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Review

Deliberate practice and mastery learning in resuscitation education: A scoping review

Aaron Donoghue[a,*], *Kenneth Navarro*[b], *Emily Diederich*[c], *Marc Auerbach*[d], *Adam Cheng*[e]

[a] *Divisions of Critical Care Medicine and Emergency Medicine, Departments of Anesthesia and Critical Care Medicine and Pediatrics, Perelman School of Medicine at the University of Pennsylvania, Philadelphia, PA, USA*

[b] *Division of EMS, Department of Emergency Medicine, University of Texas Southwestern Medical Center, Dallas, TX, USA*

[c] *Division of Pulmonary, Critical Care, and Sleep Medicine, Department of Medicine, University of Kansas School of Medicine, Kansas City, KS, USA*

[d] *Departments of Pediatrics and Emergency Medicine, Yale University, New Haven, CT, USA*

[e] *Departments of Pediatrics and Emergency Medicine, University of Calgary, Calgary, Canada*

Abstract

Study aim: To summarize the current state of knowledge of deliberate practice and mastery learning (DP and/or ML) as teaching methods for resuscitation education.

Methods: A scoping review of PubMed, Scopus, and Embase was conducted through March 1, 2021. Studies examining the effect of the incorporation of either deliberate practice and/or mastery learning during resuscitation education were eligible for inclusion. Included studies were dichotomized into studies comparing deliberate practice and/or mastery learning to other training methods (randomized controlled trials) and studies examining before and after impact of deliberate practice and/or mastery learning alone (observational studies). Studies and findings were tabulated and summarized using the scoping review methodology published by Arksey and O'Malley.

Results: 63 published studies were screened; sixteen studies met all inclusion criteria (4 randomized controlled trials and 12 observational studies). One randomized controlled trial and eleven observational studies demonstrated improvement in skill and/or knowledge following educational interventions using deliberate practice and/or mastery learning. Significant variability between studies with regard to research designs, learner groups, comparators, and outcomes of interest made quantitative summarization of findings difficult.

Conclusions: The incorporation of deliberate practice and/or mastery learning in resuscitation education may be associated with improved educational outcomes and less skill decay than other educational methods. Current literature on DP and ML suffers from a lack of consistency in research methodology, subjects, and outcomes. Future research should employ uniform definitions for deliberate practice and mastery learning, follow research design that isolates its effect, and examine generalizable and translatable outcomes.

Keywords: Life support education, Cardiopulmonary resuscitation, Deliberate practice, mastery learning

Abbreviations: DP, deliberate practice; ML, mastery learning; ALS, advanced life support; BLS, basic life support; RCT, randomized controlled trial; ACLS, advanced cardiac life support; PALS, pediatric advanced life support; NRP, neonatal resuscitation program; CPR, cardiopulmonary resuscitation; AED, automated external defibrillator.

* Corresponding author at: Division of Critical Care Medicine, Children's Hospital of Philadelphia, 34th Street and Civic Center Boulevard, Philadelphia, PA 19104, USA.

E-mail address: donoghue@email.chop.edu (A. Donoghue).

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Introduction

Resuscitation education aims to provide the knowledge and skills required to effectively manage critically ill patients suffering from life-threatening conditions. Recent systematic reviews of published studies have demonstrated an association between healthcare provider participation in life support courses and improved survival for adults with cardiac arrest.[1,2] At the same time, current instructional design results in inconsistent educational outcomes, with many providers experiencing poor knowledge and skill retention in as little as 3 months following course completion.[3,4] Identifying educational strategies that will maximize sustained learning gains in resuscitation education is required to enhance provider performance and patient outcomes.

Deliberate practice and mastery learning are instructional design features supported by a growing body of evidence.[3,5,6] Deliberate practice is a training approach where learners are given: (1) a discrete goal to achieve, (2) immediate feedback on their performance, and (3) ample time for repetition to improve performance.[7] Mastery learning is defined as the use of deliberate practice training coupled with learner assessment that uses a set of criteria to define a specific passing standard that implies mastery of the tasks being learned.[8] Educational offerings designed according to the principles of deliberate practice and/or mastery learning offer substantial learning gains across a broad range of clinical content areas.[5,6] A summary of evidence supporting the use of deliberate practice and mastery learning in resuscitation training is lacking. Given the high-stakes nature of basic life support (BLS) and advanced life support (ALS), more work is needed to describe the potential impact of incorporating deliberate practice and/or mastery learning into resuscitation courses. The magnitude of expected benefit can then be weighed against of the time and resource considerations likely to follow course design with increasingly intentional incorporation of these features.

In this study, we aimed to conduct a scoping review of literature describing the impact of deliberate practice and/or mastery learning on educational outcomes in life support training, including skill performance at course conclusion, skill retention, performance during actual resuscitations, and patient outcomes.

Methods

This review was planned, conducted and reported using the scoping review strategy as described by Arksey and O'Malley.[9] The review was conducted as part of the American Heart Association (AHA) evidence synthesis and review process for the Education chapter of the 2020 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care.[3]

Research question

We sought to identify evidence addressing the following research question: amongst students or healthcare providers taking basic or advanced life support training, does the use of deliberate practice and/or mastery learning improve skill performance at course conclusion, improve skill retention beyond course conclusion, performance in actual resuscitations, or patient outcomes?

Study eligibility

Studies were eligible for inclusion if (1) the study involved the use of either deliberate practice (DL), mastery learning (ML), or both, as determined by the definitions shown above, and (2) examined training in neonatal, pediatric, or adult life support. In an effort to be comprehensive with the review, studies could involve a comparison of DL and/or MP to another teaching method or examine pre- and post-performance from a DL and/or MP-based educational intervention. Outcomes of interest included skill or knowledge, as measured by any reproducible method (e.g. task performance, time to task performance, scores on checklists or other assessment instruments, etc.). Because the original AHA review was done as an update of previous recommendations, articles published prior to 2012 were excluded.

Identification and selection of relevant studies

We searched PubMed, Scopus, and EMBASE with a last search date of December 1, 2019. In an effort to maximize evidence quality, and in anticipation of a high degree of heterogeneity among published studies, a search of 'grey' literature was not included. The overall search strategy was adapted and expanded from the search strategy used to summarize evidence on deliberate practice and mastery learning for the recently published American Heart Association Scientific Statement on Resuscitation Education.[4] The complete search strategy is included in the Appendix. Hand searches of the bibliographies of eligible studies were conducted for additional potential references.

The titles and abstracts of identified studies were screened by two reviewers (KN, AD). Complete articles identified by both authors were reviewed for inclusion based on the above criteria. In the case of disagreement about eligibility of studies, discussions were conducted to achieve consensus. Following the initial review, an additional post hoc exclusion criterion was added: specifically, studies in which DP and/or ML was reported as a part of a grouped or bundled intervention, but for which the isolated effect of DP and/or ML could not be determined, were excluded.

Data extraction (Table 1)

Data from included studies were tabulated using a 'descriptive-analytical' method[9] to ensure that studies were described in such a way that variations in design, subjects, interventions and outcomes of interest, and limitations could be uniformly interpreted across a varied range of study types. Essential data fields included in the summary of studies included: author and publication year, intervention type (and comparator if applicable), duration of intervention, subject populations (i.e. learner groups), study aims, study method, outcomes of interest, and basic results.

Data analysis

Studies were dichotomized thematically with the following methodology: studies where subjects were randomly assigned to DP and/or ML as the solitary intervention of interest compared with another educational technique were classified as 'randomized controlled trials (RCTs)'. Studies using other methodologies (e.g. nonrandomized design, before-and-after assessment without a comparator group, etc.) were classified as 'observational studies'. In keeping with scoping review methodology, given the considerable variability in the

Table 1 – Articles included in final review.

Author(s) and publication year	Study location	Intervention type and comparator	Intervention duration	Study populations	Study aims	Methodology	Outcome measures	Important results
Boet et al., 2017[1]	Canada	ML-based BLS course vs. traditional time-based course	4 month test-retest interval	Non-healthcare undergraduate university students	Compare layperson skill acquisition and retention between instructional strategies	Quasi-RCT (randomization by course date)	Total score achieved on the AHA Heartsaver CPR AED Skills Sheet checklist	No difference in 4-month BLS skill scores regardless of instructional strategy
Braun et al., 2015[2]	United States	Pre- and post-test, single simulation-based mastery learning (SBML) session (1–2 h)	2, 4, or 6 month retest interval	Residents from four pediatric residency programs	Assess retention of SBML resuscitation performance	Multicenter, prospective randomized design	Specially designed scoring matrices used on standardized pediatric simulation scenarios	Linear decline in percent of residents maintaining mastery level performance at 2, 4, and 6 months
Cordero et al., 2013[3]	United States	Pre- and post-test following single 2-h DP session	1 month test-retest interval	Pediatric residents	Assess effects of DP on procedural skills and team performance during simulated neonatal resuscitation	Observational	Observer-rated skills proficiency, skill timeliness, and team behaviors using standardized checklist	A short (1–2 h) DP session can result in short-term improvements in neonatal resuscitation skills and team behaviors.
Devine et al., 2015[4]	Canada	Direct self-regulated learning (DSLR) vs. instructor-regulated learning (IRL) using a SBML model	5 month retention test interval	PGY1 internal medical residents	Compare educational and cost effectiveness	Randomized controlled equivalence trial	Observer-rated resuscitation skills performance using standardized checklist	Although DSLR was more cost effective by about $80 per resident, skill retention at 5 months was not different between DSLR and IRL
Diederich et al., 2019[5]	United States	"Drill"-style vs. "Scrimmage"-style training	75-min test-retest interval	PGY-1 residents from 19 specialties	Compare effects of DP of component skills to repetitious practice of entire cardiac arrest scenarios on task work and teamwork during resuscitation events	RCT	Observer-rated resuscitation task work and teamwork performance Accelerometer used for CPR quality measures	Both drill-style and scrimmage-style training demonstrated similar improvements in component resuscitation skills.
Hunt et al., 2017[6]	United States	Traditional BLS training vs. contextualized BLS training modified with Rapid Cycle Deliberate Practice (RCDP)	NA	First-year medical students	Compare BLS performance in simulated adult in-hospital cardiac arrests	Educational quality assurance evaluation with randomized block assignment	Chest compression fraction (CCF)	Traditional BLS training contextualized to the in-hospital environment and modified with RCDP significantly improved CCF and time to initiate compressions.
Hunt et al., 2014[7]	United States	Traditional pediatric resuscitation training vs. Rapid Cycle Deliberate Practice focusing on	Cohorts separated by 2 years	PGY-1 and PGY-3 pediatric residents	Compare BLS and ALS resuscitation quality markers in simulated pediatric in-hospital cardiac arrest	Historical control	Time interval between the onset of pediatric ventricular fibrillation and first shock delivery	Pediatric resuscitation training incorporating RCDP significantly reduced the time interval between the onset of

(continued on next page)

Table 1 *(continued)*

Author(s) and publication year	Study location	Intervention type and comparator	Intervention duration	Study populations	Study aims	Methodology	Outcome measures	Important results
		the first-five minutes (RCDP-FFM)						VF and first shock delivery
Jeffers et al., 2016[8]	United States	Pre- and post-test following single 1-h DP session	4-month post intervention	PGY-1 pediatric residents	Assess effects of DP and simulation-based training on defibrillation skills	Prospective observational	Observer-rated resuscitation skills performance using standardized checklist	Simulation-based training incorporating DP significantly increased the proportion of students who achieved defibrillation skills competency
Keilman et al 2021[9]	United States	Pre- and post- single RCDP session	NA	Pediatric emergency medicine attendings	Assess impact of training session on clinical process metrics during first 5 min of medical resuscitations	Observational	Time to task completion (patient transfer, primary assessment, summary statement)	All three tasks completed in a significantly increased proportion of resuscitations post intervention
Knipe et al, 2020[10]	United States	DP training during simulated cardiac arrests administered during 6 of 13 weeks of a semester long curriculum	10 weeks	Senior nursing students	Assess effects of repeated weekly to biweekly training sessions over the course of a semester	Observational	Scoring instrument evaluating BLS tasks	Repeated sessions over the course of the semester resulted in significant score improvement in week 13 as compared to week 4
Lemke et al., 2019[11]	United States	Traditional simulation training with advocacy-inquiry debriefing vs. Rapid Cycle Deliberate Practice (RCDP) training	3-month pre- post-test interval	PEM fellows, nurses, and respiratory therapists	Assess the effects of RCDP training on team performance	RCT	Team performance changes as measured by the Simulation Team Assessment Tool (STAT)	RCDP training did not significantly improve resuscitation team performance compared to traditional simulation training.
Madou et al., 2019[12]	Belgium	Mastery learning (ML) vs. Self-Directed Learning (SDL) and face-to-face vs on-line (4 conditions)	NA	Baccalaureate students in teacher education program	Evaluate the effects of ML and SDL during two phases of BLS training (face-to-face and on-line)	RCT	Composite BLS score composed of • objective CPR variables measured by an instrumented manikin • subjective CPR performance assessed by two trained observers	There were no significant between group differences in objective CPR variables, subjective CPR performance, or composite BLS scores.
Magee et al., 2018[13]	United States	Rapid cycle deliberate practice (RCDP) vs. traditional simulation debriefing (SD) (45-min teaching sessions)	4-month post intervention	Pediatric interns	Evaluate the effects of RCDP and SD on NR performance	RCT	Performance measured with Megacode Assessment Form (MCAF)	Compared to SD, training using RCDP resulted in significant immediate improvement in MCAF scores. However, this improvement was not sustained

Table 1 (continued)

Author(s) and publication year	Study location	Intervention type and comparator	Intervention duration	Study populations	Study aims	Methodology	Outcome measures	Important results
								at the 4-month retest scenario.
Reed et al., 2016[14]	United States	Pre- and post-test following single SBML training session	Skill retention test 1 –9 months post intervention	Fourth-year medical students	Evaluate the effects of SBML training on six core EM procedural skills	Prospective observational	Institutionally-developed mastery checklist	Compared to pre-testing, SBML resulted in significant improvement in the percentage of students who achieved MPS at post-test. Ninety-eight percent of the student met MPS on their first attempt during retention testing.
Surapa Raju et al, 2020[15]	United States	1. Pre- and post-test following single RCDP session 2. At 9 months, second RCDP session added for one group (compared with no additional RCDP)	6, 9, and 12 months	Pediatric interns	Evaluate the effect of training on PALS performance	Observational	Published instrument for PALS scoring	Scores were signficiantly improved post-initial RCDP session and at 6, 9, and 12 months post session; there was no difference in 12 month performance between groups with or without additional RCDP session at 9 months
Yan, 2020[16]	United States	RCDP curriculum for primary and secondary survey 1. Before and after imnplementation (C=historical controls) 2. residents without RCDP training (C='concurrent' controls	NA	Surgical interns	Evaluating the effect of a RCDP curriculum on primary and secondary survey performance	Observational with historical controls	Published instrument for completion and timeliness of primary and secondary survey	Primary survey: significant improvement between historical controls and study group, no difference between study group and concurrent controls Secondary survey: significant improvement between study group and both control groups

Abbreviations: BLS – basic life support; CCF – chest compression fraction; DP – deliberate practice; DSLR – direct self-regulated learning; EM – emergency medicine; IRL – instructor-regulated learning; MCAF – Megacode Assessment Form; ML – mastery learning; MPS – minimum passing standards; NA – not applicable; NR – neonatal resuscitation; PEM – pediatric emergency medicine; PGY – post-graduate year; RCDP – rapid cycle deliberate practice; RCDP-FFM – rapid cycle deliberate practice focusing on the first-five minutes; RCT – randomized controlled trial; SBML – simulation-based mastery learning; SD – simulation debriefing; SDL – self-directed Learning; STAT – simulation team assessment tool.

study elements described above, study findings were summarized descriptively without quantitative synthesis.

Results

The Fig. 1 demonstrates the PRISMA flow diagram for the review. The initial scoping review identified 63 potentially relevant articles. Twenty articles were initially excluded due to exclusion by date of publication or lack of relevance. 43 articles underwent abstract review; 27 studies were subsequently eliminated. The remaining 16 articles underwent full review.

Study characteristics

The study designs and participant characteristics of included studies are summarized in the Table. Four of the 16 articles were RCTs[10–13] and the remaining twelve articles were observational in nature.[14–25] One study originated in Belgium and the remaining 14 studies originated in North America, two in Canada and 12 in the United States. The curricula used in the studies was diverse; four studies involved a basic life support curriculum,[12,14,18,22] four involved pediatric advanced life support curriculum,[11,19,20,23] two involved a neonatal resuscitation curriculum,[13,16] one involved a BLS Curriculum with teamwork measures,[10] one involved a combination of PALS and NRP curriculum,[15] one adult ACLS curriculum,[17] one involved adult advanced resuscitation skills,[21] one involved primary and secondary survey performance in trauma patients,[24] and one involved leader verbalization and team prompts during the first five minutes of medical resuscitations.[25] In total, there were 1018 participants composed of bystanders (undergraduate university students with no healthcare training) and in-hospital health care providers (respiratory therapists, nurses, medical students, interns and residents from 19 specialties, pediatric emergency medicine fellows, and pediatric emergency medicine faculty). For repeated measures studies, test-retest intervals ranged from 75 min to 12 months.[10,26] One study measured skill performance in actual resuscitations[24]; no published study used patient outcomes and the outcome of interest.

Specific study characteristics and results are summarized in the Table. Study methodology involved both DP and ML in eight studies,[11–15,18,19,21] DP alone in seven,[10,16,20,22–25] and ML alone in one study.[17] Seven of the sixteen studies compared DP and/or ML with traditional training[10–14,18,19]; eight studies compared pre- and post-training performance using a DP and/or ML-based intervention[15,16,20–25]; one study compared results from DP and/or ML administered via self-directed versus instructor-led delivery.[17]

Study results: overall

Overall, 12 of the 16 studies demonstrated improved skill performance or learning scores in simulated resuscitation events associated with DP and/or ML.[10,13,15,16,18–25] The remaining four studies did not find a difference in learner outcomes.[11,12,14,17] Of the 12 positive studies, four examined performance in a simulated adult resuscitation[10,18,21,22] six in a simulated pediatric resuscitation,[13,15,16,19,20,23] one in actual trauma resuscitations,[24] and one in actual medical resuscitations.[25] Nine studies enrolled residents as subjects[10,13,15,16,18–20,23,24]; two enrolled medical students[18,21]; two enrolled non-healthcare students[12,14]; one enrolled nursing students[22]; one enrolled teams of pediatric EM fellows, nurses and therapists,[11] and one enrolled pediatric EM faculty.[25] Outcome measures were instrument or checklist-based in 13 studies; one study used time to defibrillation[19]; one used chest compression fraction[18]; and one used time to three specific initial tasks (patient transfer, primary assessment, and summary assessment)[25] as the main outcomes of interest.

Randomized trial results

Results from the four RCTs were equivocal. One RCT demonstrated improved performance parameters and quicker critical intervention delivery for learners taught with DPML when compared to traditional training.[13] The remaining three RCTs found no difference in outcomes between learners taught with DP and control groups taught using traditional course design, including one study with bystanders as subjects.[10–12] In the one positive RCT, performance advantages associated with deliberate practice were no longer present four months after training.[13]

Observational trial results

The observational studies reflected more positively on DP and ML. In a simulated resuscitation environment, nine of the eleven observational studies found a positive association between DP and/or ML and improved educational outcomes.[15–25]

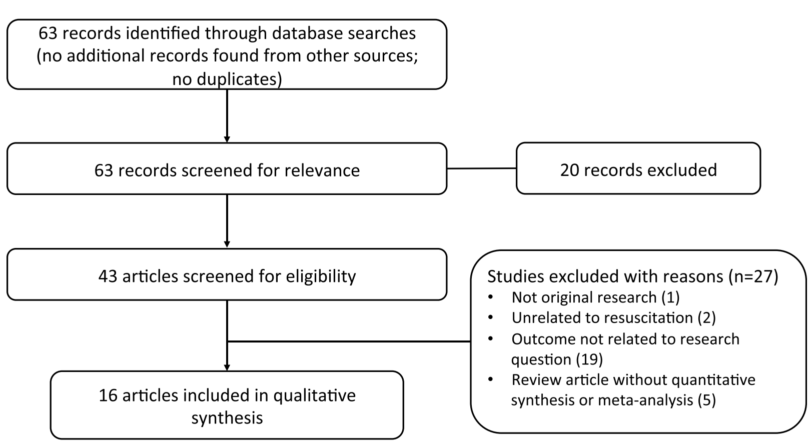

Fig. 1 – PRISMA Diagram.

Two observational studies involved measurement of clinical performance during actual patient events. Yan et al. published a prospective review of video recorded trauma resuscitations and used a scoring instrument to quantify primary and secondary survey performance by residents, comparing those who had received a DP-based curriculum with both historical and concurrent controls who had not received the same curriculum. DP-trained residents scored higher during primary surveys than historical controls and higher than both control groups during secondary surveys.[24] Keilman et al. published a before-and-after assessment of the effect of a single DP-based training session for team leaders on time to completion of three critical tasks as determined from video recorded pediatric medical resuscitations; all three critical tasks were completed in a significantly higher proportion of clinical events post-intervention.[25]

Skill decay

Six study designs included skill decay measurement using a reassessment at a remote time interval ranging from 2 to 9 months.[14,15,17,20,21,23] Five of those studies could not demonstrate significant differences in resuscitation skills performance up to nine months after training.[14,17,20,21,23] One study found significant improvement in resuscitation skills performance following a single mastery learning session, although 60% of the students did not maintain that skill performance level for six months.[15]

Discussion

In this scoping review, we identified twelve studies examining the impact of DP and/or ML in resuscitation education. Among the significant findings were that a majority of studies (1 of 4 RCTs, 6 of 8 observational studies) showed a favorable impact of DP and/or ML as determined by subsequent skill performance in simulated patient settings. Four of six studies examining skill decay found that learner skill did not significantly deteriorate over a six month period following the DP and/or ML training session(s). One study found that recurring costs for life support education using DP and/or ML are less than those for traditional training due to a decreased need for instructor involvement. Finally, one study demonstrated improved performance during actual clinical care of trauma patients following completion of a DP-based curriculum.

In 1993, Ericsson defined deliberate practice as an “alternative framework. . . on the basis of the amount of deliberate activities aimed at improving performance.[27] Published literature in medicine, education, and other fields have shown examples where investigations use methodology called ‘deliberate practice’ which, on closer examination, may not meet this definition; for example, the accumulation of a greater number of hours of didactic learning over time, while likely beneficial, lacks the repetitive, performance-level based goal of DP when properly applied.[28,29] For the present review, articles were screened carefully to attempt to ensure that the described methodology met the appropriate definitions for DP; many articles were excluded from consideration based on methodology that failed to exhibit the appropriate goals, immediate formative feedback, and repetition associated with DP. Moving forward, uniformity of criteria for DP, as applied in resuscitation training, is an essential goal in education research.

The definition of mastery learning is based in “identifying superior, reproducible behavior for representative tasks in the associated domain”.[30] Implicit in this definition is the existence of a critical threshold of skill or knowledge that, once achieved, connotes that the learner has ‘mastered’ the construct being measured. In resuscitation science, many of the fundamental concepts taught in life support education may be difficult to distill down to a single gold standard measure of ‘mastery’. As an example, CPR quality is a virtually ubiquitous concept in life support education. However, the relevant learning objectives may not necessarily be identical across different learner groups. For laypeople, it may be more important to recognize cardiac arrest and to have sufficient readiness to perform bystander CPR and use an AED[31]; for hospital-level healthcare providers, optimizing compression fraction, compression depth and rate, and simultaneously incorporating rhythm identification, manual defibrillation, and medication administration are standard expectations.[32,33] Depending on the clinical setting, even such basic concepts as compression depth may be more optimally guided by patient physiology (e.g. arterial pressure waveform, exhaled carbon dioxide) than by resuscitation guidelines for depth alone.[34–36] Acknowledging that ‘one size doesn’t fit all’ in this regard, educators need to account for appropriate clinical contexts in defining criteria for ‘mastery’ with these differences in mind.

Considering these varied concepts as a whole should elucidate the challenges in incorporating DP and/or ML into life support education. McGaghie’s definition of mastery learning dictates that the end product of such education should yield learners with little to no difference in their high level of performance, irrespective of their starting point or the amount of time required for this to be achieved.[8] As shown by the breadth of subject across the studies in this review, life support education exists in forms that target learners from very different backgrounds who would be expected to perform life support tasks in widely varied contexts (at home, in a public place, prehospital, emergency department, intensive care unit, etc.). As always, identifying learners’ needs is a prerequisite to effectively setting goals for mastery learning for all groups.

In two of the RCTs which did not demonstrate a significant difference between DP and traditional case-based training, the ‘control’ group underwent repetitions of full simulated cases from beginning to end, with feedback and debriefing at the conclusion of the cases.[10,11] For both of these trials, the ‘intervention’ arm consisted of repeated simulations with more frequent interruptions for formative and/or corrective feedback, plus time allotted to repeat tasks with the benefit of those ‘doses’ of feedback. Before-and-after differences in performance were better in both groups for both of the RCTs. Thus, even though the improvement in performance did not differ by condition, both studies provide evidence that repetitive practice paired with feedback yields positive educational outcomes. The equivocal results of these trials may represent the need for future studies to more closely examine what frequency and/or timing of feedback during repetitive practice leads to optimal results; evidence along these lines will permit the best means of leveraging DP in instructional design.

Consistent with recently published AHA guidelines, this review suggests that integrating DP and/or ML instructional design features may enhance current courses by improving educational outcomes.[3] Importantly, incorporating DP and/or ML would require restructuring of programs to allow sufficient time for repetitive practice and proper assessment, along with the identification of assessment metrics/ outcomes which were psychometrically robust with regard to validity. Additionally, DP and/or ML design features have implications for faculty development, as many instructors are insufficiently familiar with these concepts. This in turn has implications with regard to training instructors and raters in proper conduct of DP teaching and the correct application of ML standards for completing a given set of objectives.

Our study has several limitations. While this review highlights the published data of the impact of DP and/or ML in a variety of settings, it also illustrates many of the inherent challenges in summarizing data from educational literature. Studies varied in terms of their inclusion criteria for subjects, including laypeople, medical students, residents, and (in one study) subspecialty fellows; no study examined performance by more senior clinicians. Outcomes of interest also varied, with most studies examining skill performance immediately after training; even within this group, however, outcome measures varied, including time to completion of tasks (e.g. time to start compressions), objective metrics such as chest compression fraction, and performance on skill checklists. Only four studies examined skill decay, and none of those studies measured skill at time points later than six months (when typical retraining for life support courses occurs every two years). As is often the case with educational literature, drawing generalizable conclusions from this body of literature is difficult.

Among the studies included in this review, there was significant inconsistency in the definition of DP and/or ML, with some studies describing the intervention of interest with insufficient detail to determine with certainty that true DP/ML technique was being applied. The interventions of interest, study populations and their backgrounds, comparators against which interventions were studied (where applicable), and the educational outcomes were very heterogeneous, making the use of true meta-analytic analysis difficult. There is a need for clear definitions and consensus research guidelines to improve consistency and reduce heterogeneity in studies examining the effect of DP/ML as well as other specific educational phenomena.

Finally, as is the case with all resuscitation education research, linking a particular educational strategy such as DP and/or ML to improved patient outcomes remains elusive. The recently published American Heart Association 2020 Guidelines for Education specifically cited several published references that have directly examined the connection between educational endeavors and/or adjuncts such as simulation-enhanced education, debriefing, and telephone CPR instruction to patient outcomes.[37–41] We found only two studies associating DP-based training to clinical care delivery; no studies demonstrated a relationship to patient outcomes.

Conclusions

Deliberate practice and mastery learning have been recommended as educational techniques to yield improved and more durable skill and knowledge during life support education. In this scoping review, we identified 16 studies which yielded mixed results, although a greater number of studies demonstrated a positive association between the use of deliberate practice and/or mastery learning and improved educational outcomes. Research using deliberate practice and/or mastery learning is hampered by inconsistent study design, varying operational definitions, and disparate comparators, subject groups, and outcomes. Further research should seek to strengthen experimental methodology with regard to the impact of deliberate practice and/or mastery learning, with an eye towards uniform definitions, homogenous study design, and more readily interpretable results as to the effect of deliberate practice and/or mastery learning on educational outcomes.

Declarations of interest

None.

CRediT authorship contribution statement

Aaron Donoghue: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing - review & editing, Supervision. **Kenneth Navarro:** Methodology, Validation, Formal analysis, Investigation, Writing - review & editing, Visualization. **Emily Diederich:** Methodology, Validation, Formal analysis, Investigation, Writing - review & editing. **Marc Auerbach:** Methodology, Validation, Formal analysis, Investigation, Writing - review & editing. **Adam Cheng:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing - review & editing, Supervision.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.resplu.2021.100137.

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