The Role of Mastery Learning in Clinical Education: A Systematic Review

Aziz Shamsi [1] and Safoura Dorri [1, *]

[1]Department of Medical-Surgical Nursing, Iran University of Medical Sciences, Tehran, Iran

[*]*Corresponding author*: Student of Ph.D in Nursing Education, Department of Medical-Surgical Nursing, Iran University of Medical Sciences, Tehran, Iran. Email: m.dorrri@gmail.com

Abstract

Context: Effective clinical skills training of medical students can guarantee a higher quality of care, diagnosis, and treatment for patients. Therefore, selection of appropriate methods of clinical education is of great significance. Mastery learning is one of the learning models in which educational progress is not dependent on time, but rather performance. In this model, the learner is constantly assessed until achieving mastery. All students can achieve the same level of learning, although the amount of time required for mastery is variable.

Objectives: The purpose of the present study was to review the literature on the effects of mastery learning on the clinical education of medical students.

Data Sources: This systematic review was conducted in English and Persian databases to evaluate articles on mastery learning in clinical education, published from 1990 to 2016. In the primary search, 503 articles were retrieved using Persian and English keywords, including "clinical teaching" and "mastery learning". After reviewing the abstracts, 50 relevant articles were selected, and, finally, 26 articles were reviewed.

Results: Based on the findings, mastery learning can improve skill mastery among students, reduce the complications of medical interventions, increase the students' self-confidence, reduce the required time for skill acquisition, increase the students' knowledge, and improve their communication skills. Also, this method of learning has been effectively applied in medicine, nursing, and occupational therapy for students and hospital staff.

Conclusions: Mastery learning is a suitable method for teaching clinical skills to students. Considering the advantages of this method, it can be used effectively to train students from different medical disciplines.

Keywords: Clinical Education, Mastery Learning, Medical Student, Systematic Review

1. Context

Mastery learning is one of the learning models in which educational progress is not dependent on time, but rather individual performance. In this method, learners are subjected to regular assessments until reaching the designated level of mastery. All students can achieve the same level of learning, although the amount of time required for mastery is variable (1).

The model of mastery learning was first established by Benjamin Bloom, James Block, and John Carroll in 1963. Bloom believed that the learner must achieve the designated level of mastery through constant practice within an amount of time, which is needed for the learner to attain the target level of mastery. The learners are constantly tested by the instructor, and as soon as they reach the desired level of mastery (80% - 90%), they can move forward

to the next lesson or program. He/she criticized the relatively fixed time allocated to teaching learners with different competencies and considered it to be detrimental to the learning process (2). Accordingly, in the mastery learning model, the objectives are similar for all learners, while there is no fixed time for learning (3, 4).

Different stages of mastery learning include: establishment of educational objectives; primary assessment; appraisal of mastery level; training implementation; formative assessment; learning correction; and summative assessment. Similar to every other instructional model, mastery learning also has several disadvantages, such as being time-consuming and prioritizing poor learners, as instructors devote most of their time to these students. On the other hand, the advantages of this method include the learners' greater effort due to higher motivation, as they are certain that they can reach the level of more capable

students by allocating sufficient time to learning. In this regard, previous studies have confirmed the efficacy of this model in promoting learning in different disciplines (5). Also, its effectiveness in improving the learning of medical students has been established (6).

Considering the nature of medical sciences, student training in the clinical setting is one of the most important educational disciplines in medicine. Effective clinical education requires adoption of methods, which can enhance the students' knowledge and performance (7). Mastery learning is one of the models, which can be used for clinical training of students to improve the process of learning. Nevertheless, there are few studies about the application of mastery learning at universities, especially in the field of medical sciences.

Previous studies in medical fields have mostly concentrated on the effects of mastery learning on practical skills, such as insertion of central venous catheters (CVC), thoracentesis, paracentesis, cardiopulmonary resuscitation (CPR), and lumbar puncture (8-14). These studies mostly searched medical resources and databases, and the researchers were all from the Northwestern University of Chicago. However, a limited number of articles have been published in other medical disciplines, such as nursing and occupational therapy. Research suggests that this model can be applied for Iranian students or students from other medical disciplines and professions with different levels of competence.

As most clinical practitioners are looking for ways to improve practical knowledge and skill training for students (15) with respect to their individual characteristics, it seems that mastery learning is one of the models, which can take the students' characteristics into consideration (16). This model is in fact performance-oriented (17), increasing the students' level of knowledge and self-efficacy (18).

2. Objectives

According to our literature review on the efficacy of mastery learning, we aimed to determine whether mastery learning can be applied as a useful and effective method in the clinical education of medical students, who shape the future of the healthcare system of our country.

3. Data Sources

In this systematic review, relevant articles were retrieved from reliable databases. For this purpose, Google Scholar, PubMed, Scopus, Ovid, and ScienceDirect were reviewed for English articles, while Magiran, SID, ISC, Medlib,

and IranMedex were searched for Persian articles. The search strategy and article selection were agreed upon by researchers and two faculty members of Iran University of Medical Sciences, based on a predesigned form for data extraction (e.g., author's name, year of publication, type of study, target clinical skills, study population, and findings).

To retrieve English articles, MeSH keywords, including "clinical education", "medical student", "mastery learning", "health professionals", "medical education", and "practical learning", were searched independently or in combination. In addition, the Persian equivalents of these keywords were searched independently or in combination to retrieve Persian articles.

The keywords were searched in the titles of articles published from 1990 to 2016. According to our search, the primary application of mastery learning and its integration in different medical disciplines, especially clinical education, are unknown, and no specific time has been pinpointed so far. Nevertheless, its emergence in medical articles and clinical fields has been documented in the 2000's. Therefore, for comprehensiveness, all papers published between 1990 and 2016 were reviewed in this study. To prevent bias, the search was conducted by two researchers independently using the data collection form. Agreement on controversial and disputed issues was established based on scientific discussion and consensus.

The inclusion criteria in this review were as follows: (1) Compliance with the research standards based on the critical appraisal skills program (CASP); (2) relevance and structuredness of the paper; and (3) clinical, semi-experimental, case-control, or cohort design. On the other hand, lack of access to the full-text of the article and unavailability of data in the data collection form were considered as the exclusion criteria.

The articles were studied and selected in three stages. First, the title was reviewed, and then, irrelevant papers were removed from the list of findings. In the second stage, by reading the abstracts, relevant articles with clinical, Quasi -experimental, case-control, or cohort design were retrieved. Finally, in the third stage, the entire article was reviewed, and duplicate studies were removed (22 articles). In case the full-text of the manuscript was inaccessible, we sent an email to the corresponding author and asked for a copy of the manuscript. Studies with inadequate or inaccessible data (one article) were excluded from the search.

The manuscripts retrieved by each researcher were thoroughly examined via discussion, and the search results were analyzed in one session; controversial topics were resolved through scientific debate. In the final stage, after confirmation by two faculty members of the Faculty of Nursing of Iran University of Medical Sciences, a total of

Table 1. The Retrieved Articles After Abstract Review

Type of Study	Number of Studies
Clinical trials	5
Quasi-experimental studies	22
Prospective cohort and case-control studies	16
Review articles	3
Case reports	1
Qualitative studies	3

26 articles were included in the study. The search stages are presented in Figure 1. The articles were searched from March 2016 to June 2016, and data were extracted and analyzed until October 2016.

4. Results

According to our search in different databases, a total of 503 articles were retrieved, 50 of which were selected after reviewing the abstracts. By examining these articles, clinical, Quasi -experimental, case-control, and cohort trials were selected and reviewed (Table 1). Among the evaluated articles, we focused on the ones which had examined mastery learning in clinical education for medical students. The number of articles retrieved at this stage was 26 (24 articles in English and two articles in Persian language) (Table 2).

5. Discussion

The most important finding of this study is that we can use the mastery learning model in other medical disciplines. This finding is compatible with the nature of mastery learning, which is rooted in behavioral learning theories, and it seems that this instructional method can be used for training psychomotor skills (6). However, it should be noted that mastery learning influences other areas of learning, as well and can be used to increase knowledge, self-confidence, self-efficacy, and communication skills of individuals (5, 8, 14, 18, 19, 26, 27).

Based on the present findings, the most important outcome of mastery learning is improvement of the learner's competence. Besides improving clinical skills, this method is also applicable in other fields, such as nursing (5, 12, 18, 21, 22, 24, 26, 27, 30) and occupational therapy (36). Nevertheless, in a study by Kessler et al., the pretest and posttest scores of medical students were not significantly different. They stated that an independent course based on mastery learning cannot increase the skills significantly (25),

thereby highlighting the importance of time in mastery learning.

One of the disadvantages of mastery learning is being time-consuming (5). In the model proposed by Carrol, longer learning time was associated with a higher level of learning (37). On the other hand, Rahmani et al. found that mastery learning for clinical training is not more time-consuming than the conventional method. In fact, this method has been proposed for classrooms with a high number of students, where a great amount of time is devoted to students. Overall, in mastery learning, students who have achieved the level of mastery can spend more time on re-training until students with weak performance can reach their level (5); they can also help less motivated students to achieve the desired mastery level.

Based on the results of a study by Anbari and Ramezani, the goal of medical education at universities is to develop self-centered learning, improve psychomotor skills, time management skills, self-confidence, and communication skills, and discourage passivity among students (38); most of these goals were highlighted in our review of the literature. One of the most important findings of the present study was the improved performance and skill mastery of students, while one of the main goals of medical education is to improve psychomotor skills. In the study by Barsuk et al., IM residents who had participated in the mastery learning course were more confident in bedside thoracentesis and did not refer their patients to other physicians (19). Similarly, in two other studies, the participants' confidence increased after training (8, 26).

Moreover, in the study by Cohen et al., one of the positive outcomes of participation in the mastery learning course was improvement of communication skills with patients (24). Zendejas et al. also showed that time management skills of the participants improved after the mastery learning course (29, 31). Two other objectives of medical education, i.e., self-centered learning and prevention of student passivity, are also the main features of mastery learning method, which allow students to progress at their own pace according to their competencies (16).

Another important finding of this systematic review is related to the effect of mastery learning in the clinical setting on reducing post-treatment complications, especially after invasive procedures, such as CVC insertion, arterial blood sampling, and paracentesis. In a previous study, which aimed to determine the complications of CVC insertion, it was found that 54 out of 155 patients had developed complications (39). According to our review, several studies have focused on the important role of mastery learning in reducing the complications of invasive procedures (23, 26, 29, 31, 33).

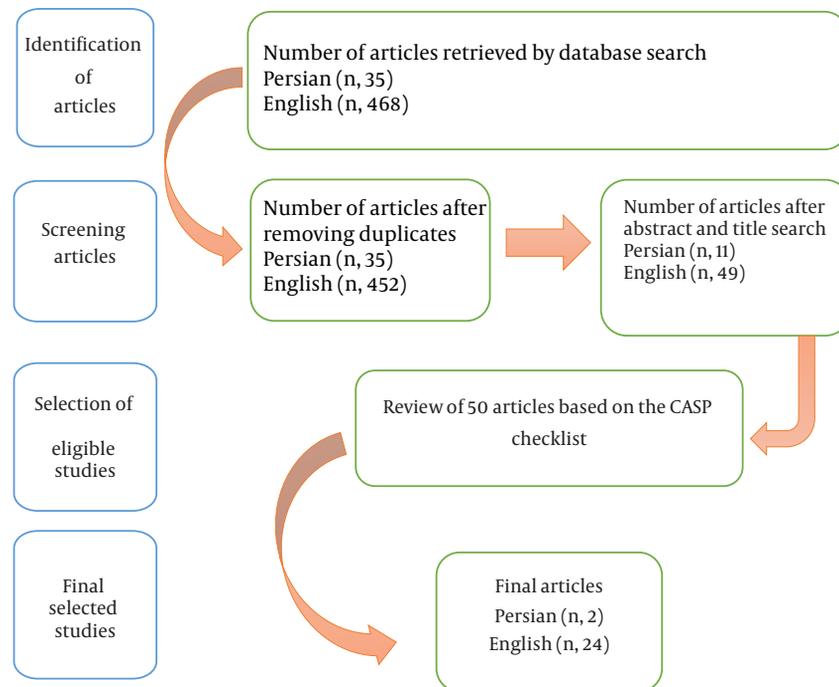In summary, the mastery learning method can be ap-

Figure 1. The process of systematic review (PRISMA, preferred reporting items for systematic reviews and meta-analyses)

plied in different branches of health sciences. Previous studies have evaluated this method in medical practice, nursing, and occupational therapy, confirming its significant role in the skill improvement of students. According to the literature, this method can be used as both an instructional approach for students and in-service training for hospital staff. Therefore, considering the community's need for professional health experts who have reached a high level of clinical competence during training, mastery learning can be applied to prevent the needless encouragement of highly motivated students and inattention to weak students, as reported in educational systems. It can be concluded that postgraduate students with mastery learning have acquired the basic clinical skills (5).

6. Conclusions

This review study supports the use of mastery learning method in the clinical education of students. Considering the great impact of this method on performance, it is recommended for practical training to ensure that most students achieve the target educational goals after the course. Also, extensive studies are suggested before the application of this model regarding its disadvantages, costs, and prerequisites.

6.1. Limitations

The main limitation of the present study is that we only searched electronic databases, whereas books, research projects, and unpublished studies could have been also taken into consideration. Also, the search only included English and Persian articles.

Supplementary Material

Supplementary material(s) is available here [To read supplementary materials, please refer to the journal website and open PDF/HTML].

References

1. Dorri S, Hakimi H. The effect of mastery learning model for suction and oxygen therapy skills in nursing students. *Res Med Educ*. 2018;**9**(4):19–0. doi: 10.29252/rme.9.4.19.

2. Kashani Z, Damavandi M, Karami Gazafi A. [The effects of mastery learning on attitude, performanceand intrinsic motivation of secondaryschool students in chemistry]. *J Innovat Educ*. 2010;**6**(2):155–72. Persian.

3. Cook DA, Brydges R, Zendejas B, Hamstra SJ, Hatala R. Mastery learning for health professionals using technology-enhanced simulation: A systematic review and meta-analysis. *Acad Med*. 2013;**88**(8):1178–86. doi: 10.1097/ACM.0b013e31829a365d. [PubMed: 23807104].

4. Eppich WJ, Hunt EA, Duval-Arnould JM, Siddall VJ, Cheng A. Structuring feedback and debriefing to achieve mastery learning goals. *Acad Med*. 2015;**90**(11):1501–8. doi: 10.1097/ACM.0000000000000934. [PubMed: 26375272].

5. Rahmani A, Fathiazar E, Roshangar F. [The effect of adapted model of mastery learning on cognitive and practical learning of nursing students]. *Iran J Med Educ*. 2008;**7**(2):277–67. Persian.

6. Haghani F, Masoomi R. [Overview of learning theories and its applications in medical education]. *Iran J Med Educ*. 2011;**10**(5):1188–97. Persian.

7. Nowroozi HM, Mohsenizadeh SM, Jafari SH, Ebrahimzadeh S. [The effect of teaching uning a blend of collaborative and mastery of learning models, on learning of vital signs: An experiment on nursing and operation room students of Mashhad University of Medical Sciences]. *Iran J Med Educ*. 2011;**11**(5):541–53. Persian.

8. Barsuk JH, McGaghie WC, Cohen ER, Balachandran JS, Wayne DB. Use of simulation-based mastery learning to improve the quality of central venous catheter placement in a medical intensive care unit. *J Hosp Med*. 2009;**4**(7):397–403. doi: 10.1002/jhm.468. [PubMed: 19753568].

9. Wayne DB, Barsuk JH, O'Leary KJ, Fudala MJ, McGaghie WC. Mastery learning of thoracentesis skills by internal medicine residents using simulation technology and deliberate practice. *J Hosp Med*. 2008;**3**(1):48–54. doi: 10.1002/jhm.268. [PubMed: 18257046].

10. Wayne DB, Butter J, Siddall VJ, Fudala MJ, Wade LD, Feinglass J, et al. Mastery learning of advanced cardiac life support skills by internal medicine residents using simulation technology and deliberate practice. *J Gen Intern Med*. 2006;**21**(3):251–6. doi: 10.1111/j.1525-1497.2006.00341.x. [PubMed: 16637824]. [PubMed Central: PMC1828088].

11. McGaghie WC, Issenberg SB, Cohen ER, Barsuk JH, Wayne DB. Medical education featuring mastery learning with deliberate practice can lead to better health for individuals and populations. *Acad Med*. 2011;**86**(11):e8–9. doi: 10.1097/ACM.0b013e3182308d37. [PubMed: 22030671].

12. Barsuk JH, Cohen ER, Caprio T, McGaghie WC, Simuni T, Wayne DB. Simulation-based education with mastery learning improves residents' lumbar puncture skills. *Neurology*. 2012;**79**(2):132–7. doi: 10.1212/WNL.0b013e31825dd39d. [PubMed: 22675080]. [PubMed Central: PMC3390539].

13. Barsuk JH, Cohen ER, Vozenilek JA, O'Connor LM, McGaghie WC, Wayne DB. Simulation-based education with mastery learning improves paracentesis skills. *J Grad Med Educ*. 2012;**4**(1):23–7. doi: 10.4300/JGME-D-11-00161.1. [PubMed: 23451302]. [PubMed Central: PMC3312528].

14. Colquitt J, Parish D, Trammell A, McCullough J, Swadener-Culpepper L. Mastery learning of ACLS among internal medicine residents. *Anal Resuscitation Curr Res*. 2013;**1**(S1). doi: 10.4172/2324-903x.s1-007.

15. Hosseiny N, Karimi Z, Malek Zadeh J. [The situation of clinical education based on nursing students' opinion in Yasuj nursing and midwifery school]. *Iran J Med Educ*. 2005;**5**(2):171–5. Persian.

16. Guskey TR. Mastery learning. In: Seel NM, editor. *Encyclopedia of the sciences of learning*. New York: Springer; 2012.

17. Parandeh A, Haji Amini Z. [Practice-based learning and its outcomes in nursing students' education]. *J Educ Ethics Nurs*. 2013;**2**(3):1–8. Persian.

18. Roha YS, Lima EJ, Issenberg SB. Effects of an integrated simulation-based resuscitation skills training with clinical practicum on mastery learning and self-efficacy in nursing students. *Collegian*. 2016;**23**(1):53–9. [PubMed: 27188040].

19. Barsuk JH, Cohen ER, Williams MV, Scher J, Feinglass J, McGaghie WC, et al. The effect of simulation-based mastery learning on thoracentesis referral patterns. *J Hosp Med*. 2016;**11**(11):792–5. doi: 10.1002/jhm.2623. [PubMed: 27273066].

20. Reed T, Pirotte M, McHugh M, Oh L, Lovett S, Hoyt AE, et al. Simulation-based mastery learning improves medical student performance and retention of core clinical skills. *Simul Healthc*. 2016;**11**(3):173–80. doi: 10.1097/SIH.0000000000000154. [PubMed: 27093509].

21. Barsuk JH, Cohen ER, Mikolajczak A, Seburn S, Slade M, Wayne DB. Simulation-based mastery learning improves central line maintenance skills of ICU nurses. *J Nurs Adm*. 2015;**45**(10):511–7. doi: 10.1097/NNA.0000000000000243. [PubMed: 26425976].

22. Cason ML, Gilbert GE, Schmoll HH, Dolinar SM, Anderson J, Nickles BM, et al. Cooperative learning using simulation to achieve mastery of nasogastric tube insertion. *J Nurs Educ*. 2015;**54**(3 Suppl):S47–51. doi: 10.3928/01484834-20150218-09. [PubMed: 25692824].

23. Barsuk JH, Cohen ER, Potts S, Demo H, Gupta S, Feinglass J, et al. Dissemination of a simulation-based mastery learning intervention reduces central line-associated bloodstream infections. *BMJ Qual Saf*. 2014;**23**(9):749–56. doi: 10.1136/bmjqs-2013-002665. [PubMed: 24632995].

24. Cohen ER, Barsuk JH, Moazed F, Caprio T, Didwania A, McGaghie WC, et al. Making July safer: Simulation-based mastery learning during intern boot camp. *Acad Med*. 2013;**88**(2):233–9. doi: 10.1097/ACM.0b013e31827bfc0a. [PubMed: 23269294].

25. Kessler DO, Arteaga G, Ching K, Haubner L, Kamdar G, Krantz A, et al. Interns' success with clinical procedures in infants after simulation training. *Pediatrics*. 2013;**131**(3):e811–20. doi: 10.1542/peds.2012-0607. [PubMed: 23439901].

26. Scholtz AK, Monachino AM, Nishisaki A, Nadkarni VM, Lengetti E. Central venous catheter dress rehearsals: Translating simulation training to patient care and outcomes. *Simul Healthc*. 2013;**8**(5):341–9. doi: 10.1097/SIH.0b013e3182974462. [PubMed: 24061335].

27. Tang WE, Dong L. Applying mastery learning in a clinical skills training program for primary care nurses. *J Contin Educ Nurs*. 2013;**44**(12):535–41. quiz 542-3. doi: 10.3928/00220124-20131015-13. [PubMed: 24143886].

28. Ahya SN, Barsuk JH, Cohen ER, Tuazon J, McGaghie WC, Wayne DB. Clinical performance and skill retention after simulation-based education for nephrology fellows. *Semin Dial*. 2012;**25**(4):470–3. doi: 10.1111/j.1525-139X.2011.01018.x. [PubMed: 22309946].

29. Zendejas B, Cook DA, Hernandez-Irizarry R, Huebner M, Farley DR. Mastery learning simulation-based curriculum for laparoscopic TEP inguinal hernia repair. *J Surg Educ*. 2012;**69**(2):208–14. doi: 10.1016/j.jsurg.2011.08.008. [PubMed: 22365867].

30. Baghaei R, Mohammadpour Y, Habibzade H, Rasouli D, Khalilzadeh H, Jafarizadeh H. [Competency- based mastery learning: A planned clinical experience for nursing students]. *J Urmia Nurs Midwifery Fac*. 2011;**9**(4):230–6. Persian.

31. Zendejas B, Cook DA, Bingener J, Huebner M, Dunn WF, Sarr MG, et al. Simulation-based mastery learning improves patient outcomes in laparoscopic inguinal hernia repair: A randomized controlled trial. *Ann Surg*. 2011;**254**(3):502–9. discussion 509-11. doi: 10.1097/SLA.0b013e31822c6994. [PubMed: 21865947].

32. Butter J, McGaghie WC, Cohen ER, Kaye M, Wayne DB. Simulation-based mastery learning improves cardiac auscultation skills in medical students. *J Gen Intern Med*. 2010;**25**(8):780–5. doi: 10.1007/s11606-010-1309-x. [PubMed: 20339952]. [PubMed Central: PMC2896602].

33. Cohen ER, Feinglass J, Barsuk JH, Barnard C, O'Donnell A, Mc-Gaghie WC, et al. Cost savings from reduced catheter-related bloodstream infection after simulation-based education for residents in a medical intensive care unit. *Simul Healthc*. 2010;**5**(2):98–102. doi: 10.1097/SIH.0b013e3181bc8304. [PubMed: 20389233].

34. Barsuk JH, McGaghie WC, Cohen ER, O'Leary KJ, Wayne DB. Simulation-based mastery learning reduces complications during central venous catheter insertion in a medical intensive care unit. *Crit Care Med*. 2009;**37**(10):2697–701. [PubMed: 19885989].

35. Barsuk JH, Ahya SN, Cohen ER, McGaghie WC, Wayne DB. Mastery learning of temporary hemodialysis catheter insertion by nephrology fellows using simulation technology and deliberate practice. *Am J Kidney Dis*. 2009;**54**(1):70–6. doi: 10.1053/j.ajkd.2008.12.041. [PubMed: 19376620].

36. Wise M, Iris V. Using mastery learning to develop patient handling skills in occupational therapy students. *Int J Ther Rehabil*. 2005;**12**(7):287–93. doi: 10.12968/ijtr.2005.12.7.19542.

37. Damavandi ME, Shekari Kashani Z. Effect of mastery learning method on performance, attitude of the weak students in chemistry. *Soc Behav Sci*. 2010;**5**:1574–9. doi: 10.1016/j.sbspro.2010.07.327.

38. Anbari Z, Ramezani M. [The obstacles of clinical education and strategies for the improvement of quality of education at Arak University of Medical Sciences in 2008]. *Arak Med Univ J*. 2010;**13**(2):110–8. Persian.

39. Shahmoradi MK, Khavaninzadeh M, Mousavi Kani K. [Catheter related complications and survival among Iranian ESRD patients treated in Hasheminejad Hospital 2010-2011]. *Razi J Med Sci*. 2013;**19**(105):21–7. Persian.

Table 2. The Retrieved Articles About Clinical Education Among Medical Students

References	Type of Study	Country	Target Clinical Skills	Study Population	Results and Conclusions
Barsuk et al. (19)	Prospective cohort	USA	Thoracentesis	Three groups including 112 IM residents completing simulation-based mastery learning during 2012-2015; 122 IM residents with traditional training; and 51 physicians working at hospital	Traditionally trained residents were more likely to refer patients to other doctors and cited lower confidence as the main reason. However, residents with mastery learning had greater confidence and were more likely to perform bedside thoracenteses than refer the patient. The difference in the pretest and posttest scores was also significant in the intervention group.
Reed et al. (20)	One-group pretest-posttest design	USA	Ultrasound-guided peripheral intravenous line placement; basic skin laceration repair; chest compression; bag-valve mask ventilation; defibrillator management during ventricular tachycardia and ventricular fibrillation; and defibrillator management during pulseless electrical activity and cardiac arrest	A total of 135 students on an EM clerkship	All students passed the tests after the course, and the percentage of students who reached the MPS was significant. Ninety-eight percent of the students scored at or above MPS for all skills after one year.
Barsuk et al. (21)	One-group pretest-posttest design	USA	Central line maintenance (medication administration; injection cap changes; tubing changes; blood drawing; and dressing changes)	A total of 49 ICU nurses	The posttest scores of nurses increased by 100% for central line maintenance, compared to the pretest.
Cason et al. (22)	Cohort study	USA	Nasogastric tube insertion	A total of 134 second-year nursing students and 52 first-year bachelor students of nursing (student pairs)	All students obtained a checklist score of 100% after the program.
Barsuk et al. (23)	Cohort study	USA	CVC insertion	EM and IM residents before mastery learning (control group; 2008 - 2010) and after participation in the mastery learning program (test group; 2010 - 2012)	The difference in the pretest and posttest scores of residents was significant regarding CVC insertion. There was a 74% reduction in the incidence of central line-associated bloodstream infections during 2010 - 2012, when the residents participated in the mastery learning program.
Roha et al. (18)	Three-group pretest-posttest design	South Korea	CPR skills	A total of 255 second-year nursing students participating in an emergency nursing course in three groups	The level of knowledge and self-efficacy significantly improved after the clinical course, compared to the baseline. However, the scores of knowledge, self-efficacy, and psychomotor skill error were not significantly different between the groups.
Cohen et al. (24)	Cohort study	USA	Cardiac auscultation, paracentesis, lumbar puncture, management of critically ill patients, and communication with patients	A total of 47 interns participating in a mastery learning course in 2011 versus 109 second-year historical controls (without participation in the course)	All trained interns met or exceeded the MPS and performed significantly better than historical control interns on all skills.
Colquitt et al. (14)	Pretest-posttest design without a control group	USA	Advanced CPR skills	A total of 16 residents	The level of knowledge and skills of students in the posttest was significantly higher than the pretest. The level of knowledge was also high after one year, and skills had significantly improved, compared to the posttest.

Kessler et al. (25)	Randomized trial	USA	Infant lumbar puncture and child intravenous line placement	A total of 200 medical interns (104 cases of lumbar puncture and 96 cases of intravenous line placement)	The difference in the pretest and posttest scores for the evaluated skills was not significant. Participation in a single mastery learning session was insufficient for these skills.
Scholtz et al. (26)	Prospective study	USA	CVC dressing change	A total of 525 inpatient nurses	Knowledge and self-confidence improved significantly in the posttest, compared to the pretest. On the other hand, the number of dressings requiring corrective prompts and central line-associated blood stream infections significantly decreased.
Tang and Dong (27)	Cohort study	Singapore	Assessment of patients with exacerbation of asthma or chronic obstructive pulmonary disease and administration of bronchodilator therapy	Eight primary care nurses	The knowledge of nurses increased successfully in the posttest, compared to the pretest. In the pretest, 67% of nurses reported moderate knowledge of target skills, while in the posttest, 90% reported good or excellent knowledge.
Ahya et al. (28)	Prospective cohort	USA	Hemodialysis catheter insertion	Eighteen nephrology fellows	The nephrology fellows who completed the training course displayed high levels of performance during insertions after six months. The results indicated a significant reduction in the posttest catheter insertion scores, compared to the immediate posttest (posttest after training based on the mastery model).
Barsuk et al. (12)	Two-group pretest-posttest design	USA	Lumbar puncture	A total of 58 first-year IM residents participating in a mastery learning intervention versus 36 nephrology residents in the second, third, and fourth years with traditional training	Comparison of the pretest and posttest scores of the test group showed significant improvements in the spinal sampling performance, and all these residents met the MPS. The performance of traditionally trained neurology residents was significantly lower than the test group, and only 6% met the MPS.
Barsuk et al. (13)	Pretest-posttest design without a control group	USA	Paracentesis	A total of 58 first-year IM residents	The residents' paracentesis skills improved significantly from pretest to posttest, and all residents met or exceeded the MPS.
Zendejas et al. (29)	One-group two-stage design	UK	Laparoscopy	Nine medical students, 36 general surgery residents, and three surgery fellows (n, 48)	All learners achieved the mastery endpoints in an acceptable amount of time. The surgery duration and complications during and after surgery decreased, while the performance and participation increased.
Baghaei et al. (30)	Semi-experimental, two-stage, pretest-posttest design	Iran	Cognitive and behavioral skills of students in ICUs	A total of 28 nursing students in the eighth postgraduate year	The pretest-posttest comparison of the mean performance scores indicated a significant difference among students. Also, comparison of clinical competence of students before and after traditional and competence-based methods showed significant differences.

Zendejas et al. (31)	Single-blind randomized clinical trial	USA	Laparoscopy	A total of 50 residents (26 residents in the intervention group and 24 residents in the control group)	The mastery learning curriculum decreased operative time, improved trainee performance, and decreased intra- and postoperative complications.
Butter et al. (32)	Two-group pretest-posttest design	USA	Cardiac auscultation	A total of 108 medical students (77 third-year students with a mastery learning-based curriculum and 31 fourth-year students with traditional training)	The trained third-year students demonstrated significantly higher cardiac auscultation performance, compared to the fourth-year students.
Cohen et al. (33)	Experimental design	USA	CVC insertion	A total of 69 IM and EM residents	The catheter-related complications decreased, and the costs decreased by 7000 dollars per year.
Barsuk et al. (34)	Observational cohort	USA	CVC insertion	A total of 103 IM and EM residents (27 traditionally trained residents and 76 simulator-trained residents)	The simulator-trained residents reported fewer needle passes, arterial punctures, catheter adjustments, and higher success rates, compared to traditionally trained residents.
Barsuk et al. (35)	Prospective observational cohort	USA	Hemodialysis catheter insertion	A total of 18 nephrology fellows (six fellows with traditional education and 12 fellows with a mastery learning-based curriculum)	Performance of traditionally trained fellows was poor, and only 17% met the MPS, while performance of simulator-trained fellows was significantly improved.
Barsuk et al. (8)	Cohort	USA	CVC insertion	A total of 41 IM residents in ICU (13 traditionally trained and 28 simulation-trained residents)	The simulation-trained group required fewer needle passes to insert a catheter. In addition, they displayed more self-confidence and accuracy in the procedural skills, compared to traditionally trained residents.
Rahmani et al. (5)	Semi-experimental, two-group, pretest-posttest design	Iran	Cognitive and functional skills in airway management, nasogastric tube insertion, rapid neurological examination, and arterial blood sampling	A total of 52 fourth-year nursing students	In all cognitive and practical skills, the difference in the pretest and posttest scores of students with mastery learning was greater than that of the traditionally trained group.
Wayne et al. (9)	Pretest-posttest design without a control group	USA	Thoracentesis	A total of 40 third-year IM residents	Performance improved by 71% from pretest to posttest in the mastery learning group, and all residents met the mastery standard.
Wayne et al. (10)	Pretest-posttest design without a control group	USA	Advanced CPR skills	A total of 41 second-year IM residents	Performance improved significantly after simulator training, and all residents met or exceeded the MPS.
Wise and Iris (36)	One-group pretest-posttest design	Australia	Patient handling skills	A total of 88 second-year occupational therapy students	Difference in the pretest and posttest scores was significant, and all students could master 100% of patient handling skills in the posttest.

Abbreviations: EM, emergency medicine; IM, internal medicine; MPS, minimum passing standard.