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RESEARCH

Patterns of change in evidence-based practice competence following a team-based learning intervention: a quasi-experimental study

Paola Ferri[1], Teresa Peduto[1], Sergio Rovesti[1] and Angela Contri[1*]

Abstract

Strengthening evidence-based practice (EBP) competence is essential for safe and high-quality nursing care. Team-based learning (TBL) is increasingly adopted in nursing education, yet evidence clarifying *how* and *for whom* it supports meaningful learning remains limited. Grounded in social cognitive theory, this study examined patterns of change in EBP competence following a TBL-based module, with specific attention to baseline-dependent learning gains. A quasi-experimental pre-post design was conducted with second-year nursing students ($n=119$). EBP competence (encompassing knowledge, skills, and attitudes) was assessed using a validated multidimensional instrument (the Evidence-Based Practice Competence Questionnaire EBP-COQ). Beyond group-level analyses, Reliable Change Index (RCI) methods were applied to identify changes exceeding measurement error and to characterise individual learning trajectories. Associations between baseline preparation and subsequent gains were explored to examine equity-related effects. Substantial improvements were observed in the total EBP-COQ score (mean increase: 16.06; $p<0.001$; $d=1.17$) and all subdomains, with the largest effect in Knowledge ($d=1.43$), followed by Skills ($d=0.85$) and Attitude ($d=0.59$). RCI analyses indicated that 58.8% of participants achieved meaningful improvement in overall EBP competence. Baseline competence explained only a small proportion of post-intervention variance (R^2: 1.3–9.4%), suggesting a compensatory effect where lower-performing students demonstrated the greatest reliable improvement. When accounting for ceiling effects, the proportion of students demonstrating reliable improvement increased further, reaching 38.0% in Attitude among those with measurable room for change. These findings clarify mechanisms through which structured collaborative learning may redistribute learning gains within heterogeneous cohorts. By integrating individual-level change metrics with a theoretically informed interpretation, this study contributes evidence on how structured collaborative learning may support equitable EBP competence development in undergraduate nursing education.

Trial registration

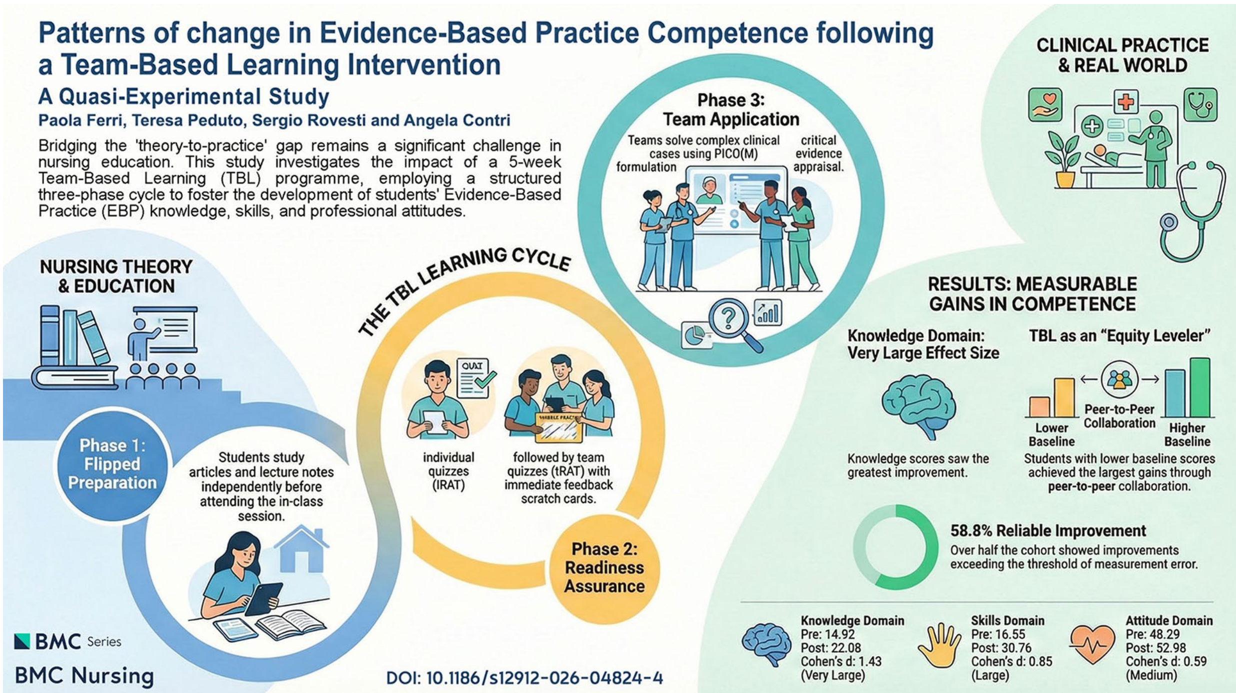
Registered at ClinicalTrials.gov (Identifier: NCT07364994 – Registration Date 15-01-2026).

Keywords Evidence-based practice, Team-based learning, Health professions education, Active learning, Educational measurement, Individual learning differences

*Correspondence:
Angela Contri
angela.contri@unimore.it

Full list of author information is available at the end of the article

Graphical Abstract



Introduction

Evidence-Based Practice (EBP) is universally acknowledged as a core competency in modern nursing, requiring learners to integrate the best available research evidence, clinical expertise, and contextual judgment in decision-making [1–4]. The strategic imperative for EBP is clear: when clinical decisions are informed by professional expertise, respect for patient values, and high-quality evidence, patient outcomes and healthcare quality improve, whereas failures in this domain remain potent predictors of adverse events and increased mortality [3, 5]. Consequently, international regulatory bodies, including the European Federation of Nurses Associations (EFN), have mandated the integration of EBP as a central competence within undergraduate nursing curricula [6].

Despite this professional mandate, a persistent discrepancy, often termed the 'theory-practice gap,' remains documented between students' positive attitudes towards EBP and their actual ability to enact its principles in clinical settings [7, 8]. Developing EBP competence poses substantial educational challenges, primarily because EBP requires moving beyond mere declarative knowledge toward active engagement, developing the ability to apply, justify, and negotiate evidence-informed decisions in complex and uncertain clinical contexts [3, 9].

Learners frequently exhibit limited procedural knowledge, difficulties in appraising and applying evidence, and uncertainty in translating theoretical models into clinical reasoning [3, 10, 11]. In the European context, these challenges are further compounded by fragmentation of curricular approaches to EBP, which is frequently embedded within other courses and delivered through instructional formats that may inadequately support the development of applied competence [6, 12–15].

Educational research increasingly suggests that the primary challenge does not lie merely in the extent of content coverage, but rather in the congruence between instructional design and the cognitive demands inherent in EBP learning [3, 16]. EBP requires critical thinking, transfer across contexts, and iterative decision-making. These competencies are characterised by significant baseline heterogeneity among learners [6–8]. Traditional teacher-centred models, such as Lecture-Based Learning (LBL), often facilitate only surface learning and may inadvertently reproduce or amplify baseline differences in student preparedness [17–19]. To address these shortcomings, nursing education is shifting towards active, student-centred methodologies rooted in social constructivism [20–25]. Learning is conceptualised as a socially mediated process where knowledge is co-constructed and regulated through interaction and feedback. Within this framework, structured collaborative learning environments provide the scaffolding, feedback, and shared accountability necessary to support learners within their *Zone of Proximal Development* [23, 26]. Such frameworks predict that learners with lower baseline competence may derive disproportionate benefit when instructional conditions are optimally aligned with learning demands [27, 28].

Team-based learning (TBL) represents a highly structured form of collaborative learning that operationalises these principles through a specific sequence: individual preparation; readiness assurance testing, incorporating Individual (iRAT) and Team Readiness Assurance Test' (tRAT) components; and immediate application to complex clinical scenarios [29, 30]. Unlike general active learning techniques, TBL combines inherent mechanisms of accountability and peer regulation that may influence how learning gains are distributed within heterogeneous cohorts [24, 31–33]. Through repeated cycles of individual preparation, peer discussion, and decision-making on complex problems, TBL is theorised to support the development of higher-order cognitive skills (such as critical appraisal, justification of choices, and collaborative reasoning) required to navigate real-world EBP demands [32, 34, 35]. Crucially, TBL has been hypothesised to function as an instructional design capable of reducing baseline disparities in learning gains [28, 36].

While TBL has been widely adopted, empirical evidence examining its impact on the multidimensional construct of EBP competence (encompassing attitude, knowledge, and practical skills) remains limited, particularly regarding individual learning trajectories. There is a lack of research examining whether observed changes reflect meaningful learning at the individual level, or how learning gains are distributed across students with heterogeneous baseline levels of preparedness. These gaps are particularly evident in healthcare education contexts characterised by a continued reliance on traditional lecture-based approaches, with the Italian health nursing education context offering a pertinent exemplar [37].

The present study examines patterns of change in the multidimensional construct of EBP competence among nursing students following a TBL-based module in an undergraduate programme. By combining group-level analyses with individual-level change metrics via the Reliable Change Index (RCI) [38], this research seeks to illuminate not only whether learning occurs, but how learning gains are distributed across baseline levels of competence. This contribution aims to provide a more nuanced understanding of active learning mechanisms, aligning with the global effort to standardise and enhance EBP education for improved healthcare delivery and patient safety. By integrating psychometrically informed change metrics within an applied educational intervention, this study contributes to methodological innovation in the evaluation of EBP training in nursing.

Methods

Study design and reporting

This study adopted a quasi-experimental pre-test/post-test design with a single intervention group. The study protocol was registered at ClinicalTrials.gov (Identifier: NCT07364994) and the manuscript was drafted in accordance with the Transparent Reporting of Evaluations with Nonrandomized Designs (TREND) statement checklist for the reporting of non-randomised evaluations [39]. The study protocol was approved by the University Ethics Committee for Research (CEAR). Prior to enrolment, all participants received detailed information regarding the study objectives, the voluntary nature of participation, and data protection measures, and provided written informed consent.

Participants

Eligibility criteria

Participants were recruited from an undergraduate nursing cohort. To ensure a homogeneous sample within a comparable stage of training, specific inclusion criteria were applied at the subject level: (1) formal enrolment as a second-year student in the Bachelor of Nursing programme for the academic year 2023–2024; (2) attendance at the introductory didactic session where the research protocol was presented; and (3) provision of voluntary, written informed consent. Exclusion criteria comprised: (1) students participating in international exchange programmes (e.g., Erasmus+); (2) students with an 'out-of-course' status; (3) those who had previously obtained academic credit for the specific module; and (4) students absent during the recruitment phase or who declined consent.

Method of recruitment

A non-probability, consecutive sampling strategy was employed (census sampling). The recruitment process targeted the entire eligible cohort attending the second-year Evidence-Based Nursing course. No random selection was performed; instead, all students meeting the inclusion criteria were invited to participate. This was done in order to reflect the natural educational environment where curricular innovations are typically implemented cohort wide.

Recruitment setting

Recruitment was conducted directly within the academic setting. The research protocol, objectives, and ethical implications were formally presented by the researchers during the inaugural face-to-face lecture of the module. This ensured that all potential participants received standardised information simultaneously prior to the commencement of the educational intervention.

Settings and locations of data collection

The study was conducted at a single site: a Bachelor of Nursing degree programme within a large public university in Northern Italy. Data collection took place within university classrooms using a paper-based version of the Evidence-Based Practice Competence Questionnaire (EBP-COQ) to maximise response rates. Baseline data were collected in March 2024, prior to the intervention, and post-intervention data were collected in April 2024, immediately following the conclusion of the module. The immediate post-test assessment (one month after baseline) was chosen to capture proximal learning outcomes directly following the intervention, before students encountered additional EBP-related coursework or clinical experiences that could confound the measurement of change attributable to the TBL module.

Intervention

Educational context and structure

The educational intervention was embedded within the second year 'Evidence-Based Nursing' course (64 contact hours total). The course curriculum was divided into five modules: Medical Statistics (20 h), Informatics (14 h), Bibliographic research (6 h, library laboratory), Research Methodology (12 h), and Core EBP (12 h). The experimental intervention specifically targeted the Core EBP module, which was delivered exclusively using a TBL strategy. This structure allowed the implementation of a theoretically coherent EBP learning environment while isolating the TBL-based instructional component within the broader curriculum.

Intervention delivery and timeline

The TBL intervention consisted of three 4-hour sessions conducted in university classrooms over a five-week period, with an interval of approximately 17 days between sessions (March 19, April 5, and April 22, 2024). The intervention was delivered by a single instructor, a senior researcher with 25 years of academic teaching experience and an established research profile in EBP education. Each session followed a standardised TBL cycle comprising three phases. The first phase, 'Flipped Preparation', took place asynchronously and involved the individual study of preparatory learning materials uploaded to the university's Moodle platform one to two weeks prior to each session. Content included ten selected scientific articles on research methodology and nursing care, alongside specific lecture notes authored by the instructor focusing on PICO formulation, critical appraisal, and implementation strategies, which students were required to master before the face-to-face sessions.

The in-class component commenced with the 'Readiness Assurance Process' (Phase 2). At the start of the session, students completed an iRAT, consisting of a 10-item multiple-choice assessment quiz (10 min) to assess their understanding of the preparatory materials. Immediately following the iRAT, students convened in their assigned teams to complete the same quiz as a tRAT within 20 min (see Appendix A.1 for sample questions). The tRAT employed 'scratch cards' (Immediate Feedback Assessment Technique, IF-AT), which provided immediate real-time feedback on the correctness of consensus answers; if the initial scratch revealed an incorrect answer, teams could re-attempt for partial credit (see Appendix A.2 for an illustration of the 'scratch card' used). Following the testing, teams were permitted to submit written appeals based on question ambiguity, disagreement with the answer key, or insufficient material coverage, provided they cited supporting evidence from the pre-class readings. The instructor then delivered a targeted mini lecture to clarify concepts where class performance was weak.

The final and most substantial portion of the session (approximately 2.5 to 3 h) was dedicated to 'Team Application' (Phase 3). This phase focused on solving complex clinical cases that required critical thinking and the practical application of EBP principles. Teams discussed specific clinical problems and, upon reaching a consensus, simultaneously revealed their answers using voting cards. This method facilitated inter-team debate and instructor-mediated feedback, consolidating the learning process.

Unit of delivery

The class was divided into 20 permanent teams of 5–7 students. Teams were randomised at the beginning of the academic year and remained stable throughout the three TBL sessions to foster cohesion and accountability.

Compliance and adherence

To maximise student engagement and accountability, the final course grade was determined entirely by TBL-related performance. The assessment weighting was distributed as follows: 25% for iRAT, 35% for tRAT, and 35% for the team application exercises. The remaining 5% was derived from an anonymous Peer Evaluation, where team members rated each other's contribution to group work at the end of the module.

Objectives

The primary objective of this study was to examine patterns of change in EBP competence following a structured TBL intervention, with specific attention to individual-level responsiveness and baseline-dependent learning gains.

The study tested the directional hypothesis that participants would demonstrate improvements across the attitude, skills, and knowledge domains of EBP competence.

Outcomes

The primary outcome was the change in overall EBP competence from pre- to post-intervention, assessed at both group and individual levels. Secondary outcomes included specific variations across the three constituent domains (Attitude, Skills, and Knowledge), baseline-dependent patterns of improvement, and exploratory correlations between competence levels and sociodemographic variables.

Data collection and quality enhancement

Data were collected via a paper-based survey administered in the classroom to maximise response rates. To minimise social desirability bias and enhance measurement quality, a strict pseudonymisation protocol was implemented. Participants self-generated a unique alphanumeric code to link pre- and post-test data, ensuring complete anonymity and dissociating research participation from academic assessment.

Competence was assessed using the Italian validated version of the Evidence-Based Practice Evaluation Competence Questionnaire (EBP-COQ) [40, 41]. This 25-item instrument, specifically designed for nursing students, utilises a 5-point Likert scale (from 1 = 'Strongly disagree' to 5 = 'Strongly agree') distributed across three robust subscales/domains: Attitude (13 items), Skills (6 items), and Knowledge (6 items). This ensures that the assessment captures distinct components of professional competence rather than reflecting a generic 'satisfaction' or 'liking' towards the educational intervention. The EBP-COQ was selected as it operationalises competence-related constructs rather than subjective satisfaction or perceived learning. The instrument has demonstrated strong psychometric properties in previous validation studies [40–42]; for the present study, EBP-COQ internal consistency was re-verified on the baseline data using Cronbach's alpha coefficient to confirm the instrument's reliability within this specific sample.

Sample size

Sample size was determined by the total available population (census method) to reflect the natural educational cohort. A total of 119 students completed both assessments and were included in the final analysis. Given this design, no a priori power calculation was used to determine sample size. Precision of estimates was instead evaluated through effect sizes and 95% confidence intervals.

Assignment method

Assignment to the study condition was non-random and determined by formal enrolment in the nursing curriculum (cohort-level assignment). All eligible students received the identical educational intervention. To mitigate bias associated with the lack of a control group, a paired pre-test/post-test design was employed, allowing each participant to serve as their own control (within-subjects analysis). This design was considered appropriate for examining within-individual change patterns in a naturalistic educational setting.

Statistical methods

Consistent with previous validation studies, EBP-COQ summed scores were treated as approximately continuous variables [41–43]. Normality was assessed using the Shapiro–Wilk test. Group-level pre-post comparisons were performed using paired-samples t-tests to estimate mean differences and standardised effect sizes (Cohen's *d*). Where significant deviations from normality were observed, non-parametric Wilcoxon signed-rank tests were conducted as sensitivity analyses to corroborate the robustness of the primary parametric findings.

To address potential mathematical coupling (i.e., the statistical dependency between baseline values and computed change scores) and regression-to-the-mean artefacts (the natural tendency for extreme initial scores to move closer to the average upon retesting), supplementary linear regression analyses were conducted with post-intervention scores as dependent variables and baseline scores as predictors for each domain. This approach allows for a formal assessment of baseline dependency without relying on potentially biased difference scores.

In addition to mean-level comparisons, individual-level change was assessed using the RCI [38]. Unlike raw difference scores, the RCI accounts for measurement error (filtering out measurement noise to distinguish genuine progress from random fluctuation) by determining whether an observed pre-post change exceeds the threshold expected due to measurement error alone and establishes a formal threshold for reliable improvement. This enables a statistically robust classification of individual change. This approach aligns with educational research frameworks that emphasise responsiveness beyond group averages [44]. RCI was calculated for the total EBP-COQ score and for each domain. The standard error of measurement (SEM) was calculated for each domain using the baseline standard deviation and Cronbach's α coefficient ($\mathrm{SEM} = \mathrm{SD} \times \sqrt{1-\alpha}$), and standard error of difference (S_{diff}) was then obtained as $\sqrt{2 \times (\mathrm{SEM}^2)}$, in accordance with the Jacobson and Truax method [38]. Participants were classified as showing *reliable improvement* (RCI > 1.96), *no change* (-1.96 ≤ RCI ≤ 1.96), or *reliable deterioration* (RCI < -1.96), using a 95% confidence interval threshold ($p < 0.05$).

To account for potential ceiling effects, a secondary responsiveness analysis was performed. Participants were considered *potential improvers* only if their baseline scores allowed for an increment exceeding the 95% Minimal Detectable Change (MDC_{95}), calculated as 1.96 $\times$ S_{diff}. Individuals whose baseline scores were within one MDC_{95} of the scale's maximum were excluded from *responder* classification to avoid underestimating the intervention's effectiveness due to instrument limitations.

Conversely, non-parametric procedures were applied for analyses involving variables with inherently non-normal distributions. This included evaluating the impact of collaborative learning, operationalised as the *improvement gain* (defined as the difference between tRAT and iRAT scores), which was analysed using Spearman's rank correlation coefficient (r_s) to investigate the compensatory dynamics of the team phase. Given the structural mathematical dependency between baseline and change scores, these correlations were interpreted cautiously as descriptive of the cohort trend rather than as pure inferential evidence. Exploratory subgroup analyses for sociodemographic variables were conducted using independent-samples *t*-tests or one-way ANOVA, as appropriate, while associations between continuous variables were examined using Pearson's correlation coefficients.

Data were handled using a complete-case analysis strategy (listwise deletion), excluding participants absent at either time point. All analyses were performed using SPSS Statistics (version 27.0). Graphical representations of distributions and individual-level change patterns were generated using JASP (version 0.95.4). Statistical significance was defined as $p < 0.05$.

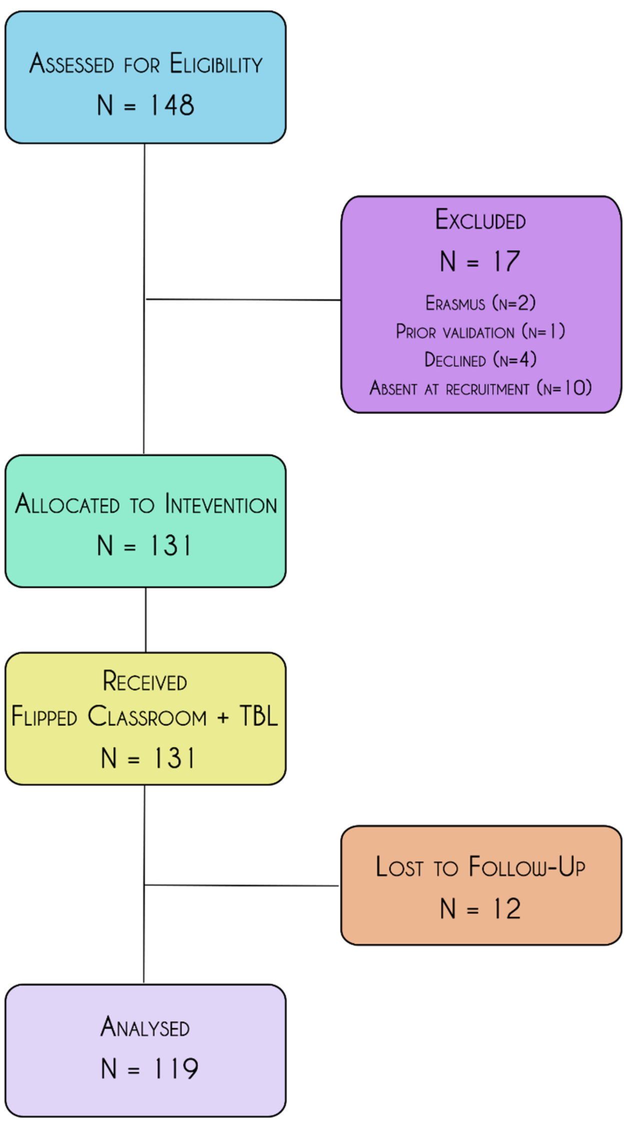


Fig. 1 Participant flow chart

Results

Participant flow

The flow of participants through the study is detailed in Fig. 1. Out of 148 eligible second-year nursing students, 131 were enrolled and allocated to the intervention. The final analysis included 119 participants (90.8%) who completed both the baseline and post-intervention assessments. Reasons for exclusion and attrition are reported in the flow diagram.

Recruitment

Recruitment and baseline assessment took place on 4th March 2024. The final follow-up data collection was conducted on 22nd April 2024, marking the end of the study period.

Baseline Data

Table 1 summarises the baseline characteristics of the 119 participants included in the final analysis. The sample was predominantly female (74.8%), with a mean age of 23.4 ± 6.1 years. Educational background was largely homogeneous, with 89.9% of students holding a high school diploma as their highest qualification. Regarding variables relevant to the educational intervention, participants demonstrated a novice profile: 87.4% reported minimal prior EBP training (< 40 h) and 81.5% had not performed any evidence searches in the prior three years. Comparison between those retained in the study ($n = 119$) and those lost to follow-up ($n = 12$) revealed no significant differences in baseline demographics or EBP competence scores. As the study employed a census sampling of the cohort, the participants are considered representative of the target student population.

Table 1 Baseline demographic and academic characteristics of the study participants ($N = 119$)

Characteristic		Category	*n* (%) or Mean ± SD
Sociodemographic variables	Age (years)		23.4 ± 6.1
	Sex	Female	89 (74.8%)
		Male	30 (25.2%)
Educational Background	Highest qualification	High School Diploma	107 (89.9%)
		University Degree/ Master	12 (10.1%)
EBP Training & Experience	Prior EBP Training (hours)	None	5 (4.2%)
		< 40 h	104 (87.4%)
		40–150 h	6 (5%)
		> 150 h	4 (3.4%)
	Evidence searches (last 3 years)	None	97 (81.5%)
		1–2 searches	18 (15.1%)
		3–4 searches	2 (1.7%)
		> 4 searches	2 (1.7%)
	Scientific articles read (last month)	None	61 (51.3)
		1–2 articles	37 (31.1%)
		3–4 articles	14 (11.8%)
		> 4 articles	7 (5.9%)
Baseline EBP Competence	EBP-COQ Total Score (range 26–130)		79.76 ± 9.82
	Subscales (range 1–5)	Attitude	3.71 ± 0.50
		Knowledge	2.76 ± 0.66
		Skills	2.49 ± 0.64

Note: SD: Standard Deviation; EBP: Evidence-Based Practice; EBP-COQ: Evidence-Based Practice Competence Questionnaire. Values are presented as frequency (percentage) for categorical variables and Mean ± SD for continuous variables

Table 2 Pre-post comparison of EBP competence scores (EBP-COQ) and effect size estimates ($N = 119$)

Outcome	Baseline Mean (SD)	Post-test Mean (SD)	Mean Diff. (95% CI)	t-value (df = 118)	*p*-value	Cohen's d
Total Score	79.76 (9.82)	95.82 (12.54)	16.07 (13.57, 18.57)	12.73	< 0.001	1.17
Attitude	48.29 (6.52)	52.98 (7.05)	4.69 (3.24, 6.14)	6.39	< 0.001	0.59
Skills	16.55 (3.94)	20.76 (3.66)	4.22 (3.13, 5.12)	9.22	< 0.001	0.85
Knowledge	14.92 (3.83)	22.08 (3.72)	7.16 (6.25, 8.07)	15.56	< 0.001	1.43

Note: SD: Standard Deviation; df: degrees of freedom

Numbers analysed

Outcomes were analysed on the 119 participants who completed the entire protocol. A complete-case analysis strategy was employed; non-compliers (lost to follow-up, $n = 12$) were excluded, and denominators were constant for all outcome variables. Notably, the amount of missing data per item among the analyzed participants was negligible (< 2%).

Outcomes and estimation

Table 2 provides detailed summary statistics, mean differences, and effect sizes for all study outcomes. Regarding the primary outcome, the analysis revealed a significant increase in the total EBP-COQ score, which rose from 79.76 (± 9.82) at baseline to 95.82 (± 12.54) post-intervention ($t_{(118)} = 12.73$, p < 0.001), demonstrating a large effect size (Cohen's $d = 1.17$). This positive trend was consistently observed across all secondary outcomes (Attitude, Skills, and Knowledge), as illustrated by the longitudinal distributions and individual trajectories in Fig. 2, which all showed statistically significant improvements (p < 0.001). The magnitude of the intervention's effect varied across domains, ranging from medium for Attitude ($d = 0.59$) to large for Skills ($d = 0.85$) and very large for Knowledge ($d = 1.43$, see Fig. 2 for the evident 'cloud' shift in this domain). The 95% confidence intervals for the mean differences did not cross zero for any outcome, confirming the robustness of the estimates. No negative trends or adverse effects were recorded. Preliminary normality testing via Shapiro-Wilk indicated minor but statistically significant deviations from normality in the Knowledge subscale at baseline ($p = 0.031$), the Total EBP-COQ score at baseline ($p = 0.007$), and the Total change score ($p = 0.043$). However, visual inspection of

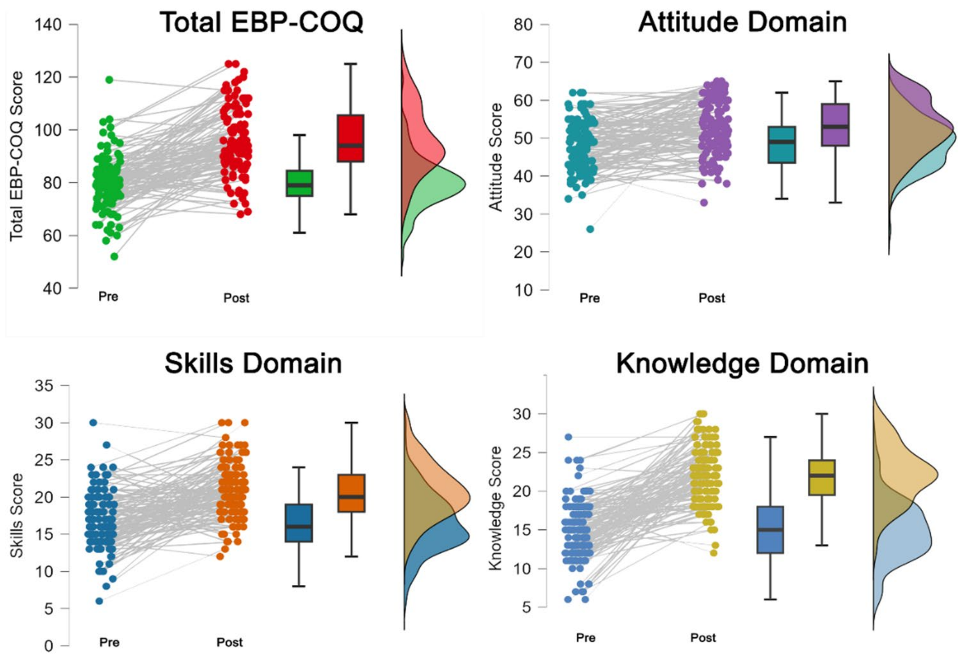


Fig. 2 Longitudinal development of EBP competence across domains. Raincloud plots of EBP-COQ scores before (Pre) and after (Post) the TBL intervention ($N=119$). Each plot shows probability density of the scores (half-violin, the 'cloud'), individual observations (jittered points), boxplots (medians and interquartile ranges), and individual trajectories (grey lines). Post-intervention scores are higher across all domains, the largest effect is in the Knowledge domain (Cohen's d = 1.43). Note. Subscales are presented on their original metric and are not directly comparable in magnitude

data distributions and the consistency with non-parametric sensitivity analyses supported the use of parametric reporting, which was preferred for its greater interpretability and the inclusion of standardized effect sizes [45, 46]. Indeed, the parametric results remained highly consistent with the Wilcoxon sensitivity check ($z=8.79$ $p<0.001$), justifying the continued use of parametric reporting for its greater interpretability and inclusion of effect sizes.

Supplementary regression analyses were performed to examine baseline dependency of post-intervention scores. Baseline Attitude significantly predicted post-intervention Attitude ($\beta=0.33$, p = 0.001; R^2 = 0.09). In contrast, baseline Skills ($\beta=0.13$, p = 0.135; R^2 = 0.02), and baseline Knowledge ($\beta=0.11$, p = 0.210; R^2 = 0.01) did not significantly predict post-intervention performance. For the total score, baseline competence modestly predicted post-intervention performance ($\beta=0.33$, p = 0.004; R^2 = 0.07) (see Appendix A.3).

The RCI analysis revealed a substantial individual response to the intervention. By incorporating measurement error into the estimation of change, the RCI provides a more conservative and individually meaningful indicator of responsiveness compared with raw gain scores. Regarding the primary outcome, 58.8% of students ($n=70$) demonstrated a reliable improvement in their total EBP competence, while 41.2% ($n=49$) remained stable. No students showed reliable deterioration in the total score (see Table 3). Across domains, the highest frequency of reliable improvement was observed in Knowledge (68.1%, $n=81$), followed by Skills (48.7%, $n=58$) and Attitude (34.5%, $n=41$). The intervention's responsiveness was further assessed by accounting for baseline ceiling effects. In the Attitude domain, where the ceiling effect was most prominent, the proportion of students achieving reliable improvement rose from 34.5% in the full cohort to 38.0% among potential improvers. Similarly, small but consistent increments in improvement rates were observed across all domains when excluding participants with limited psychometric headroom (see Table 3).

Figure 3 illustrates the proportion of participants whose change scores exceeded the 95% reliable change threshold ($\pm 1.96 \times S_{\text{diff}}$) for the total EBP-COQ score and its subscales. The distribution of change scores and reliable change thresholds are presented in Appendix A.4.

Ancillary analyses

Internal consistency analysis confirmed the reliability of the EBP-COQ for the study population (Total $\alpha=0.83$; subscales α range: 0.76–0.83). Exploratory subgroup analyses showed that sex, age, and research habits did not significantly influence competence gains (Pearson's r ranging from -0.085 to 0.121; t-values from -0.764 to 0.525; F-values from 0.267 to 1.940; all $p>0.05$). Regarding prior education, although ANOVA

Table 3 Individual-level responsiveness and Reliable Change Index (RCI) analysis ($N = 119$)

Domain	Cronbach's α (baseline)	SD (baseline)	SEM	S_{diff}	MDC_{95}	Group	*n*	Reliable Improvement *n* (%)	No Change *n* (%)	Reliable Deterioration *n* (%)
Attitude	0.83	6.52	2.7	3.7	7.3	**Full Cohort**	119	41 (34.5%)	73 (61.3%)	5 (4.2%)
						Potential Improvers*	108	41 (38.0%)	64 (59.3%)	3 (2.8%)
Skills	0.8	3.94	1.8	2.5	4.85	**Full Cohort**	119	58 (48.7%)	54 (45.4%)	7 (5.9%)
						Potential Improvers*	117	58 (49.6%)	53 (45.3%)	6 (5.1%)
Knowledge	0.78	3.83	1.8	2.5	4.97	**Full Cohort**	119	81 (68.1%)	37 (31.1%)	1 (0.8%)
						Potential Improvers*	113	78 (69%)	34 (30.1%)	1 (0.9%)
EBP-COQ Total	0.83	9.82	4	5.7	11.22	**Full Cohort**	119	70 (58.8%)	49 (41.2%)	0 (0%)
						Potential Improvers*	118	70 (59.3%)	48 (40.7%)	0 (0%)

Note: EBP-COQ: Evidence-Based Practice Competence Questionnaire; SD: Standard Deviation; SEM: Standard Error of Measurement; S_{diff}: Standard Error of the Difference; MDC_{95} Minimum Detactable Change at 95% confidence level

Reliable change was calculated using the Jacobson and Truax (1991) method

*Potential Improvers are participants with baseline scores at least one MDC_{95} below the scale's maximum (ceiling thresholds: Attitude ≥ 57.7; Skills ≥ 25.15; Knowledge ≥ 25.03; Total ≥ 113.78)

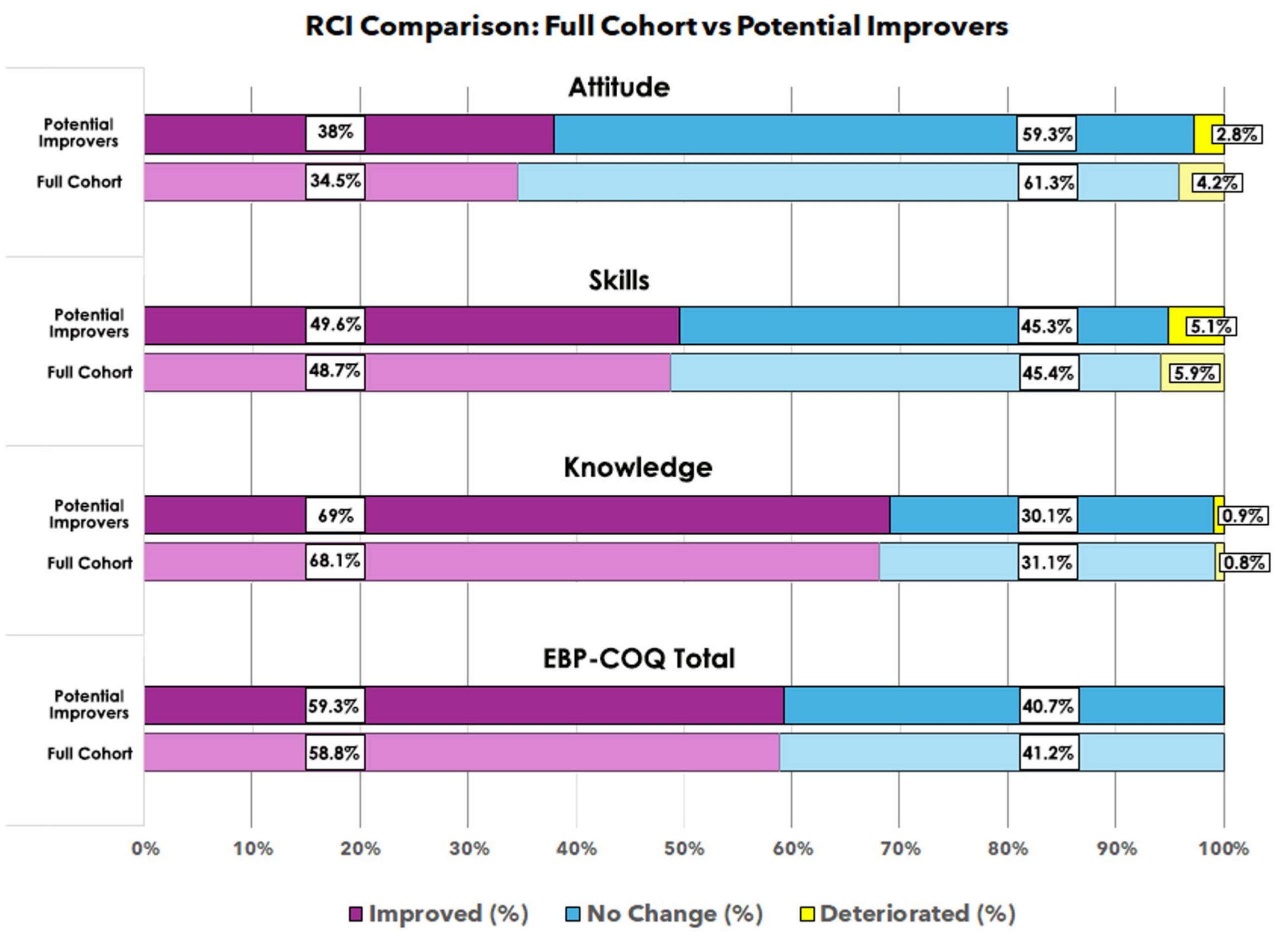


Fig. 3 Comparison of individual-level responsiveness to the TBL intervention: Full cohort versus potential improvers. Individual-level responsiveness to TBL: full cohort ($N = 119$) versus of 'potential improvers', participants with psychometric room for change ($n = 118$ for Total; $n = 113$ for Knowledge; $n = 117$ for Skills; $n = 108$ for Attitude). Categories: Reliable Improvement (RCI > 1.96, violet segments), No Change (− 1.96 ≤ RCI ≤ 1.96, green segments), and Reliable Deterioration (RCI < − 1.96, yellow segments). Data labels within each segment represent the percentage of the total cohort

Table 4 Improvement gains between individual and team-based tests

TBL Session	N	iRAT Score (Mean ± SD)	tRAT Score (Mean ± SD)	Improvement Gain (Mean ± SD)	Spearman's r_s	p-value
Session 1	133	81.35 (± 17.96)	99.23 (± 2.97)	17.88 (± 17.99)	-0.996	< 0.001
Session 2	130	92.38 (± 14.67)	97.04 (± 15.00)	5.37 (± 8.72)	-0.935	< 0.001
Session 3	135	91.41 (± 13.50)	97.76 (± 12.19)	7.07 (± 10.69)	-0.958	< 0.001

Note: iRAT: Individual Readiness Assurance Test; tRAT: Team Readiness Assurance Test; SD: Standard Deviation

Improvement Gain is calculated as the difference between the tRAT score and the iRAT score. While the primary pre-post analysis was restricted to 119 participants, these session-specific data include all students present during each module to accurately reflect team dynamics and classroom performance

indicated marginal variance in Skills ($F = 3.14$, $p = 0.047$) and Knowledge ($F = 3.13$, $p = 0.047$), Bonferroni post-hoc tests confirmed no significant differences between students with a high school diploma and those with a university degree ($p = 0.106$ and $p = 0.219$, respectively). Conversely, prior EBP training significantly impacted the Skills domain ($p = 0.001$); post-hoc comparisons showed that participants with minimal prior training (< 40 h) achieved significantly larger improvements than those with no ($p = 0.013$) or intermediate (40–150 h) training ($p = 0.034$).

Table 4 shows the association between individual preparation and team based 'improvement gain' (tRAT - iRAT). As expected, Spearman's rank correlation revealed an inverse correlation emerged between initial individual performance and gain scores. High coefficients (r_s values ranging from − 0.935 to -0.996; $p < 0.001$) reflected this trend: lower individual scores were consistently associated with larger score increases during the team phase.

Discussion

This study aimed to evaluate changes in EBP competence following a TBL intervention among undergraduate nursing students. The findings support our primary hypothesis: the TBL educational strategy significantly enhanced students' attitudes, knowledge, and skills, leading to a statistically significant improvement in the total EBP-COQ score and across all three subscales. These results align with previous international evidence supporting the effectiveness of active learning methodologies for teaching complex constructs like EBP [15, 24, 32, 33, 47–49]. While the present study does not directly assess clinical outcomes, strengthening EBP competence during undergraduate education represents a foundational step toward improving evidence-informed practice.

Magnitude and distribution of learning gains

Our baseline data revealed a distinct *belief-implementation gap*, a phenomenon frequently reported in nursing literature [7, 8, 50, 51]. Initially, students demonstrated high 'Attitude' scores, indicating they already valued EBP as essential for practice, yet they exhibited moderate-to-low 'Skills' and 'Knowledge', revealing a lack of technical capability to actually execute the EBP process. The intervention narrowed this divide through a hierarchical gain across domains. The largest impact was observed in the 'Knowledge' domain ($d = 1.43$), suggesting that the Readiness Assurance Process (iRAT/tRAT) was associated with marked improvements in methodological knowledge, effectively deconstructing complex concepts. A substantial increasewas also observed in the 'Skills' domain ($d = 0.85$), suggesting that the team application phase effectively transitioned students from passive supporters of the EBP concept to practitioners possessing the foundational readiness required to integrate evidence into their future clinical decision-making [6]. The more moderate gain in the 'Attitude' domain ($d = 0.59$) reflects the challenge of shifting deeply held perceptions whitin a short-term intervention, but confirms that building knowledge and skills is the primary driver for aligning student beliefs with professional practice.

Supplementary regression analyses indicated that baseline competence explained only a small proportion of post-intervention variance. In the Knowledge and Skills domains, where substantial gains were observed, baseline scores did not significantly predict post-intervention performance ($R^2 = 0.01$ and 0.02, respectively). Only Attitude and the total score retained modest baseline dependency ($R^2 = 0.09$ and 0.07). This pattern suggests that improvements were not merely a function of initial positioning and is consistent with a partial redistribution of competence levels following the intervention.

Individual responsiveness and the equity-lever effect

A key strength of this study is the application of the RCI, which allowed us to identify individually meaningful changes beyond simple group-level mean shifts [38, 52]. This method is particularly valuable when interpreting the *catch-up effect* observed in our exploratory analyses, where students starting with lower baseline competence achieved the most substantial gains. While such inverse correlations are common in educational research and can be vulnerable to regression to the mean [53, 54], our RCI data indicate that these improvements exceeded the instrument's measurement error and are unlikely to be attributable to statistical artefacts alone [38, 55]. Nearly 60% (58.6%) of students achieved a reliable improvement in total competence, and nearly 70% (68.1%) in the Knowledge domain. This suggests that the TBL model was associated with a narrowing of the competence gap within the cohort. The relative stability observed in the Attitude domain (61.3% no change) likely reflects the inherent difficulty of modifying deeply held professional values within a single module. However, when accounting for the ceiling effect, by excluding participants who entered the study at the scale's maximum, the proportion of students showing reliable improvement in Attitude rose from 34.5% to 38.0%. This subtle *equity leveller* effect suggests that while the instructional method maintained high baseline attitudes without risk of deterioration, it catalysed a meaningful shift in those who still possessed room for professional growth. Internal dynamics of the TBL sessions provided mechanistic support for this pattern. The observed inverse relationship between initial iRAT and team-based gains across all three sessions suggests that TBL facilitate speech-mediated knowledge redistribution [33]. From a social cognitive perspective, this environment supports learners within their *Zone of Proximal Development* [23] by enabling peer-regulation and shared accountability [56]. Heterogeneous teams allow academically weaker or less experienced students to benefit disproportionately from collective intelligence, effectively narrowing the competence gap. Consequently, these findings carry implications for nursing practice and patient safety. By ensuring a more uniform redistribution of learning gains, TBL prepares a workforce with a shared, high-quality foundation in evidence-based decision-making, reducing clinical variance and mitigating the risk of outdated practices.The steepest learning curves in the 'Skills' domain were not observed in absolute beginners, but in students with minimal prior training (<40 hours). Consistent with *Cognitive Load Theory* [57], absolute novices may experience cognitive overload during the rapid-fire argumentation of the tRAT, whereas students with minimal priming possess the rudimentary schemas required to integrate new, complex clinical reasoning from their peers [30]. This finding implies that TBL interventions for EBP might be preceded by a very brief *levelling* induction to ensure no student starts from absolute zero.

Contrary to expectations, having a prior university degree did not confer an advantage in learning EBP compared to holding only a high school diploma. This suggests that EBP represents a 'novel literacy' and a specific form of clinical reasoning that is distinct from general academic ability [58, 59]. When taught using structured, student-centred methodologies like TBL, EBP is equally accessible to all students, regardless of their academic history [32, 33]. EBP competence is therefore predicted more by the quality of the instructional strategy than by pre-existing academic hierarchies [28, 60].

From an organisational perspective, this study addresses the critical challenge of faculty shortages and large cohorts. We successfully delivered high-intensity training to ≈130 students with a single expert facilitator, a model more resource-efficient than other active learning strategies, such as Problem-Based Learning [61–63]. Moreover, our strategic use of a 17-day interval between sessions may have acted as a catalyst for 'spaced learning'. Cognitive psychology literature robustly demonstrates that increasing the inter-study interval enhances long-term retention and the ability to retrieve complex information [64, 65]. In the context of EBP, these intervals may have allowed for a 'cognitive maturation' period. During these gaps, students potentially encountered real-world clinical scenarios in their hospital placements, facilitating a 'contextual interference' effect that consolidates learning more effectively than massed practice [66, 67].

Theoretical and contextual considerations

In the specific socio-cultural context of Italian nursing education, high *power distance* remains prevalent [68, 69]. Historically, nurse-physician hierarchies have relegated nurses to subordinate roles [70, 71]. Such a paradigm is no longer compatible with the contemporary framework of autonomous professional responsibility. TBL facilitates a *cultural de-hierarchisation* by mandating intra-team consensus and inter-team debate. This strategy encourages students to develop a professional 'voice' and the confidence to challenge peer and instructor opinions through evidence-based appeals. Consequently, the transition from passive recipient to active negotiator equips students with the assertiveness required to advocate for evidence-based decisions within multidisciplinary teams [72–74].

Implications for EBP curriculum design

Our findings suggest three considerations for the design of undergraduate EBP curricula. First, baseline assessment is essential. Mapping multidimensional competence prior to instruction allows educators to identify belief-implementation gaps, anticipate ceiling effects, and calibrate scaffolding strategies. Second, educational evaluation should extend beyond mean score differences. Reporting individual-level responsiveness, such as RCI metrics, provides a more precise understanding of whether observed gains exceed measurement error and how learning trajectories vary within the group. Third, structured active learning architectures may contribute to a compensatory pattern of competence development within heterogeneous cohorts. While causal inferences cannot be established, the observed distribution of gains suggests that collaborative scaffolding may support learners with lower baseline preparation, narrowing intra-cohort disparities. Collectively, these considerations support a shift from evaluating EBP teaching solely in terms of average score increases toward examining how, and for whom, competence development occurs.

Limitations

The generalizability of these findings is influenced by several factors. The study was conducted at a single public university in Northern Italy, which may reflect specific regional educational standards. Although the study had a 9.2% attrition rate, our attrition analysis showed no significant differences between retained and lost participants, suggesting that missing data occurred at random and did not introduce systematic selection bias.

Despite the significant gains observed, several limitations of this study warrant consideration. First, the quasi-experimental design, lacking a concurrent control group, limits causal interpretation and does not allow for conclusions regarding the superiority of TBL over other traditional instructional methods, despite such comparisons being suggested in previous studies [32, 33, 75, 76]. The absence of a delayed post-test means we cannot determine the long-term retention of the observed gains or their transfer to clinical practice. The immediate post-test design was appropriate for examining short-term patterns of change, but future research should incorporate longitudinal follow-up to establish whether these improvements are sustained over time and translate into clinical behaviour change. Furthermore, while the EBP-COQ is a robustly validated instrument, its reliance on self-reporting inevitably captures students' perceived self-efficacy and competence rather than objectively measured clinical behaviour [77]; students might overestimate their proficiency following an engaging pedagogical approach such as TBL. However, from a social cognitive perspective, Bandura argues that perceived self-efficacy is a fundamental prerequisite for the actual translation of knowledge into clinical behaviour [56, 78]. Consequently, while subjective, these perceptions represent a critical psychological proxy for the future implementation of evidence-based practice in clinical settings. From a statistical perspective, although minor distributional nuances were identified via the Shapiro-Wilk test in specific subscales, the overarching alignment between our primary parametric findings and the non-parametric sensitivity checks ($p < 0.001$) ensures the analytical integrity of the results. This consistency, bolstered by a substantial sample size ($N = 119$), reinforces the validity of our approach and confirms that the reported effect sizes (Cohen's d) reflect a genuine and substantial shift in student proficiency rather than mere artifacts of data distribution.

Future research should employ longitudinal designs to assess long-term retention and the actual transfer of these competencies into postgraduate practice.

Conclusion

By integrating group-level analysis with rigorous individual-level psychometric indicators, this study provides dual-level evidence that a structured TBL intervention produces EBP competence gains that are both statistically significant and reliably measurable among undergraduate nursing students. By employing the RCI, we demonstrated that these improvements extend beyond aggregate group-level effects and constitute clinically and educationally meaningful individual gains that exceed measurement error, particularly in the domains of Knowledge and Skills. From a pedagogical standpoint, the observed effectiveness of TBL is consistent with social constructivist theories of learning: through peer collaboration and systematically designed scaffolding, TBL operationalizes the concept of the *Zone of Proximal Development* to narrow competence gaps and function as both an academic and social equalizer. As a scalable, resource-efficient, and equity-oriented instructional strategy, TBL represents a sustainable approach to mitigating the theory-practice gap in large undergraduate nursing programs and cultivating a workforce equipped to deliver high-quality, evidence-based care in increasingly complex clinical environments.

Abbreviations

ANOVA	Analysis of Variance
CEAR	University Ethics Committee for Research (Comitato Etico per la Ricerca)
CI	Confidence Interval
EBP	Evidence-Based Practice
EBP-COQ	Evidence-Based Practice Competence Questionnaire
EFN	European Federation of Nurses Associations
IF-AT	Immediate Feedback Assessment Technique
iRAT	Individual Readiness Assurance Test
LBL	Lecture-Based Learning
MDC_{95}	95% Minimal Detectable Change
PICO	Population, Intervention, Comparison, Outcome
RCI	Reliable Change Index
SD	Standard Deviation
S_{diff}	Standard Error of Difference
SEM	Standard Error of Measurement
TBL	Team-Based Learning
tRAT	Team Readiness Assurance Test
TREND	Transparent Reporting of Evaluations with Nonrandomized Designs
ZPD	Zone of Proximal Development

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

Supplementary Material 4

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Conceptualization, P.F. and T.P.; methodology, P.F. and T.P.; software, P.F. and A.C.; formal analysis, P.F. and A.C.; investigation, P.F., S.R. and T.P.; data curation, P.F. and T.P.; writing—original draft preparation, P.F., T.P. and A.C.; writing—review and editing, P.F., T.P., S.R. and A.C.; supervision, P.F.; project administration, T.P. All authors read and approved the final manuscript.

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Data availability
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The study was conducted in accordance with the Declaration of Helsinki and approved by the University Ethics Committee for Research (CEAR) of the University of Modena and Reggio Emilia (reference number 0298750, protocol 2024-UNMRCLE-0062686). Informed consent was obtained from all subjects involved in the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]Department of Biomedical, Metabolic and Neural Sciences, University of Modena and Reggio Emilia, 2nd Floor, Via Campi 287, 41125 Modena, Italy

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References

1. Nandiwada DR, Kormos W. Interprofessional Evidence-Based Practice Competencies. Jama Netw Open. 2018;1:e180282.
2. Govaerts M, Vleuten Cvd, Schut S. Implementation of Programmatic Assessment: Challenges and Lessons Learned. Educ Sci. 2022;12:717.
3. Albarqouni L, Hoffmann T, Straus S, et al. Core Competencies in Evidence-Based Practice for Health Professionals: Consensus Statement Based on a Systematic Review and Delphi Survey. JAMA Netw Open. 2018;1:e180281.
4. Sackett DL, Rosenberg WM, Gray JA, Haynes RB, Richardson WS. Evidence based medicine: what it is and what it isn't. BMJ. 1996;312:71–2.
5. Eekholm S, Samuelson K, Ahlström G, Lindhardt T. Tailored multifaceted strategy for implementing fundamental evidence-based nursing care: an evaluation study. Nurs Rep. 2024;4070–90.
6. Dolezel J, Zelenikova R, Finotto S, et al. Core Evidence-Based Practice Competencies and Learning Outcomes for European Nurses: Consensus Statements. Worldviews Evid Based Nurs. 2021;18:226–33.
7. Melnyk BM, Gallagher-Ford L, Zellefrow C, et al. The First U.S. Study on Nurses' Evidence-Based Practice Competencies Indicates Major Deficits That Threaten Healthcare Quality, Safety, and Patient Outcomes. Worldviews Evid Based Nurs. 2018;15:16–25.
8. Saunders H, Gallagher-Ford L, Kvist T, Vehviläinen-Julkunen K. Practicing Healthcare Professionals' Evidence-Based Practice Competencies: An Overview of Systematic Reviews. Worldviews Evid Based Nurs. 2019;16:176–85.
9. Ramis MA, Chang A, Conway A, Lim D, Munday J, Nissen L. Theory-based strategies for teaching evidence-based practice to undergraduate health students: a systematic review. BMC Med Educ. 2019;19:267.
10. Kistler KB, Tyndall DE, Peery A. Bottlenecks to learning evidence-based practice: recommendations for nursing faculty. Nurse Educ. 2024;49.
11. Howard B, Diug B, Ilic D. Methods of teaching evidence-based practice: a systematic review. BMC Med Educ. 2022;22:742.
12. Antão C, Santos B, Santos N, et al. Nursing Degree Curriculum: Differences and Similarities Between 15 European Countries. Nurs Rep. 2025;15:112.
13. Skela-Savič B, Gotlib J, Panczyk M, et al. Teaching evidence-based practice (EBP) in nursing curricula in six European countries-A descriptive study. Nurse Educ Today. 2020;94:104561.
14. Lehane E, Leahy-Warren P, O'Riordan C, et al. Evidence-based practice education for healthcare professions: an expert view. BMJ Evidence-Based Med. 2019;24:103–8.
15. Patelarou AE, Mechili EA, Ruzafa-Martinez M, et al. Educational interventions for teaching evidence-based practice to undergraduate nursing students: a scoping review. Int J Environ Res Public Health. 2020;17.
16. Redmond C, Farrell R, Cunningham C, et al. Development of the EVIBEC Learning Outcomes Framework to support the delivery of evidence-based practice curricula in health care professional programmes: a codesign approach. BMC Med Educ. 2024;24:3.
17. Tilson JK, Kaplan SL, Harris JL, et al. Sicily statement on classification and development of evidence-based practice learning assessment tools. BMC Med Educ. 2011;11:78.
18. Nwachukwu EL, Nwamaka Goodness Egbue N, Ijeoma Victor-Nwakaku N. Adaptive Learning Systems: Bridging Instructional Technology and Personalized Pedagogy Through Design Thinking. J Digit Learn Distance Educ. 2025;4:1689–703.
19. Hu WL, Hong Y, Wang H, et al. Assessing evidence-based practice competencies of undergraduate nursing students using a developed multi-criteria decision-analysis model. Nurse Educ Pract. 2024;76:103919.
20. Fu KA, Chan JM, Stepanyan K, et al. Education Research: A Mixed-Methods Analysis of Journal Club Formats to Enhance Evidence-Based Practice Through Social Cognitive Learning Theory. Neurol Educ. 2025;4:e200195.
21. Islam KF, Awal A, Mazumder H, et al. Social cognitive theory-based health promotion in primary care practice: A scoping review. Heliyon. 2023;9:e14889.
22. Choi YR, Lee YN, Kwon DY, Kim D, Park WH, Chang SO. The development and effects of a social constructivist approach in an interprofessional discomfort care online education program. BMC Med Educ. 2024;24:1363.
23. Vygotsky LS, Cole M. Mind in society: development of higher psychological processes. Harvard University Press; 1978.
24. Gao X, Yan D, Zhang Y, et al. Comparison of the impact of team-based learning and lecture-based learning on nursing students' core competencies: A systematic review and meta-analysis. Nurse Educ Pract. 2024;76:103945.
25. Lehane E, Leahy-Warren P, O'Riordan C, et al. Evidence-based practice education for healthcare professions: an expert view. BMJ Evid Based Med. 2019;24:103–8.
26. Haider M, Yasmin A. Significance of Scaffolding and Peer Tutoring in the Light of Vygotsky's Theory of Zone of Proximal Development. Int J Lang Literature Linguistics. 2015;1:170–3.
27. Philpott J, Batty H. Learning best together: social constructivism and global partnerships in medical education. Med Educ. 2009;43:923–4.
28. Theobald EJ, Hill MJ, Tran E, et al. Active learning narrows achievement gaps for underrepresented students in undergraduate science, technology, engineering, and math. Proc Natl Acad Sci U S A. 2020;117:6476–83.
29. Considine J, Berry D, Allen J, et al. Team-based learning in nursing education: A scoping review. J Clin Nurs. 2021;30:903–17.
30. Parmelee D, Michaelsen LK, Cook S, Hudes PD. Team-based learning: a practical guide: AMEE guide 65. Med Teach. 2012;34:e275–287.
31. Burgess A, van Diggele C, Roberts C, Mellis C. Team-based learning: design, facilitation and participation. BMC Med Educ. 2020;20:461.
32. Alberti S, Motta P, Ferri P, Bonetti L. The effectiveness of team-based learning in nursing education: A systematic review. Nurse Educ Today. 2021;97:104721.
33. Alizadeh M, Masoomi R, Mafinejad MK, Parmelee D, Khalaf RJ, Norouzi A. Team-based learning in health professions education: an umbrella review. BMC Med Educ. 2024;24:1131.

34. Xiaoyan W, Lifeng Y, Jing J. Effects of TBL teaching on nursing students' knowledge, practical skills and core ability: A systematic review and meta-analysis. Nurse Educ Pract. 2024;80:104125.
35. Tatterton MJ, Fisher MJ. Team-based learning and nurse education: a systematic review. Evid Based Nurs. 2022.
36. Zhang Q, Tang X, Zhao Y, Wang Z. Team-based learning vs. lecture-based learning in nursing: a systematic review of randomized controlled trials. Front Public Health. 2023;10.
37. Bertoni G, Deretti L, Negri A, et al. Evidence-based practice among italian physiotherapists: a national cross- sectional survey on competencies and contextual determinants; 2025.
38. Jacobson NS, Truax P. Clinical significance: a statistical approach to defining meaningful change in psychotherapy research. J Consult Clin Psychol. 1991;59:12–9.
39. Des Jarlais DC, Lyles C, Crepaz N. Improving the reporting quality of nonrandomized evaluations of behavioral and public health interventions: the TREND statement. Am J Public Health. 2004;94:361–6.
40. Finotto S, Garofalo E. Italian Validation of Evidence Based Practice Evaluation Competence Questionnaire (EBP-COQ). Prof Inferm. 2020;73:98–105.
41. Ruzafa-Martinez M, Lopez-Iborra L, Moreno-Casbas T, Madrigal M. Development and validation of the competence in evidence based practice questionnaire (EBP-COQ) among nursing students. BMC Med Educ. 2013;13:19.
42. Jafari F, Azadi H, Abdi A, Salari N, Faraji A. Cultural validation of the competence in evidence-based practice questionnaire (EBP-COQ) for nursing students. J Educ Health Promotion. 2021;10.
43. Ivziku D, Giannetta N, D'Angelo D, et al. Italian EBP beliefs scales: a psychometric validation study. Worldviews Evidence-Based Nurs. 2025;22.
44. Brown ST, Kirkpatrick MK, Mangum D, Avery J. A Review of Narrative Pedagogy Strategies to Transform Traditional Nursing Education. J Nurs Educ. 2008;47:283–6.
45. Norman G. Likert scales, levels of measurement and the laws of statistics. Adv Health Sci Educ Theory Pract. 2010;15:625–32.
46. Sullivan GM, Artino AR Jr. Analyzing and interpreting data from likert-type scales. J Grad Med Educ. 2013;5:541–2.
47. Lombardi D, Shipley TF, Astronomy Team BT, Chemistry Team E, Team G, Team. Geoscience Team, Team P. The curious construct of active learning. Psychol Sci Public Interest. 2021;22:8–43.
48. Martinez ME, Gomez V. Active learning strategies: a mini review of evidence-based approaches. Acta Pedagogia Asiana. 2025;4:43–54.
49. Park I, Suh Y. Meta-analysis of flipped learning effects in nursing education. Int J Environ Res Public Health. 2021;18.
50. Saunders H, Vehviläinen-Julkunen K, Stevens KR. Effectiveness of an education intervention to strengthen nurses' readiness for evidence-based practice: A single-blind randomized controlled study. Appl Nurs Res. 2016;31:175–85.
51. Mehra M, Raj CB, Sharma R, Singh A, Tiwari SK. Factors associated with beliefs and implementation of evidence-based practice among nurses: a cross-sectional study. BMC Nurs. 2025;24:929.
52. Evans C, Margison F, Barkham M. The contribution of reliable and clinically significant change methods to evidence-based mental health. Evid Based Mental Health. 1998;1:70–2.
53. Tu Y-K, Gilthorpe MS. Revisiting the relation between change and initial value: a review and evaluation. Stat Med. 2007;26:443–57.
54. Bland JM, Altman DG. Regression towards the mean. BMJ. 1994;308:1499.
55. Zahra D, Hedge C. The Reliable Change Index: Why isn't it more popular in academic psychology? Psychol Postgrad Affairs Group Q. 2010;76:14–9.
56. Bandura A. Self-efficacy in changing societies. Cambridge: Cambridge University Press; 1997.
57. Sweller J. CHAPTER TWO - Cognitive load theory. In: Mestre JP, Ross BH, eds. Psychology of Learning and Motivation. Academic Press, 2011; 37–76.
58. Fiset VJ, Graham ID, Davies BL. Evidence-Based Practice in Clinical Nursing Education: A Scoping Review. J Nurs Educ. 2017;56:534–41.
59. Leiviska E, Pezaro S, Kneafsey R, Morini L, DeWinter A. Teaching and interconnecting research and evidence-based practice in midwifery and nursing education: A mixed methods systematic review. Nurse Educ Today. 2025;150:106701.
60. Banks L, Kay R. Exploring flipped classrooms in undergraduate nursing and health science: A systematic review. Nurse Educ Pract. 2022;64:103417.
61. Barrows HS. The tutorial process. (No Title). 1992.
62. Dolmans DH, De Grave W, Wolfhagen IH, van der Vleuten CP. Problem-based learning: future challenges for educational practice and research. Med Educ. 2005;39:732–41.
63. Barrows H. The tutorial process (Rev. ed). Springfield: Southern Illinois University School of Medicine. 1988.
64. Cepeda NJ, Pashler H, Vul E, Wixted JT, Rohrer D. Distributed practice in verbal recall tasks: A review and quantitative synthesis. Psychol Bull. 2006;132:354–80.
65. Kang S. Spaced repetition promotes efficient and effective learning: policy implications for instruction. Policy Insights Behav Brain Sci. 2016;3.
66. Toppino TC, Gerbier E. About practice: Repetition, spacing, and abstraction. Psychol Learn motivation. 2014;60:113–89.
67. Versteeg M, Hendriks RA, Thomas A, Ommering BWC, Steendijk P. Conceptualising spaced learning in health professions education: A scoping review. Med Educ. 2020;54:205–16.
68. Hofstede G. Dimensionalizing cultures: the hofstede model in context. Int J Behav Med. 2007;2.
69. Ouyang S, Zhang W, Xue L, Rashid AM, Pyng HS, Hassan AB. The Cultural Compass: A Systematic Review on Cultural Dimensions Theory in Educational Settings. Sage Open. 2025;15:21582440251342160.
70. Yang J, Huang J, Han M, Qi H, Xu M, Leadership, Roles. Care Models, and Effectiveness of Advanced Practice Nurse-Led Multidisciplinary Teams: A Scoping Review. Int Nurs Rev. 2025;72:e70079.
71. Dechairo-Marino AE, Jordan-Marsh M, Traiger G, Saulo M. Nurse/physician collaboration: action research and the lessons learned. J Nurs Adm. 2001;31:223–32.
72. Palese A, Gonella S, Grassetti L, et al. Multilevel National Analysis of Nursing Students' Perceived Opportunity to Access Evidence-Based Tools During Their Clinical Learning Experience. Worldviews Evid Based Nurs. 2018;15:480–90.
73. Ndoro S. Effective multidisciplinary working: the key to high-quality care. Br J Nurs. 2014;23:724–7.
74. Ominyi J, Alabi A. Promoting evidence-based nursing through collaboration, autonomy, and agency: a qualitative case study. Int J Nurs Sci. 2025.
75. Smith N. Evidence-based practice in medical education: team-based learning in a blended curriculum. 2024.
76. Kim JS, Gu MO, Chang HK. Effects of an evidence-based practice education program using multifaceted interventions: a quasi-experimental study with undergraduate nursing students. BMC Med Educ. 2019;19.
77. Hagedorn Wonder A, McNelis AM, Spurlock D Jr., et al. Comparison of Nurses' Self-Reported and Objectively Measured Evidence-Based Practice Knowledge. J Contin Educ Nurs. 2017;48:65–70.
78. Bandura A. Self-efficacy: toward a unifying theory of behavioral change. Psychol Rev. 1977;84:191–215.

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