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Impact of Formative Feedback on Skill Acquisition in Simulation-Based Training

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ABSTRACT

Simulation-based learning is widely used in healthcare education to teach clinical skills in a safe, structured environment. However, the integration of systematic formative feedback within simulation remains inconsistent, particularly in undergraduate programs. **Objectives:** To evaluate the impact of structured formative feedback on clinical skill acquisition, self-reported confidence, and learner satisfaction among undergraduate students in medicine, dentistry, and nursing. **Methods:** A quasi-experimental study was conducted at Rawal Institute of Health Sciences with 72 undergraduate students. Participants were recruited via convenience sampling and randomly assigned to either a feedback group or a control group (n=36 each). Both groups performed the same simulation tasks, but only the feedback group received structured, real-time formative feedback after the initial assessment. Data collection included pre- and post-test knowledge scores, Objective Structured Clinical Examination (OSCE) performance, confidence rating scales, and satisfaction questionnaires. Data were analyzed using SPSS version 26.0. **Results:** The feedback group showed significantly higher post-test and OSCE scores compared to the control group ($p<0.001$), with large effect sizes (Cohen's d >1.5). Improvement scores and post-training confidence ratings were also significantly greater in the feedback group. Learner satisfaction scores in the feedback group were consistently high across all domains. **Conclusions:** Structured formative feedback in simulation-based training leads to substantial improvements in clinical performance, learner confidence, and satisfaction. These findings support the routine incorporation of feedback into undergraduate simulation curricula, particularly in resource-limited educational settings.

INTRODUCTION

Simulation-based learning has transformed healthcare education by offering students the opportunity to develop clinical reasoning and procedural skills in a realistic yet controlled environment [1]. It reduces the risk to actual patients, supports repetitive practice, and bridges the gap between theoretical knowledge and clinical application, which is essential in outcome-based curricula [2, 3]. However, the effectiveness of simulation hinges on the quality of feedback provided during or after the session. Formative feedback, defined as timely, specific input aimed at guiding learners toward improvement, is widely recognized as a cornerstone of experiential learning [4]. It promotes reflection, reinforces strengths, and addresses gaps in performance [5]. Yet, in many undergraduate programs, feedback during simulation remains unstructured, inconsistent, or absent. Although numerous international studies have explored simulation-based training, most have been conducted in high-resource

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settings or postgraduate contexts, often focusing on performance metrics alone [6-8]. Far fewer studies have examined formative feedback at the undergraduate level, particularly in diverse healthcare disciplines like medicine, dentistry, and nursing. Even less attention has been paid to how feedback affects learner confidence and satisfaction, which are crucial for motivation and long-term competence development [9]. In the Pakistani and broader South Asian context, the lack of organized feedback integration in simulation-based training is even more pronounced [10, 11]. Medical, dental, and nursing institutions in low-resource settings often adopt simulation without the structured debriefing that maximizes its pedagogical value. There was currently a paucity of local evidence on how feedback influences clinical skill development, learner confidence, or satisfaction with simulation-based instruction. As such, educators are left without data-driven strategies to enhance the value of simulation for undergraduates in these contexts. There is currently no structured model for delivering formative feedback in simulation-based training at the undergraduate level in Pakistan. This gap leads to suboptimal skill acquisition and undermines the potential benefits of simulation pedagogy. By comparing outcomes between those who received structured feedback and those who did not, this study aims to contribute context-specific evidence to inform future curriculum design in resource-limited undergraduate health education.

Simulation-based learning is widely adopted in undergraduate health education; however, the integration of structured formative feedback within simulation sessions remains inconsistent, particularly in low-resource settings. While international literature supports the value of feedback in enhancing clinical competence, limited evidence exists from South Asian undergraduate programs across medicine, dentistry, and nursing. Moreover, few local studies have simultaneously evaluated objective performance outcomes alongside learner confidence and satisfaction. This gap underscores the need for context-specific research to guide structured feedback implementation in undergraduate simulation curricula. This study aimed to evaluate the effect of structured formative feedback on clinical skill acquisition, self-reported confidence, and satisfaction among undergraduate students in a simulation setting.

METHODS

A quasi-experimental study was conducted at the clinical skills lab of Rawal Institute of Health Sciences from January 2025 to May 2025. The simulation setting was equipped with standardized manikins, skill stations, trained facilitators, and audio-visual recording capabilities. Ethical approval for this study was granted by the Institutional Review Board (IRB) of Rawal Institute of Health Sciences, Islamabad, under reference number RIHS/IRB/31/2025. This research used a quasi-experimental design with two groups: one receiving formative feedback and the other receiving no feedback with standard simulation instruction. A total of 72 participants were recruited for this study through convenience (non-probability) sampling, including undergraduate students from MBBS, BDS, and Nursing programs. Participants were then randomly assigned to two equal groups using a computer-generated simple randomization list. This randomization list was generated and maintained by an independent staff member not involved in training or data collection to ensure allocation concealment. The sample size was determined using G*Power software version 3.1.9.7, applying an independent-samples t-test model. The parameters set for calculation included an effect size (Cohen's d) of 0.8, a power of 0.80, and a significance level (α) of 0.05, which yielded a required sample size of 64 participants (32 per group). To account for potential dropouts or incomplete responses, the final sample was expanded to 72. The chosen effect size was based on findings from an interventional study by Lebdai *et al.* [12]. Informed written consent was obtained from all participants after explaining the purpose, process, and voluntary nature of participation. Confidentiality was maintained, and no personally identifiable information was used. Participants were randomly allocated into two equal groups (n=36 each): Group A (Feedback Group): Received structured formative feedback after simulation, and Group B (Control Group): Completed the same simulation tasks but without any formal feedback. All participants, regardless of discipline (MBBS, BDS, Nursing), undertook the same simulation tasks: CPR, IV cannulation, and basic airway management (bag-valve-mask ventilation). These procedures were selected for their cross-disciplinary relevance, as they are foundational emergency skills required in medical, dental, and nursing education. Group allocation was blinded to data analysts, although blinding of participants was not possible due to the intervention. Inclusion criteria were undergraduate health sciences students (3rd year or above). Voluntary consent to participate and no prior participation in the same simulation modules. Exclusion criteria were prior training in the simulation stations. incomplete pre-/post-assessment data and withdrawal of consent. A structured skill assessment checklist was done. Developed and validated by subject experts. It included stepwise criteria for each simulation task, scored out of 100. OSCE Score Sheet: A standardized Objective Structured Clinical Examination (OSCE), scored out of 20 by two blinded assessors. This OSCE format followed established protocols as described by Harden and Gleeson (1979) and

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further validated in simulation-based medical education [13]. Confidence Questionnaire: A 5-point Likert scale (1 = not confident, 5 = very confident) was used pre- and post-simulation to assess self-reported confidence. The scale was adapted from validated tools in similar simulation studies [14]. Satisfaction Survey: Completed only by the feedback group, assessing satisfaction across five domains (clarity, timeliness, usefulness, relevance, and overall satisfaction). This questionnaire was developed for this study and reviewed by experts for content validity. It was pilot-tested with 10 students, and internal consistency was confirmed (Cronbach's alpha = 0.86). Both groups attended a pre-simulation orientation. Participants then completed a pre-test knowledge assessment and a baseline skill performance using manikins on standardized stations (IV cannulation, CPR, Basic Life Support). Feedback Group: Received real-time formative feedback after the pre-test, including verbal comments, video playback, and structured improvement guidance aligned with defined performance criteria. Control Group: Performed the same tasks but received no feedback until the final debriefing. All participants then completed a post-test assessment and OSCE. Confidence and satisfaction data were collected using structured, self-administered tools. To ensure instrument reliability, all checklists and rating tools were pilot-tested. Inter-rater reliability for OSCE scores was high (Cohen's Kappa > 0.85). Simulation stations and checklists were developed through expert consensus and aligned with curriculum standards, ensuring both content and face validity. Feedback scripts were standardized, and facilitators received calibration training to reduce bias. All statistical analyses were performed using IBM SPSS Statistics version 26.0. All statistical analyses were performed using IBM SPSS version 26. Data were cleaned and checked for missing values; only complete cases were included in the final analysis. Descriptive statistics (means ± SD, frequencies, percentages) were used to summarize demographic and performance variables. Tests for normality (Kolmogorov–Smirnov and Shapiro–Wilk) were applied within each group to all continuous outcome variables, supported by histograms and Q–Q plots. All main variables demonstrated approximate normality, allowing the use of parametric tests. For between-group comparisons, Independent Samples t-tests were used for continuous variables (pre-test scores, post-test scores, OSCE scores, confidence ratings), and Chi-square tests were applied for categorical data (e.g., gender, year of study, discipline). Levene's Test for Equality of Variances was applied before each t-test. Cohen's d effect sizes and 95% confidence intervals were reported to quantify the magnitude of group differences. Cohen's d values were interpreted as small (0.2), medium (0.5), and large (≥0.8). Although pre- and post-assessments were administered, the analysis emphasized between-group differences using change scores (improvement) as the primary outcome. A sub-analysis was conducted for the feedback group (n=36), where descriptive statistics were used to summarize satisfaction across five feedback domains.

RESULTS

Both groups were statistically comparable in terms of age, gender, year of study, clinical experience, and prior feedback or simulation exposure. However, the field of study significantly differed between groups (p=0.006), with the feedback group having a higher proportion of nursing students. Cramer's V of 0.379 indicates a moderate association. This variation should be considered when interpreting learning outcomes, as baseline discipline may influence simulation performance (Table 1).

Table 1: Baseline Demographic Characteristics of Participants (n=72)

Variables	Category	Feedback Group (n=36)	Control Group (n=36)	p-Value / Statistic
Age	Mean ± SD	23.01 ± 1.68	23.22 ± 1.62	0.593
Gender	Male	17 (47.2%)	18 (50.0%)	0.814
	Female	19 (52.8%)	18 (50.0%)	
Year of Study	3rd Year	16 (44.4%)	17 (47.2%)	0.813
	Final Year	20 (55.6%)	19 (52.8%)	
Field of Study	MBBS	15 (41.7%)	24 (66.7%)	χ^2=10.366, df=2, p=0.006, Cramer's V=0.379
	BDS	8 (22.2%)	10 (27.8%)	
	Nursing	13 (36.1%)	2 (5.6%)	
Prior Simulation Exposure	Yes	13 (36.1%)	14 (38.9%)	0.808
	No	23 (63.9%)	22 (61.1%)	
Clinical Experience	<6 Months	17 (47.2%)	19 (52.8%)	0.637
	≥6 Months	19 (52.8%)	17 (47.2%)	
Previous Feedback Sessions	None	12 (33.3%)	19 (52.8%)	0.247
	1-2 Sessions	15 (41.7%)	11 (30.6%)	
	≥3 Sessions	9 (25.0%)	6 (16.7%)	

The two groups had similar pre-test scores, confirming equal baseline knowledge (p=0.694). The pre- and post-tests referred to structured written knowledge assessments scored out of 100. After training, the feedback group demonstrated significantly greater improvement in test performance and skill execution, with large effect sizes (Cohen's d >2). Notably, OSCE scores were also significantly higher in the feedback group, reinforcing the value of formative feedback in enhancing clinical competence (Table 2).

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Table 2: Knowledge and Skill Scores Before and After Simulation-Based Training(n=72)

Measures	Feedback Group (Mean ± SD)	Control Group (Mean ± SD)	Mean Difference	95% CI	p-Value	Effect Size (Cohen's d)
Pre-Test Score	57.60 ± 5.63	57.13 ± 4.53	0.48	-1.93 to 2.88	0.694	0.09
Post-Test Score	83.66 ± 7.60	72.76 ± 5.57	10.90	7.77 to 14.03	<0.001	1.61
Improvement Score	26.06 ± 5.11	15.63 ± 4.33	10.42	8.19 to 12.65	<0.001	2.18
OSCE Score (out of 20)	17.56 ± 0.96	14.65 ± 1.71	2.91	2.26 to 3.56	<0.001	2.00

Pre- and post-test scores reflect structured written assessments; OSCE scores reflect practical skill performance out of 20

Pre-training confidence was statistically similar between groups (p=0.771). However, post-training, the feedback group reported significantly higher confidence(mean=4.36 vs. 3.48, p<0.001), suggesting that formative feedback enhances both skill and self-perception(Table 3).

Table 3: Self-Reported Confidence Levels Before and After Training(n=72)

Confidence Measure	Feedback Group (Mean ± SD)	Control Group (Mean ±SD)	Mean Difference	95% CI	p-Value
Confidence (Pre-Test)	2.79 ± 0.52	2.75 ± 0.61	0.04	-0.23 to 0.31	0.771
Confidence (Post-Test)	4.36 ± 0.44	3.48 ± 0.41	0.87	0.67 to 1.07	<0.001

The feedback group also reported high satisfaction across all five domains, with mean scores above 4.5. "Overall Satisfaction"(4.82) and "Usefulness for Improvement"(4.81) received the highest ratings(Table 4).

Table 4: Satisfaction with Feedback in Feedback Group Only (n=36)

Satisfaction Domain	Mean ± SD
Clarity of Feedback	4.66 ± 0.30
Timeliness of Feedback	4.68 ± 0.30
Usefulness for Improvement	4.81 ± 0.19
Relevance to Clinical Skills	4.60 ± 0.40
Overall Satisfaction	4.82 ± 0.27

DISCUSSION

This study aimed to explore the role of formative feedback in enhancing clinical skill acquisition during simulation-based training. The findings strongly support the hypothesis that structured, timely feedback significantly improves performance, confidence, and learner satisfaction. Participants who received formative feedback demonstrated higher post-test and OSCE scores than those in the control group. The feedback group's mean improvement score exceeded the control group by over 10 points, with large effect sizes (Cohen's d>2), indicating substantial educational benefit. These results align with previous findings by Cole and Pannekoeke, who emphasized that high-quality feedback enhances learning when it is timely, specific, and actionable [15, 16]. Self-reported confidence also increased more markedly in the feedback group, echoing the findings of Kaur *et al.* Yang *et al.* and Agostino *et al.* who reported enhanced student confidence and reduced performance anxiety following feedback-supported simulation [17-19]. Satisfaction levels in the feedback group were uniformly high, with the highest scores for "Overall Satisfaction" (mean=4.82) and "Usefulness for Improvement" (mean=4.81). These ratings indicate that learners viewed the feedback not merely as corrective but as a supportive and motivating element of their learning. These findings are consistent with prior research. who highlighted the emotional and educational impact of feedback during simulation-based education [20-22]. Although demographic characteristics were balanced between groups, the distribution of disciplines (MBBS, BDS, Nursing) was not. The feedback group had a higher proportion of nursing students, while the control group had more MBBS participants. While no formal subgroup analysis was conducted, the consistently superior performance and satisfaction outcomes across the feedback group suggest that the intervention was beneficial regardless of academic background. Future studies should perform discipline-specific subgroup analyses to evaluate whether feedback effectiveness differs significantly across fields. Simulation-based education is now widely recognized as a safe and effective modality for developing clinical competence [23-25]. However, this study reaffirms that the educational impact of simulation is highly dependent on the quality of feedback and debriefing provided. Structured formative feedback helps transform simulation from a passive activity into a reflective, improvement-focused learning experience.

This study was limited by its single-institution setting and relatively small sample size, which may affect generalizability. The imbalance in participant disciplines between groups and the quasi-experimental design may also introduce potential confounding factors. Additionally, long-term retention of skills was not assessed. Future multicenter randomized trials with larger, discipline-stratified samples and longitudinal follow-up are recommended to evaluate sustained competency gains and to develop standardized feedback models for simulation-based undergraduate training.

CONCLUSIONS

This study demonstrated that incorporating structured formative feedback into simulation-based training leads to measurable improvements in clinical skill performance (OSCE and post-test scores), increased self-reported

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confidence, and high learner satisfaction. These results reinforce the critical role of feedback in enhancing the educational value of simulation. By embedding feedback as a routine part of simulation training, educational programs can foster more effective and learner-centered skill development. Future research should explore the retention of skills over time and investigate discipline-specific impacts of feedback to guide tailored simulation curricula.

Authors' Contribution

Conceptualization: AHA
Methodology: MZB, FP, NG
Formal analysis: ZA, MZB, FP
Writing and Drafting: AHA, ZA, NJ, NG
Review and Editing: AHA, ZA, NJ, NG, MZB, FP

All authors approved the final manuscript and take responsibility for the integrity of the work

Conflicts of Interest

The authors declare no conflict of interest.

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