

# Peer Teaching in Undergraduate Medical Education: What are the Learning Outputs for the Student-Teachers? A Systematic Review

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**Introduction:** To achieve quality in medical education, peer teaching, understood as students taking on roles as educators for peers, is frequently used as a teaching intervention. While the benefits of peer teaching for learners and faculty are described in detail in the literature, less attention is given to the learning outputs for the student-teachers. This systematic review focuses on the learning outputs for medical undergraduates acting as student-teachers in the last decade (2012–2022).

**Aim:** Our aim is to describe what learning outputs student-teachers have from peer teaching, and map what research methods are used to assess the outputs. We defined learning outputs in a broad sense, including all types of learning experiences, intended and non-intended, associated with being a peer teacher.

**Methods:** A literature search was conducted in four electronic databases. Title, abstract and full text were screened by 8 independent reviewers and selection was based on predefined eligibility criteria. We excluded papers not describing structured peer teaching interventions with student-teachers in a formalized role. From the included articles we extracted information about the learning outputs of being a student-teacher as medical undergraduate.

**Results:** From 668 potential titles, 100 were obtained as full-texts, and 45 selected after close examination, group deliberation, updated search and quality assessment using MERSQI score (average score 10/18). Most articles reported learning outputs using mixed methods (67%). Student-teachers reported an increase in subject-specific learning (62%), pedagogical knowledge and skills (49%), personal outputs (31%) and generic skills (38%). Most articles reported outputs using self-reported data (91%).

**Conclusion:** Although there are few studies that systematically investigate student-teachers learning outputs, evidence suggests that peer teaching offers learning outputs for the student-teachers and helps them become better physicians. Further research is needed to enhance learning outputs for student-teachers and systematically investigate student-teachers' learning outputs and its impact on student-teachers.

**Keywords:** peer-assisted learning, medical school, medical student, peer teacher

## Introduction

Peer teaching, defined as teaching performed by “A person who is the same age or has the same social position or the same abilities as other people in the group” is being used worldwide both in undergraduate and postgraduate medical education.<sup>1,2</sup> Studies have shown that students learn as much from being taught by peers as they do from expert teachers.<sup>3,4</sup> In addition, it has been argued that the social and cognitive congruence that characterize the student-learner and student-teacher relationship creates psychological safe learning spaces, mutual understanding of difficulties and customized models for explaining the learning content.<sup>5–7</sup> Also, it is argued that peer teaching alleviates teaching pressure for faculty.<sup>6</sup>

Whitmans description of “teaching as learning twice” from 1988<sup>8,9</sup> suggests that peer teaching also benefits the student-teacher. Previous studies point to improved written and/or practical examination scores for students that were teaching peers in basic sciences,<sup>10</sup> participated in a small-group based Gastroenterology/Hematology course where they alternated being group facilitators<sup>11</sup> and students acting as student-teachers in musculoskeletal ultrasound interpretation compared to their same year peers.<sup>12</sup> Burgess et al<sup>13</sup> found that the benefits of peer teaching for the student-teacher can be described in two main categories: Development in understanding of knowledge content and development of professional attributes. The two categories include increased awareness of facilitation, teaching and feedback techniques, leadership qualities, confidence, open-mindedness and autonomy. Finally, a review conducted in 2020 by Bower et al<sup>14</sup> documented opportunities for student-teachers to consolidate their own learning while contributing to the medical school community. However, the 2020 review focused on informal near peer teaching and not formalized peer teaching initiatives.<sup>14</sup> For peer teaching to have positive learning outputs for the student-teacher, the literature highlights the need for teacher training and support from faculty.<sup>15</sup>

Many of the competencies used to evaluate learning outputs of student-teachers are reflected in medical curricula worldwide as part of the CanMEDS framework designed by the Royal College of Physicians and Surgeons of Canada. CanMEDS identifies and describes the competences required of medical doctors to meet the health care needs of patients. The competences are organized under a set of roles: medical expert, communicator, collaborator, leader, health advocate, scholar and professional.<sup>16</sup> This framework enables us to organize the potential learning outputs gained from peer teaching and to explore how being a peer teacher can facilitate the development of core competencies among student-teachers.

While the CanMEDS framework provides a useful basis for identifying key competencies, systematizing the available knowledge about learning outputs of student-teachers is challenged by overlapping definitions of peer teaching in the literature. Peer teaching is often used as an umbrella term including both collaborative learning, peer-assisted learning, near-peer teaching, teaching assistants, peer and near-peer supervision, mentoring and more. As a result, the student-teachers role can become unclear as it can both entail being a collaborative resource for fellow students within the same program and having a dedicated role as an educator for same level or more junior students. While recognizing that the role of an educator might entail assessment, feedback and supervision, we limited our screening to studies that described teaching activities where students had a clear and formalized role as an educator. This means that peer assessment, peer feedback and reciprocal learning activities, where peers take turns teaching each other or engage in group learning activities, were excluded. While previous reviews have focused more broadly on the effectiveness of peer teaching, this systematic review focuses on the learning outputs for student-teachers in formalized peer teaching settings. To further limit our review, we focused on undergraduate medical education, thus excluding postgraduate education, residency training and interdisciplinary studies. Previous reviews provide sufficient summaries of evidence prior to 2012,<sup>13</sup> hence, we limit our review to qualitative and quantitative studies focusing on learning outputs for student-teachers published between 2012 and 2022. Knowledge regarding outputs of peer teaching for the student-teachers might help medical faculties design peer teaching regimes with benefits for all the parties involved. Thus, our aim was to describe what learning outputs student-teachers have from peer teaching, and map what research methods are used to assess these outputs.

## Materials and Method

To achieve our aim, a systematic search in four databases was conducted. The findings from the studies were summarized in tables, and the results were set up against CanMEDS framework.

The literature search was conducted during October and November 2021, and updated in November 2022, in Embase, ERIC databases, MEDLINE and PubMed. The search was conducted using search terms: “near peer teaching”, “peer assisted learning”, “peer mentor”, “peer tutor” and “peer teacher(s)”, additionally the search was restricted to undergraduate medical education (Table 1). The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines 2020 was used as a guide to record the review process (Figure 1).<sup>17</sup> All articles were retrieved in the bibliography management program EndNote X9. Duplicates were removed before the remaining articles were uploaded in Rayyan AI where the articles were screened using the inclusion and exclusion criteria outlined below (Table 2). The inclusion and exclusion criteria were developed based on our aim to gather information about student-teachers at undergraduate medical education level.

One reviewer (first author) screened all the 668 articles that were retrieved in the original search, whereas the co-authors (four researchers from University of Bergen, and three researchers from Karolinska Institutet) screened

**Table I** Search Terms and Keywords Used in the Literature Search

PubMed	Embase, ERIC Databases and MEDLINE
In PubMed the search was conducted using search terms: "near peer teaching"[Title/Abstract] OR "peer assisted learning"[Title/Abstract] OR "peer mentor"[Title/Abstract] OR "peer tutor"[Title/Abstract] OR "peer teach*"[Title/Abstract] combined with search terms "Education, medical, undergraduate"[MeSH Terms] OR "undergraduate medical"[Title/Abstract] using the Boolean operator AND	The search on Embase, ERIC databases and MEDLINE was conducted using search terms: "exp Medical school" or "exp Medical student" combined with search terms "near peer teaching.mp" OR "peer assisted learning.mp" OR "peer mentor.mp" OR "peer tutor.mp" OR "peer teach\$.mp" using the Boolean operator AND.

**Notes:** \*Truncation symbol in PubMed. \$ Truncation symbol in Embase, ERIC databases and MEDLINE. exp = "explosion", meaning this search not only look for the subject term selected but also many related subjects. mp = "multi-purpose", meaning this search look at several fields at once, including title, abstract, keyword, original title and heading word.

approximately 100 articles each, ensuring a double blinded review process. Conflicts were resolved by discussion between four of the authors (MAT, TM, MK and HHA). Out of 668 records, 100 articles were contained initially and subjected to full-text screening. After the initial full-text screening and data extraction 40 articles were selected. After the updated search 45 articles were included in this review as the final material.

To ensure reliable and valid data, the quality of the quantitative studies included was evaluated by two reviewers (MAT, IGS) using The Medical Education Research Study Quality Instrument (MERSQI).<sup>18–20</sup> The instrument is based on 10 items, reflecting six domains of study quality: (1) study design, (2) number of institutions studied and response rate, (3) data type, (4) validity evidence for evaluation instrument, (5) data analysis sophistication and appropriateness, and (6) outcome level. The maximum domain score is 3, and a minimum of 0–1, producing a potential range of 5–18 MERSQI scores.<sup>20</sup>

The results were critically synthesized by multiple reviewers using categories based on past literature and CanMEDS framework. The findings from the studies are summarized in tables, giving an appropriate schematic informative focus to this review.

## Results

A total of 45 articles were included in the review. Table 3 gives an overview of the included articles and presents each publication with authors, quality assessment using MERSQI score, country of origin, number of student-teachers and student-learners, study design, and teacher training intervention. Furthermore, dimensions of teaching encounters are described using three subcategories: frequency and dimension, group size and teaching subject. The last category reports learning outputs for student-teachers and what methods that were used to assess the outputs.

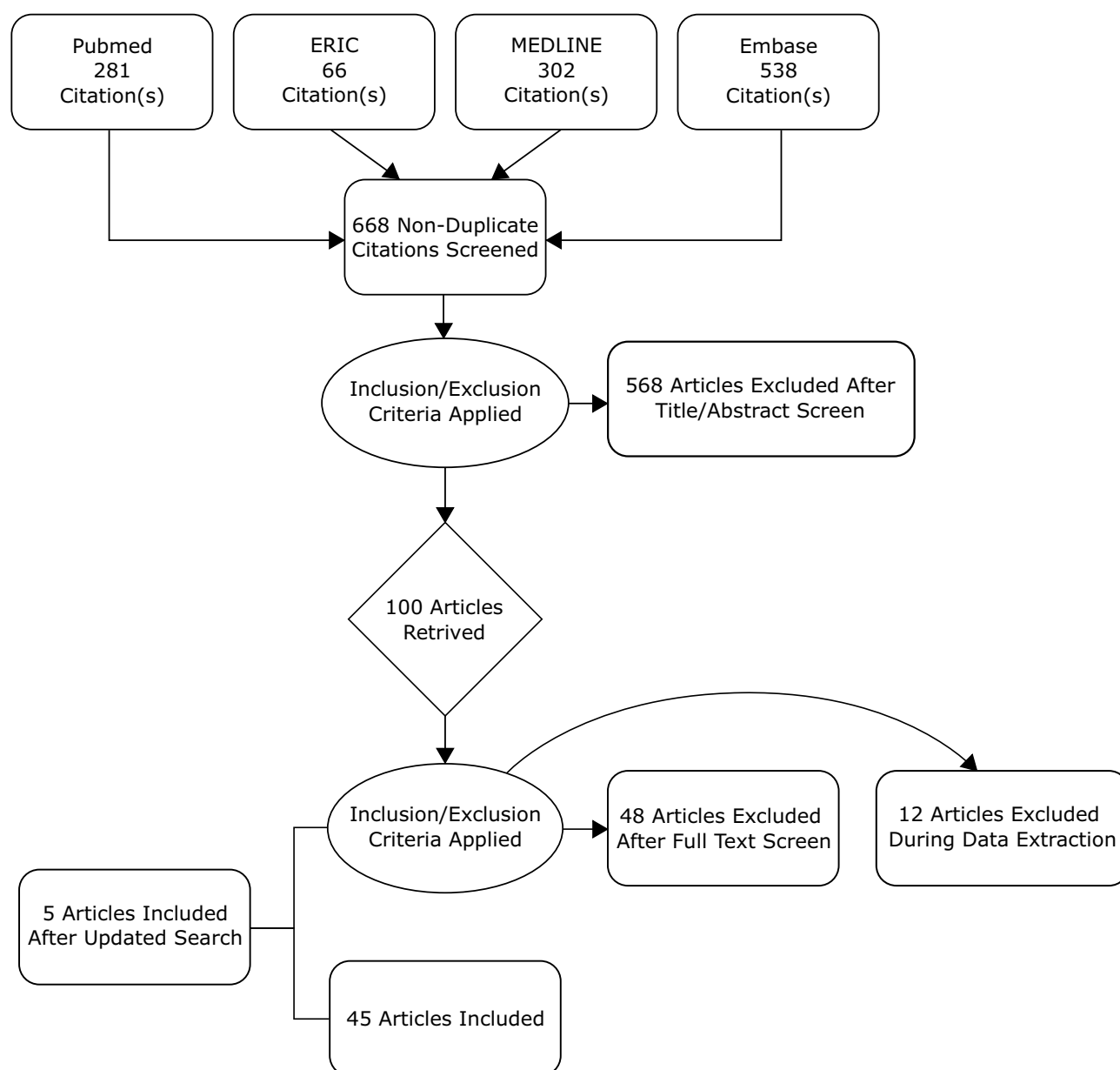
## Description of the Student-Teachers

The included studies describe peer teaching activities set in 14 different countries with the USA, Australia and the UK as the most predominant. Student-teachers in the articles reviewed were recruited from all levels of medical school. Most of the studies reported having a one-year gap between the student-teachers and student-learners. Number of student-teachers included in the studies ranged from 3 student-teachers<sup>55</sup> to 481 student-teachers,<sup>35</sup> and number of student-learners included in studies ranged from 5 student-learners<sup>55</sup> to 1053 student-learners.<sup>42</sup>

Anatomy, clinical skills and communication were the most frequent subjects taught by the student-teachers. The amount of teaching sessions varied in frequency from only one teaching session<sup>48</sup> to 26 sessions.<sup>57</sup> They also varied in duration from 30 minutes<sup>51,60</sup> to 4 hours.<sup>53</sup> Furthermore, peer teaching was deployed in various group sizes of learners ranging from 4 students in the smallest group<sup>47,49</sup> to 25 in the biggest group.<sup>48</sup> Some articles did not specify group sizes.

## Reported Learning Outputs

Most of the studies reported multiple learning outputs for the student-teachers (see Table 4). In the following section, outputs for the student-teachers are reported in four domains set by the reviewers based on previous literature and CanMEDS framework: subject-specific learning outputs, pedagogical knowledge and skills, personal outputs and generic skills.



**Figure 1** Flow chart displaying the whole process of assessing and selecting articles for this review.

### Subject-Specific Learning Outputs

Several studies reported that student-teachers increased their learning about the content they were teaching. Additionally, improved skillset and technical performance were also frequently reported. One article reported better results in objective structured clinical examination (OSCE)<sup>39</sup> and another article reported better results in anatomy examinations.<sup>21</sup> Furthermore, two articles reported that student-teachers felt better prepared for OSCE after completing the peer teaching program.<sup>38,41</sup>

### Pedagogical Knowledge and Skills

Improved pedagogical knowledge and skills were reported in several articles, where student-teachers reported developing better understanding and awareness of the teaching process and feedback strategies. In one study the student-teachers reported improved teaching skills, which they in turn considered helpful to their future roles as residents and attendings within the field of surgery.<sup>43</sup>

**Table 2** Inclusion and Exclusion Criteria for Screening of Articles

Inclusion Criteria	Exclusion Criteria
<ul style="list-style-type: none"> <li>• All study participants are undergraduate medical students</li> <li>• Quantitative and qualitative studies</li> <li>• Empirical research where learning outputs for student-teachers are reported</li> <li>• Studies where students have a dedicated role as student-teachers. Student-teachers may have different assignments, but studies including interchanging roles between teacher and learner are excluded</li> <li>• Original research articles published in the last decade (2012–2022)</li> </ul>	<ul style="list-style-type: none"> <li>• Programs involving postgraduates, residents or other health professions than medicine</li> <li>• Interdisciplinary studies involving medical education students</li> <li>• Studies involving peer assessment or peer supervision in clinical settings</li> <li>• Reciprocal peer teaching (studies with interchanging roles between teacher and learner)</li> <li>• Studies reporting solely on outputs for the student-learners and not student-teachers</li> <li>• Articles focusing on student-teacher training courses</li> <li>• Studies published prior to 2012</li> <li>• Full-text article not available</li> <li>• Article not available in English</li> <li>• Review studies, comments, letters to editor and grey literature</li> </ul>

### Personal Outputs and Generic Skills

Many of the studies found teaching activities to be useful related to personal outputs such as confidence, self-awareness and courage. In one longitudinal mixed method study within anatomy, student-teachers reported strengthened confidence, optimism and resilience.<sup>24</sup> In several studies, student-teachers thought of the experience as helpful in improving their generic skills such as communication, teamwork, leadership and becoming role models for their junior peers. The teaching experience was also considered as supporting students' professional identity formation.<sup>55,57,64</sup>

Three studies reported unwanted outputs of peer teaching.<sup>29,30,34</sup> Two of those found that student-teachers experienced lack of control and authority.<sup>29,30</sup> One of the three studies found that student-teachers felt uncomfortable teaching their peers due to the lack of necessary skills.<sup>34</sup> The authors suggested that this is likely caused by student-teachers receiving inadequate training before taking on the teacher role.<sup>34</sup>

### Methodological Quality of Studies

#### Quality Assessment

All the included quantitative studies were quality assessed using MERSQI. The scores ranged from 6 (lowest)<sup>50,58,64</sup> to 13 (highest),<sup>22,40</sup> and the average score for all the included quantitative studies was 10. As eight of the studies reported qualitative research, they were not subjected to MERSQI score assessment.<sup>26,27,32,33,48,49,55,57</sup> No articles were excluded based solely on their MERSQI score.

#### Study Design

A mixed-method study design was used in 67% (30/45) of the included studies, with qualitative and quantitative data extracted from student-teacher(s) and/or student-learner(s). Qualitative study design was used in 18% (8/45) of the studies, and 16% (7/45) had a quantitative study design. As shown in Table 5, most of the studies included in this review used self-reported data to gather information about learning outputs from peer teaching experiences. Questionnaires and interviews were the most frequently used data collection methods. Most questionnaire-based studies included closed-ended questions with Likert scale response options, whereas some also used open-ended questions or comments to collect qualitative data. Six studies included external data sources such as exams, practical/oral exams, and evaluation by student-learners.

**Table 3** Schematic Overview of Included Articles

Authors (Article Quality Assessment)	Country of Origin	Student- Teacher (N)	Student- Learner (N)	Study Design	Teacher Training Intervention	Dimensions of Teaching Encounter			Reported Learning Outputs and Method
						Frequency and Duration	Group Size	Subject	
Agius & Stabile <sup>21</sup> (12.5/18)	Malta	Year 1–2 (12)	Year 1–2 (191)	Comparative longitudinal study – Quantitative	No	6 sessions	Not specified	Anatomy	1. Student-teachers scored significantly better in anatomy spotting exam 2. Student-teachers scored significantly better in upper limb and biomedical sciences written exam
Ahmad et al <sup>22</sup> (13/18)	USA	Year 4 (36)	Year 3 (75)	Non-inferiority – Mixed method	Yes	1 session	Not specified	Rheumatology	1. Student-teachers reported deeper understanding, experience in teaching, developing skills as future educators and residents in reflective comments
Ahn et al <sup>23</sup> (12/18)	USA	Year 4 (20)	Year 1 (155) and Year 2 (155)	Evaluation research – Quantitative	Yes	1–5 sessions	1:14; tutor tutees	Ultrasound/ Physical examination	1. Improved teaching effectiveness score and ultrasound skill from first to last session 2. Student-learners evaluated student-teachers using Likert scale; students who taught more tended to have better evaluation score
Alvarez et al <sup>24</sup> (11.5/18)	Germany	Year 2 (24)	Not specified	Longitudinal mixed method	Yes	18 months, sessions not specified	Not specified	Anatomy	1. Improvement in professional behavior, communication skills and gross anatomy skills reported in semi-structured interviews and questionnaire using Likert-scale 2. Improvement in stress management, self-confidence and self-awareness reported by student-teachers
Blohm et al <sup>25</sup> (10.5/18)	Germany	Year 3–5 (10)	Year 1 and 2 (135)	Longitudinal mixed method	Yes	2 sessions	1:20; tutor: tutees	Internal medicine	1. Good preparation for clerkship and development of leadership skills reported in acceptance ratings, pre- and post- self-assessment ratings and interviews

Bugaj et al <sup>26</sup> (n/a)	Germany	Year 3–5 (10)	Not specified	Qualitative study	Yes	Not specified	Not specified	Physiology & internal medicine	1. Improvement in social, theoretical and cognitive skill reported in semi-structured interviews
Burgess et al <sup>27</sup> (n/a)	Australia	Year 3 (46) and Year 4 (60)	Year 1 (50) and Year 2 (51)	Qualitative study	No	1 h session per week. 1 year	Not specified	Multiple subjects	1. Improved medical knowledge and teaching skills reported in focus group interviews
Cansever et al <sup>28</sup> (8/18)	Turkey	Year 1 (11)	Year 1 (330)	Survey study – Mixed method	Yes	Not specified	Not specified	Biochemistry, medical genetics, histology and embryology, anatomy and microbiology	1. Improved teaching, self-confidence and benefited their own learning 2. Student-teachers were assessed by other students on a 5-point scale.
Cho et al <sup>29</sup> (8/ 18)	Korea	Year 2–4 (Not specified)	Year 2–4 (Not specified)	Mixed method	Yes	Not specified	Not specified	Multiple subjects	1. Increased motivation and self-development reported in survey and focus group interview
Chopra et al <sup>30</sup> (7/18)	USA	Year 4 (14)	Not specified	Mixed method observational study	No	Not specified	Not specified	Ophthalmology	1. Improved teaching skills and benefited their own learning reported in survey and telephone interview
Clarke et al <sup>31</sup> (7/18)	Australia	Year 3–4 (42)	Year 1–2 (66)	Mixed method	Yes	1 h × 1–13 sessions. 7 months	2:3–4; tutor: tutees	Clinical skills, professionalism	1. Gain in clinical skills, better preparation for exam and future job reported in Likert-scale from 1–5 and open-ended questions
Cusimano et al <sup>32</sup> (n/a)	Canada	Year 3 (20)	Year 1 (100)	Qualitative descriptive research study	Yes	2 h × 3 sessions	1:20; tutor: tutees	Ethics, professionalism, behavior	1. Gain in leadership skills, adjustment in behavior online and professionalism reported in semi- structured focus group interviews
de Menezes et al <sup>33</sup> (n/a)	Australia	Year 5 (30)	Year 3 (40)	Longitudinal qualitative study	Yes	1 h × 6 sessions	1:4–6; tutor: tutees	Multiple subjects	1. Gain in knowledge, preparation before internship and overall confidence reported in questionnaire prior to exam and focus group interview after the exam
Dickman et al <sup>34</sup> (10/18)	Israel	Year 2 (4–6)	Year 1 (ca. 70)	Mixed method	Yes	Not specified	Not specified	Anatomy, ultrasound	1. Gain in confidence and skill reported in questionnaires in quantitative Likert scale ratings from 1–5 and qualitative comments

(Continued)

Table 3 (Continued).

Authors (Article Quality Assessment)	Country of Origin	Student- Teacher (N)	Student- Learner (N)	Study Design	Teacher Training Intervention	Dimensions of Teaching Encounter			Reported Learning Outputs and Method
						Frequency and Duration	Group Size	Subject	
Engels et al <sup>35</sup> (10/18)	USA	Year 1–5 (481)	Year 1–5 (Not specified)	Cross sectional study – Quantitative	Yes	Not specified	1:5–10	Anatomy, Neuro- Physiology	1. Shape course for younger students, gain more knowledge and support to lower students reported in questionnaires
Gottlieb et al <sup>36</sup> (10/ 18)	USA	Year 4 (12)	Year 2 (Not specified)	Mixed method	Yes	2 h × 7 sessions	Not specified	Respiratory pathophysiology	1. Social-, cognitive development and increased skills in subject and teaching reported in a multiple- choice survey and reflection essay
Hall et al <sup>37</sup> (8/18)	UK	Not specified (51)	Not specified	Mixed method	Yes	Not specified	Not specified	Anatomy	1. Communication skills and improved subject matter reported in questionnaire consisting of rating of 0–10 and free text.
Gandhi et al <sup>38</sup> (8/18)	UK	Year 6 (30)	Year 5–6 (140)	Mixed method	Yes	Not specified	1:2; tutor:tutee	Pediatrics	1. Better prepared for objective structured clinical examination, better confidence overall and bet- ter communication reported in questionnaire using Likert scale from 1–5 and free text.
Iwata et al <sup>39</sup> (12.5/18)	UK	Year 6 (172)	Not specified	Retrospective cohort study	Yes	Not specified	Not specified	Multiple subjects	1. Better results in final exam and long-station objective structured clinical examination
Khaw et al <sup>40</sup> (13/18)	Australia	Year 6 (45)	Year 1–2 (348)	Survey study – Mixed method	Yes	Not specified	Not specified	Physical examination, history taking	1. Improved knowledge and better overall confidence reported on Likert scale from 1–5 and free text questionnaire
Kumar et al <sup>41</sup> (10.5/18)	UK	Not specified (10)	Not specified (61)	Longitudinal study- Quantitative	Not specified	80 min × 6 sessions	Not specified	Orthopedic examination	1. Better prepared for objective structured clinical examination, less anxious and better confidence reported using pre- and post- session test and feedback form using Likert scale from 1 to 5



Liew et al <sup>42</sup> (12/18)	Malaysia	Year 3–5 (51)	Year 1–3 (1053)	Longitudinal study- Quantitative	Yes	2 h × 4 sessions	Not specified	Communication and clinical skills	1. Increased skills, motivation for study and better exam preparation reported in pre- and post- ques- tionnaire using rating from 1 to 6
Lin et al <sup>43</sup> (12/18)	USA	Not specified (6)	Not specified (55)	Retrospective cohort study – Mixed method	Yes	Not specified	1:3; tutor:tutee	Basic surgery skills	1. Teaching and surgical skills improved reported using pre- and post-narrative reflection and pre- and post-survey using Likert scale from 1–5
Lufler et al <sup>44</sup> (11/18)	USA	Year 4 (32)	Year 1 (402)	Longitudinal study- Mixed method	Yes	Not specified	Not specified	Anatomy	1. Better teaching- and anatomy skills reported using pre- and post-test questionnaire using 1–10 scale and open-ended comments
Mohd Shafiai et al <sup>45</sup> (10.5/ 18)	Malaysia	Year 2 (40)	Year 1 (Not specified)	Longitudinal study- Mixed method	Yes	Not specified	Not specified	Communication	1. Communication, leadership, inter- personal skills and personal growth reported using pre- and post-test questionnaire using Likert scale and a focus group interview one year later
Naeger et al <sup>46</sup> (11/18)	USA	Year 4 (17)	Year 1 (120)	Survey study – Mixed method	Yes	1.5 h × 1 session	1:5–6; tutor: tutees	Radiology	1. Improved teaching skill and bene- fited their own learning reported using questionnaire using Likert scale and open comments
Nelson et al <sup>47</sup> (10/18)	Australia	Year 6 (24)	Year 1–2 (358)	Longitudinal mixed method	No	2 h sessions × 4 times a week	1:4; tutor: tutees	Clinical skills	1. Improved own clinical skill, conso- lidating previous knowledge and developed teaching skills reported using a survey using a scale form 1– 7 and focus group interview two years after the rotation
Nshimiyimana et al <sup>48</sup> (n/a)	Rwanda	Year 5 (Not specified)	Year 5 (Not specified)	Qualitative study	No	3 h × 1 session	1:18–25; tutor: tutees	Paediatrics	1. Enhanced learning of content, over- coming anxiety and developed teaching skill reported in semi- structured interview

(Continued)

Table 3 (Continued).

Authors (Article Quality Assessment)	Country of Origin	Student- Teacher (N)	Student- Learner (N)	Study Design	Teacher Training Intervention	Dimensions of Teaching Encounter			Reported Learning Outputs and Method
						Frequency and Duration	Group Size	Subject	
Prunuske et al <sup>49</sup> (n/a)	USA	Year 2 (9)	Year 1 (31)	Qualitative study	No	4 weeks	1:4–5; tutor: tutees	Multiple subjects	1. Beneficial to their own skill development, communication and professionalism skill reported in semi-structured or focus group interview within 1 year
Reyes- Hernández et al <sup>50</sup> (6/18)	Mexico	Year 2–5 (120)	Year 1 (Not specified)	Cross- sectional study – Quantitative	Yes	Not specified	1:6–5; tutor: tutees	Anatomy	1. Improved teaching skill and benefited their own learning reported in a survey using a scale from 1–10-point Likert scale
Sahoo et al <sup>51</sup> (9.5/18)	Malaysia	Year 4 (6)	Year 4 (98)	Longitudinal mixed method	No	0.5 h × 1 session × 4 week	1:9.5; tutor: tutees	Ophthalmology	1. Better understanding, improved confidence and improved presentation reported using pre- and post-test questionnaire using Likert scale and focus group interview
Siddiqi et al <sup>52</sup> (12.5/18)	Pakistan	Year 1 (10)	Year 1 (62)	Cross- sectional study – mixed method	Yes	Not specified	1:7–11; tutor: tutees	Pharmacology & physiology	1. Improved confidence, communication, presentation and teaching skills reported using questionnaire with closed-ended and open-ended questions and Kahoot.
Silbert et al <sup>53</sup> (11/18)	Australia	Year 4–6 (64)	Year 3 (321)	Longitudinal quantitative study	Yes	4 h session × 6	1:12; tutor: tutees	Multiple subjects	1. Increased confidence in teaching and improvement in knowledge reported in surveys completed using Likert scale
Srivastava et al <sup>54</sup> (12/18)	India	Year 1 (20)	Year 1 (87)	Non- randomized interventional mixed method	No	4 sessions	1:10; tutor: tutees	Physiology	1. Consolidating previous learning and improved teaching reported using pre- and post-test score containing closed-ended questions and open-ended questions. 2. Average post score was more for cases, though not significant

Tamachi et al <sup>55</sup> (n/a)	UK	Year 4 (3)	Year 3–5 (5)	Qualitative study	Not specified	Not specified	Not specified	Multiple subject	I. Increased learning, professional congruence and camaraderie reported through individual interviews
Walser et al <sup>56</sup> (9.5/18)	Germany	Year 3+ (38)	Year 2 (388)	Longitudinal mixed method	Yes	16 sessions	1:10; tutor: tutees	Anatomy	I. Student-teacher met the requirements of the course and adjusted their activities reported using semi-structured reports; pie-chart for quantitative data and open-ended questions for qualitative data
Yang et al <sup>57</sup> (n/a)	USA	Year 3 (Not specified)	Year 3 (Not specified)	Longitudinal qualitative study	No	26 sessions or more	Not specified	Clinical clerkship	I. Personal and professional development reported using semi-structured interviews
Young et al <sup>58</sup> (6/18)	UK	Year 4 (103)	Year 3 (245)	Cross-sectional study – Mixed method	No	3 sessions	Not specified	Multiple subjects (Objective structured clinical examination)	I. Motivation to continue with peer-assisted learning and improved teaching reported using questionnaire involving qualitative responses and closed-ended questions in a survey using scale from 1–4
Nomura et al <sup>59</sup> (9/18)	Japan	Year 5 (6)	Year 4 (58)	Mixed method	Yes	1.5 h–3 h × 4 sessions	Not specified	Medical interview training	I. Tutor act as role models, create comfortable learning environment, effective feedback and practical advice based on clinical experience, all data reported in focus group interview
Zuo et al <sup>60</sup> (8/18)	USA	Year 2 (52)	Year 1 (240)	Survey study – Mixed method	Yes	30–45 min × 2 session	1:6; tutor: tutees	Anatomy	I. Value of giving back, making means of experience, and continued learning through peer teaching reported in survey and focus group interview

(Continued)

Table 3 (Continued).

Authors (Article Quality Assessment)	Country of Origin	Student- Teacher (N)	Student- Learner (N)	Study Design	Teacher Training Intervention	Dimensions of Teaching Encounter			Reported Learning Outputs and Method
						Frequency and Duration	Group Size	Subject	
Avonts et al <sup>61</sup> (9/18)	Belgium	Year 3–5 (Not specified)	Year 3–5 (78)	Retrospective cohort study –Mixed method	Yes	3–5 sessions per year	5–8:30–50; tutor: tutees	Multiple subjects (Objective structured clinical examination)	<ol style="list-style-type: none"> <li>1. Better performing medical students are more likely to volunteer for peer-teaching program</li> <li>2. No evidence of additional benefits related to score compared to fellow-students</li> <li>3. Improved competencies related to CanMEDS framework</li> </ol>
Aydin et al <sup>62</sup> (8/18)	Turkey	Year 1–2 (159)	Year 3 (43)	Cross- sectional study – Mixed method	Yes	2 hour × 10 days	Not specified	Clinical skills	<ol style="list-style-type: none"> <li>1. Open-ended question showed tutors believed peer-assisted learning is beneficial for tutors</li> <li>2. The tutors answers to Likert scale was not significant</li> </ol>
Diebolt et al <sup>63</sup> (8/18)	USA	Year 3 (106)	Year 4 (40)	Prospective study – Mixed method	Yes	2 days	Not specified	Surgery clerkship	<ol style="list-style-type: none"> <li>1. Tutors reported statistically significant increase in self-efficacy and confidence in teaching skills scores increasing with each session reported on survey including close- and open-ended question</li> </ol>
Orsini et al <sup>64</sup> (6/18)	Italy	Year 1–2 and 4 (Not specified)	Year 3–6 (348)	Retrospective study – Mixed method	Yes	Not specified	1:6–8; tutor: tutees	Anatomy	<ol style="list-style-type: none"> <li>1. Tutors develop educational, professional, and personal skills reported on survey including close- and open-ended question</li> </ol>
Shah <sup>65</sup> (7/18)	UK	Year 4 (72)	Year 5 (13)	Longitudinal study – Mixed method	No	22 session × 3 months	2:11–49; tutor: tutees	OSCE	<ol style="list-style-type: none"> <li>1. Tutors thought the program helped them better understand and retain material answered on questionnaire including close-ended and open-ended question</li> </ol>

**Table 4** Overview of Studies Reporting Types of Learning Outputs

Reported Outputs	Number of Studies	References
Subject-specific learning outputs	62% (28/45)	[21–24,26,27,30,31,34–39,41–44,46,47,49,50,56,60–62,64,65]
Pedagogical knowledge and skills	49% (22/45)	[22,23,27,28,30,35,36,43,44,46,48,50,52–54,58,59,61–65]
Personal outputs	31% (14/45)	[24,28,29,33,34,40,51–53,59,62–65]
Generic skills	38% (17/45)	[22,24–26,32,37,38,45,49,52,55,57,59–62,64]

**Table 5** Overview of Studies Reporting Learning Outputs for Student-Teachers Using Various Data Sources

Data Source	Research Instrument	Number of Studies	References
Self-reports 91% (41/45)	Interviews	18	[24–27,29,30,32,33,45,47–49,51,55,57,59–61]
	Reflection essay	2	[36,43]
	Questionnaire (open-ended questions)	17	[22,31,34,37,38,40,44,46,49,52,54,58,60,62–65]
	Questionnaire (closed-ended questions)	31	[24,26,29–38,40–47,50–54,58,61,63–65]
External data source 13% (6/45)	Practical/oral exam/written exam	3	[21,39,61]
	Evaluation by student learners	3	[23,28,44]

### Relation Between Learning Outputs and Data Source of Studies

Among studies using self-reports as data source, 61% (25/41) reported subject-specific learning outputs, 49% (20/41) reported learning outputs related to pedagogical knowledge and skills, 34% (14/41) reported learning outputs related to personal outputs and 44% (18/41) reported learning outputs related to generic skills. Of the studies using external data sources, 4/6 reported subject-specific learning outputs, 4/6 reported increased pedagogical knowledge and skills and 1/6 reported learning outputs related to personal outputs.

## Discussion

This review included findings from 45 different studies published 2012–2022 on student-teachers in undergraduate medical education.<sup>13</sup> In line with previous review (including 19 articles published before 2012), we found improved learning outputs for student-teachers within several domains, including better knowledge retention, improved skills, improved leadership, improved communications capabilities and increased confidence.<sup>13</sup> Most of the evidence available was based on qualitative interview data or survey responses, whereas only six documented learning outputs using external data such as students' exam results.<sup>21,23,28,39,44,61</sup> We found limited, but encouraging, evidence suggesting that peer teaching programs enhance student-teachers' performances on exams. In most cases, senior students have already passed their exams in the courses in which they later teach junior students and seldom retake the exam after having functioned as student-teachers. Therefore, comparable knowledge or skills tests are available only in designs where students are teaching fellow students and are taking the same exam, as was done in the study by Aguis et al,<sup>21</sup> or in a retrospective cohort study design such as Iwata et al.<sup>39</sup> Furthermore, final exam scores might not include testing in the topics where student-teachers have gained peer teaching related learning outputs.

We found that student-teachers tend to rate themselves higher than non-teaching students on competence areas in the CanMEDS framework related to academic knowledge. However, research suggests that student-teachers do not perform better on final exams compared to other academically well-performing students who do not participate as student-

teachers, thus suggesting that students' academic knowledge obtained by being student-teachers, can be explained by a recruitment bias rather than a peer teaching effect itself.<sup>61</sup> The evidence base for other competence areas in the CanMEDS framework, is somewhat different. The CanMEDS framework recommends physicians to promote a culture that recognizes, supports and responds effectively to colleagues.<sup>16</sup> By being a student-teacher, students become role models for their junior peers, thereby promoting the mentioned culture.<sup>5</sup> Furthermore, professional skills such as skills in leadership, communication, feedback and collaboration are all part of the CanMEDS framework.<sup>16</sup> Amongst the 45 studies we reviewed, 31 articles reported positive learning outputs related to confidence, leadership skills and professional attributes. However, only one article used the CanMEDS framework to assess student-teachers.<sup>61</sup> In 14 of the articles included, peer teaching was associated with increased confidence, which is considered important for the professional development of physicians<sup>66</sup> and for reduced feelings of imposter syndrome.<sup>67</sup> In line with previous reviews, we identified increased learning outputs in similar domains of CanMEDS framework as a result of being a student-teacher.<sup>13</sup> A judicious suggestion may therefore be to encourage medical schools to expand teaching and learning opportunities for student-teachers and facilitate the development of their CanMEDS competencies by incorporating peer teaching into their curriculum. This approach would provide a platform for students to enhance their leadership and teaching skills, which are critical components of the CanMEDS framework.<sup>6,13</sup>

Three articles presented negative outputs of being a student-teacher such as lack of authority due to teachers and student-learners being at the same level,<sup>29,30</sup> and feeling uncomfortable teaching their peers due to the lack of necessary skills.<sup>34</sup> Despite being reported as a negative experience for the student-teachers, the lack of authority and social congruence associated with peer teaching is elsewhere highlighted as one of the key explanations as to why peer teaching works.<sup>68</sup> Negative experiences can likely be avoided with proper training in learning facilitation and group management, clarification of expectations and attention given to building mutual respect in the student-teacher and student-learner relationship.<sup>69</sup>

Future research could consider developing theory-driven designs that test students' capabilities in all physician roles. Validated tools for assessing professional skills are readily available, yet infrequently used to test learning outputs of peer teaching for the student-teachers.<sup>70</sup> Research should look at the methodological approach of peer teaching programs including recruitment, training interventions, design and content. A deeper understanding of the factors contributing to successful student-teacher practices and outputs has the potential to inform a discussion on how peer teaching activities can be applied more systematically in undergraduate medical education programs, thus securing learning benefits for all parties involved.

## Strengths and Limitations

Although we did a thorough search in four databases, our findings are likely inexhaustive due to our exclusion of articles not available in full text, not published in English or not matching the search string. Furthermore, unpublished and/or grey literature was not included. To decrease the risk of bias, eight independent reviewers screened the articles using "blind mode".<sup>71</sup> The results were critically synthesized and interpreted by multiple reviewers to enhance the validity of our findings.

## Conclusion

Results from this review indicate that serving as a student-teacher during undergraduate medical school is likely to strengthen subject-specific learning outputs, pedagogical knowledge and skills, personal outputs and generic skills. Peer teaching has the potential to foster professional development in many of the competencies outlined in the CanMEDS framework including communication, collaboration, leadership and health advocacy. Hence, peer teaching programs may be strategically planned and designed to enhance learning outputs for all parties involved, including student-teachers.

## Abbreviations

CanMEDS, Canadian Medical Education Directions for Specialists; MERSQI, The Medical Education Research Study Quality Instrument; OSCE, objective structured clinical examination.

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The authors report no conflicts of interest in this work.

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