzis JL, Hillen TJ, Long JR, Rubin DA. Impact of an Interactive Diagnostic Case Simulator on  
15 a Medical Student Radiology Rotation. *AJR.* 2017;208(6):1256-1261.  
16
- 17 19. Belfi LM, Dean KE, Bartolotta RJ, Shih G, Min RJ. Medical student education in the time of COVID-19: A virtual  
18 solution to the introductory radiology elective. *Clin Imaging.* 2021;75:67-74.  
19
- 20 20. Gomez E, Azadi J, Magid D. Innovation Born in Isolation: Rapid Transformation of an In-Person Medical Student  
21 Radiology Elective to a Remote Learning Experience During the COVID-19 Pandemic. *Acad. Radiol.* 2020;27(9):1285-  
22 1290.  
23
- 24 21. Visccher K, Faden L, Wiseman D. Radiology Exposure in the Undergraduate Curriculum: A Medical Student  
25 Perspective on Quality and Opportunities for Positive Change. *Can Assoc Radiol J.* 2017 Aug;68(3):249-256.  
26
- 27 22. Cohen MD, Gunderman RB, Frank MS, Williamson KB. Challenges Facing Radiology Educators. *JACR.*  
28 2005;2(8):681-687.  
29
- 30 23. Newbury A, Cerniglia CA, Lo HS. Implementation of a Novel Hands-on Advanced Radiology Elective. *Curr. Probl.*  
31 *Diagn. Radiol.* 2021;50(2):123-125.  
32
- 33 24. Wu Y, Theoret C, Burbridge BE. Flipping the Passive Radiology Elective by Including Active Learning. *Can Assoc*  
34 *Radiol J.* 2021;72(4):621-627.  
35
- 36 25. Strickland CD, Lowry PA, Petersen BD, Jesse MK. Introduction of a Virtual Workstation Into Radiology Medical  
37 Student Education. *AJR.* 2015;204(3):W289-W292.  
38
- 39 26. Belfi LM, Dean KE, Jordan SG. I.C.A.R.U.S. in Flight: A Radiology Simulator Teaches Imaging Appropriateness,  
40 Anatomy, and Image Interpretation Skills. *Acad. Radiol.* 2022;29:S94-S102.  
41

- 1 27. Mauro DM, Ellis JA, Lilly JF, Dallaghan GLB, Jordan SG. Creating an Open-Access Educational Radiology Website  
2 for Medical Students: A Guide for Radiology Educators. *Acad. Radiol.* 2021;28(11):1631-1636.  
3
- 4 28. Huang J, Bingham B, Jordanov M. The “Look Ahead” Technique: A Novel Way to Engage Medical Students in the  
5 Radiology Reading Room. *Acad. Radiol.* 2021;28(2):250-254.  
6
- 7 29. Visscher KL, Faden L. Designing a Comprehensive Undergraduate Medical Education Radiology Curriculum Using  
8 the 5C’s of Radiology Education Framework. *Can Assoc Radiol J.* 2018;69(4):362-366.  
9
- 10 30. Smith EB, Boscak A, Friedman EM, et al. Radiology Medical Student Education 2020: Surveys of the Alliance of  
11 Medical Student Educators in Radiology and Medical Students. *Acad Radiol.* 2022;29(2):298-311.  
12
- 13 31. Zou L, King A, Soman S, et al. Medical Students’ Preferences in Radiology Education: A Comparison Between the  
14 Socratic and Didactic Methods Utilizing PowerPoint Features in Radiology Education. *Acad Radiol.* 2011;18(2):253-  
15 256.  
16
- 17 32. Martin J, Fimbres D, Wang S. Prevalence of Novel Pedagogical Methods in the Radiology Education of Medical  
18 Students. *South Med J.* 2022 Dec;115(12):874-879.  
19  
20

Accepted, in press

1  
2  
3

Accepted, in-press

1 **FIGURES AND TABLES.**

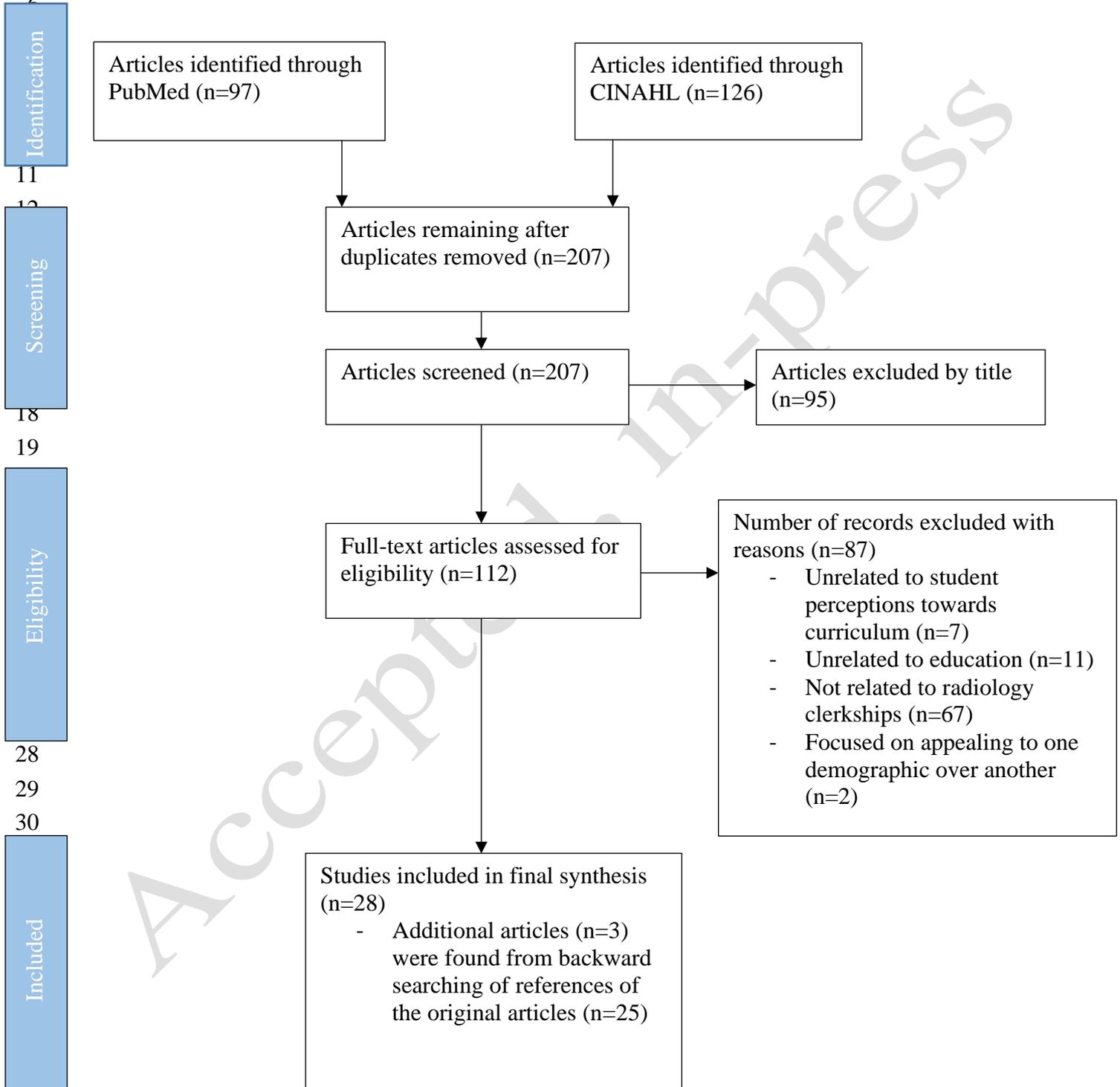
2

3

4 **Figure 1. PRISMA Flowchart Demonstrating the Selection Process During the Literature Search**

5

6



11

12

18

19

28

29

30

38

39

40

1 **Table 1.** Primary literature sources included in review, detailing the sample size, survey methodologies, study  
2 intervention, and study type.

3

Reference	Population	Data collection method	Study intervention	Research design
Belfi et al (2021)	26 4th year students	5-point Likert test for perception, unpaired t-test for pre-post intervention	2 week in-person elective converted to virtual elective	case study
Belfi et al (2015)	101 3rd year students	Post completion ranking survey of preferred learning method	different learning methodologies (traditional, blended, independent)	case study
Belfi et al (2022)	95 students enrolled in clerkship	5-point Likert scale survey to test student perception	ICARUS interactive gaming modules	case study
Benedetti et al (2014)	5 medical students	10-point Likert scale and open response	Newly designed radiology elective focused on career development	case study
Darras et al (2019)	95 medical students and 31 faculty	5-point Likert scale, and open response comments	survey assessed student perceptions towards the elective for: (1) goal orientation, (2) organization/regulation, and (3) relationships	case study
Desai et al (2016)	35 medical students	5-point Likert scale survey to test student perception	Integrated website built for elective	case study
Friedman et al (2017)	40 medical students	5-point Likert scale survey to test student perception	Set up an interactive workstation with anonymized cases for MSK related pathology	case study
Gomez et al (2020)	116 medical students enrolled	Likert scale survey and open response feedback	switched to virtual elective in setting of COVID	case study
Huang et al (2021)	34 medical students	a combination of 100-point Likert scale and open response	flipped classroom approach	case study
Larocque et al (2018)	36 surveyed of 58 students who completed elective,	Survey items: dichotomous, ranking, 5-point Likert-type scale questions, as well as open-ended questions	2 studies. First study is needs assessment survey, second study implements changes to meet those needs.	case study

Reference	Population	Data collection method	Study intervention	Research design
Mauro et al (2021)	120 medical students surveyed, 97 were in elective	student satisfaction surveys including Likert scale and narrative comments	built a cost-effective website	case study
Mullins et al (2005)	13 medical students surveyed prior to elective start	Open response survey	Survey was conducted to determine the objectives students want met for radiology electives	Observational study
Newbury et al. (2021)	4th year medical students	Entrance and exit surveys given to medical students	Medical students were given PGY-1 level responsibilities	case study
O'Connor et al (2016)	175 medical students	Likert scale questionnaires evaluating task value, enjoyment, anxiety, boredom, etc.	Alternated flipped learning with didactic lectures	Prospective cohort study
Poot et al (2012)	3rd and 4th year medical students	questionnaires composed of Likert, free response, and multiple choice	optional survey distributed to 3rd and 4th year medical students	Observational study
Redmond et al (2020)	91 4th year medical students	Likert scale questionnaires to assess attitudes towards radiology	Active learning (integrated) vs. traditional passive method	Prospective cohort study
Smith et al. (2022)	80 medical students	post-clerkship surveys consisting of multiple choice, ranking, Likert scale, and open response	Surveys given during COVID pandemic to assess how students perceived radiology virtual training	Observational study
Strickland et al. (2015)	25 medical students that completed the elective	post-clerkship survey of Likert scale questions to assess perceptions	Virtual MSK radiology workstation	Case study
Visccher et al (2017)	28 medical students across all years	multiple choice, audio recordings, and open response surveys	Surveyed medical students to assess exposure, perceptions, and suggestions for positive change	Observational study

Reference	Population	Data collection method	Study intervention	Research design
Webb et al. (2016)	medical students who completed elective	10-point Likert scale and narrative comments questionnaire given to students	new "teaching resident" role developed	Case study
Wu et al. (2021)	23 medical students	post-clerkship survey composed of 5-point Likert scale	newly added online learning platform and e-book	Case study
Zou et al. (2011)	74 3rd and 4th year medical students	post-conference questionnaire composed of ranking choices	didactic lecture format vs. active participation	case study

1  
2  
3

Accepted, in-press