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Technology-Enhanced Feedback for Procedural Skill Development in Undergraduate Medical Education: A Systematic Review

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ADMINISTRATIVE INFORMATION

Support - None.

Review Stage at time of this submission - Preliminary searches.

Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 22 June 2026 and was last updated on 22 June 2026.

INTRODUCTION

Review question / Objective What is the effectiveness of technology-enhanced feedback interventions for procedural skill development among undergraduate medical students?

Condition being studied This review focuses on procedural skill development in undergraduate medical education. Procedural skills, such as suturing, cannulation, cardiopulmonary resuscitation, lumbar puncture, and other technical clinical procedures, are core competencies for medical students but can be difficult to teach consistently because of limited faculty time, variable clinical exposure, patient-safety concerns, and differences in feedback quality. Technology-enhanced feedback, including video-based, simulator-generated, device-generated, computer-assisted, artificial intelligence-assisted, mixed-reality, augmented-reality, haptic, and remote feedback, may support more objective, timely, and scalable procedural skills training. This review will evaluate randomized controlled trials assessing whether technology-enhanced feedback improves objective procedural skill performance among undergraduate medical students.

METHODS

Participant or population Undergraduate medical students participating in procedural skills training.

Intervention Technology-enhanced feedback interventions, including simulator-, mannequin-, device-generated, digital, audiovisual, or computer-assisted feedback during procedural skills training.

Comparator Conventional teaching, standard feedback, instructor feedback alone, alternative feedback methods, or no technology-enhanced feedback.

Study designs to be included Randomized controlled trials, randomized clinical trials, randomized educational trials, and randomized crossover trials evaluating technology-enhanced feedback interventions for procedural skills training in undergraduate medical students will be included.

Eligibility criteria Randomized controlled trials, randomized clinical trials, randomized educational trials, and randomized crossover trials evaluating technology-enhanced feedback interventions for procedural skills training in undergraduate medical students will be included. Nonrandomized, quasi-experimental, observational, qualitative, protocol, review, editorial, and conference abstract-only studies will be excluded.

Information sources The electronic databases to be searched will include Scopus, PubMed/MEDLINE, and ERIC from database inception to the final formal search date. Searches will be limited to English-language studies and full-text original research articles. Reference lists of included studies and relevant reviews will be manually screened to identify additional eligible studies. When eligibility details or outcome data are unclear, study authors may be contacted for clarification. Grey literature, conference abstracts without full text, dissertations, editorials, commentaries, letters, and protocols will not be included.

Main outcome(s) Procedural skill performance measured by objective assessments (e.g., OSATS scores, procedural checklists, global rating scales, task completion, accuracy, errors, success rates, skill retention, or competency achievement).

Quality assessment / Risk of bias analysis Risk of bias in included randomized studies will be assessed using the revised Cochrane risk-of-bias tool for randomized trials (RoB 2). The assessment will consider bias arising from the randomization process, deviations from intended interventions, missing outcome data, measurement of outcomes, and selection of the reported result. For randomized crossover trials, the RoB 2 variant for crossover trials will be used when applicable. Two reviewers will independently assess risk of bias for each included study. Disagreements will be resolved through discussion and consensus. Each study will be judged as having low risk of bias, some concerns, or high risk of bias.

Strategy of data synthesis Risk of bias in included randomized studies will be assessed using the revised Cochrane risk-of-bias tool for randomized trials (RoB 2). The assessment will consider bias arising from the randomization process, deviations from intended interventions, missing outcome data, measurement of outcomes, and selection of the reported result. For randomized crossover trials, the RoB 2 variant for crossover trials will be used when applicable. Two reviewers will independently assess risk of bias for each included study. Disagreements will be resolved through discussion and consensus. Each study will be judged as having low risk of bias, some concerns, or high risk of bias. Risk-of-bias findings will be summarized narratively and considered when interpreting the strength and consistency of the evidence.

Subgroup analysis If sufficient data are available, findings will be summarized by dominant intervention modality, including video-based feedback, remote asynchronous feedback, AI-assisted or automated feedback, mixed-reality/augmented-reality/haptic feedback, and device- or simulator-generated feedback. Additional grouping by procedural skill domain, such as suturing, cannulation, cardiopulmonary resuscitation, lumbar puncture, or simulated surgical skills, may be considered. Formal subgroup meta-analysis is not planned unless studies within a subgroup are sufficiently homogeneous in intervention, comparator, outcome measure, and assessment time point.

Sensitivity analysis Sensitivity analysis will be considered only if quantitative synthesis is feasible. If meta-analysis is performed, sensitivity analyses may include excluding studies judged to have high risk of bias, excluding studies with unclear randomization procedures, excluding studies with substantial missing outcome data, and comparing results using alternative effect-size approaches when appropriate. If meta-analysis is not feasible because of heterogeneity in procedures, intervention modalities, comparators, outcomes, or assessment time points, formal sensitivity analysis will not be performed. Instead, the robustness of the findings will be explored narratively by considering study design quality, risk-of-bias judgments, sample size, intervention type, comparator type, and consistency of results across procedural skill domains.

Language restriction English.

Country(ies) involved Thailand.

Keywords medical students; procedural skills; technology-enhanced feedback; simulation training; randomized controlled trials; systematic review.

Contributions of each author

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