

International Journal of Mobile Learning and Organisation

ISSN online: 1746-7268 - ISSN print: 1746-725X

<https://www.inderscience.com/ijmlo>

Scaffolding GenAI-assisted peer feedback provision through metacognitive activities in nursing clinical training

Shuling Wei, Wei Wei, Gwo-Jen Hwang

DOI: [10.1504/IJMLO.2026.10081240](https://doi.org/10.1504/IJMLO.2026.10081240)

Article History:

Received:	12 January 2026
Last revised:	02 June 2026
Accepted:	18 June 2026
Published online:	28 September 2026

Scaffolding GenAI-assisted peer feedback provision through metacognitive activities in nursing clinical training

Shuling Wei

Faculty of Applied Sciences,
Macao Polytechnic University,
Room P325, Pearl Jubilee Building, Taipa,
Macao Special Administrative Region, 999078, China
Email: p2314941@mpu.edu.mo
and

Center for Research Management and Services,
Guangxi Open University,
No. 1-1, Dongbao Rd., Qingxiu Dist., Nanning 530022,
Guangxi Zhuang Autonomous Region, China

Wei Wei*

Faculty of Applied Sciences,
Macao Polytechnic University,
Room P325, Pearl Jubilee Building, Taipa,
Macao Special Administrative Region 999078, China
Email: weiweitesting@hotmail.com

*Corresponding author

Gwo-Jen Hwang

Graduate Institute of Educational Information and Measurement,
National Taichung University of Education,
No. 140, Minsheng Rd., West Dist.,
Taichung City 40306, Taiwan, ROC
and

Graduate Institute of Digital Learning and Education,
National Taiwan University of Science and Technology,
No. 43, Keelung Rd., Sec. 4, Da'an Dist.,
Taipei City 106335, Taiwan, ROC
and

College of Management,
Yuan Ze University,
No. 135, Yuandong Rd., Zhongli Dist.,
Taoyuan City 320315, Taiwan, ROC
Email: gjhwang.academic@gmail.com

Abstract: Effective peer feedback is fundamental to nursing students' clinical training, yet its provision is often constrained by peer expertise and feedback training. Generative artificial intelligence (GenAI) can support peer feedback by offering timely guidance, but concerns remain about how it shapes students' learning processes. This study examined whether metacognitive scaffolding could improve nursing students' use of metacognitive strategies during GenAI-assisted peer feedback. A three-week quasi-experimental study involved 66 undergraduate nursing students assigned to a scaffolding group or a non-scaffolding group. Learning process data were collected from Moodle logs, behavioural traces, and interviews. Overall feedback quality did not differ between groups. However, the experimental group showed more metacognitive activities, with a significantly higher level of monitoring. These findings highlight the role of metacognitive scaffolding in shaping learning processes in GenAI-assisted peer feedback.

Keywords: generative artificial intelligence; GenAI; metacognition; epistemic network analysis; ENA; peer feedback; scaffolding.

Reference to this paper should be made as follows: Wei, S., Wei, W. and Hwang, G-J. (2026) 'Scaffolding GenAI-assisted peer feedback provision through metacognitive activities in nursing clinical training', *Int. J. Mobile Learning and Organisation*, Vol. 20, No. 7, pp.1–24.

Biographical notes: Shuling Wei is an Associate Research Fellow at the Center for Research Management and Services, Guangxi Open University, and concurrently a PhD candidate at the Faculty of Applied Sciences, Macao Polytechnic University. His main research areas include artificial intelligence in education, and technology-enhanced learning.

Wei Wei is an Associate Professor at Faculty of Applied Sciences, Macao Polytechnic University, Macao. He obtained his PhD from School of Education, University of Leeds, UK. His areas of research are learning oriented assessment, language assessment, and computer assisted teaching and learning.

Gwo-Jen Hwang is a Chair Professor at the Graduate Institute of Educational Information and Measurement, National Taichung University of Education, and Chair Professor at the Graduate Institute of Digital Learning and Education, National Taiwan University of Science and Technology, Taiwan. He is also the Emeritus Chair Professor of Yuan Ze University, Taiwan. His research interests include mobile learning, digital game-based learning, flipped classrooms, and artificial intelligence in education.

1 Introduction

Effective feedback is crucial for enhancing nursing students' learning gains in clinical settings (Carless and Boud, 2018; Clynes and Raftery, 2008; Hattie and Timperley, 2007). However, due to large class sizes and demanding clinical learning requirements, providing timely and high-quality teacher feedback to each student has become increasingly challenging, hindering the professional development of future nurses (Er et al., 2021; Wong and Shorey, 2022; Yoong et al., 2023). As a result, peer feedback is increasingly viewed as a viable alternative to teacher feedback (Valero Haro et al., 2023). It can enhance learning performance, self-regulation, and metacognition by

stimulating deep learning processes such as comparison, evaluation, reflection, and higher-order thinking (Lerchenfeldt et al., 2019; Noroozi et al., 2023; Yu and Schunn, 2023). Evidence also suggests that giving feedback may be more beneficial than receiving it, as it enhances students' self-efficacy and ability to revise future work (Lee and Evans, 2019). Nevertheless, the quality of peer feedback is still limited by peers' professional knowledge and feedback training levels (Alfehaid et al., 2018; Loda et al., 2020; Valero Haro et al., 2023). Additionally, students tend to seek high-quality, practical, detailed, and personalised feedback (Dawson et al., 2019; Valero Haro et al., 2023), but in practice, peers often struggle to provide such support (Nelson and Schunn, 2009; Noroozi et al., 2016). Therefore, it is necessary to utilise instructional scaffolding to provide structured support for the peer feedback process, helping students clarify objectives, apply evaluation criteria, and engage in deep reflection (Alemdag and Yildirim, 2022; Loda et al., 2020).

Although faculty, peer, and self-generated feedback each have limitations, GenAI offers unique advantages as an innovative feedback source (Banihashem et al., 2024; Järvelä et al., 2023; Molenaar, 2022; Wan and Chen, 2024). Recent studies have demonstrated the potential of generative AI to support competency development and clinical learning in nursing education (Chang et al., 2024b; Chang et al., 2022; Han et al., 2022; Mollick and Mollick, 2023). For example, Chang and Su (2025) found that GenAI-supported instructional strategies could enhance students' competency development and learning engagement in nursing-related tasks. In addition, Chang et al. (2024a) showed that generative AI-based learning approaches can facilitate self-directed learning, reflective thinking, and empathy development in long-term care education. Accordingly, we conceptualise GenAI-assisted peer feedback as a dynamic process in which students enhance the provision of feedback by comparing and integrating their own understanding or performance with reference information generated by GenAI chatbots (Banihashem et al., 2025; Hattie and Timperley, 2007; Nicol, 2021). Previous empirical evidence indicates that GenAI-assisted peer feedback can improve feedback quality (Darvishi et al., 2024; Escalante et al., 2023; Guo et al., 2024b; Steiss et al., 2024). Recent reviews have shown that generative AI is increasingly used to support personalised learning, feedback generation, and collaborative knowledge construction across educational settings (Tu and Lu, 2025). Despite these benefits, the deployment of GenAI introduces pedagogical and ethical concerns, including information bias, misinformation, academic plagiarism, and overreliance on technology (Barrot, 2023; Kasneci et al., 2023). A randomised experiment employing frequency analysis and process mining found that when learners depend heavily on GenAI for task completion, their metacognitive monitoring and evaluation behaviours decline significantly, illustrating the phenomenon of 'metacognitive laziness' in hybrid intelligence environments (Fan et al., 2024). Scholars have warned that this laziness may evolve into dependence on AI, leading learners to outsource metacognitive activities such as planning, monitoring, and evaluating to GenAI, which may undermine their higher-order thinking abilities (Fan et al., 2024; Zhai et al., 2024). Therefore, nursing students using GenAI should emphasise metacognitive strategies rather than depend solely on the convenience of GenAI-assisted problem solving (Hwang et al., 2026; Urban et al., 2024). This underscores the urgent need to implement metacognitive strategies that enable students to critically evaluate GenAI generated suggestions, engage in reflective reasoning, and minimise potential risks (Yao et al., 2025). Prior studies have demonstrated that the use of metacognitive strategies in nursing education not only

enhances learning gains and self-regulated learning abilities (August-Brady, 2005) but also enables the tracing of nursing students' cognitive processes to identify misconceptions and knowledge gaps (Church and Carroll, 2023). Metacognitive strategies involve nursing students deliberate regulation of their own cognitive activities, encompassing three interrelated dimensions: planning, monitoring, and evaluating (Flavell, 1979; Ku and Ho, 2010).

Within peer feedback practices, metacognitive strategies not only improve the quality of feedback but also foster more structured thinking when students' judge, compare, and reflect on peers' work (Molenaar et al., 2010). Nursing students with advanced metacognitive skills exhibit more sophisticated reasoning patterns in clinical contexts and manage complex patient scenarios more effectively (Zeb et al., 2020). However, there remains a lack of research systematically integrating metacognitive strategies into peer feedback practice, limiting educators' insights into how students employ each sub-dimension of these strategies to shape their clinical reasoning (Church and Carroll, 2023). (Allison et al., 2025) further argued that educational computing research should pay greater attention to how learners critically interact with AI-generated content rather than passively accepting machine-generated outputs. Designing and providing metacognitive scaffolding can maximise the learning gains for feedback providers within this practice (Gatrell et al., 2025). Research indicates that metacognitive scaffolding significantly enhances students' higher-order thinking and efficiency in problem-solving contexts (Shin et al., 2023; Wang et al., 2023; Zheng et al., 2023). However, learners' adoption of metacognitive scaffolding is constrained by instructional design and accessibility: students tend to favour familiar scaffold types and overlook their pedagogical value (Zheng et al., 2023). Prior studies have identified planning, monitoring, and evaluating as the most critical metacognitive activities during learning (Ku and Ho, 2010), and emphasise that providing targeted support during these phases promotes metacognitive skill development (Shin et al., 2023). At the same time, the learning environment itself-through exemplars, textbooks, peer work, instructor comments, and rubrics can serve as scaffolding or comparator that support the generation and delivery of GenAI-assisted peer feedback (Banihashem et al., 2025; Lipnevich et al., 2014; Vandermeulen et al., 2023). Accordingly, the metacognitive scaffolding designed for this study aims to guide nursing students along the three dimensions of planning, monitoring, and evaluating within the GenAI-assisted peer feedback giving (Shin et al., 2023):

- 1 clarifying the objectives of feedback and maintaining focus
- 2 making strategies required to achieve these objectives
- 3 engaging in self-monitoring and self-evaluation throughout task execution
- 4 reflecting on feedback effectiveness by concentrating on controllable factors to foster the implementation of metacognitive strategies.

To clarify how metacognitive scaffolding influences nursing students' feedback giving, this study employs epistemic network analysis (ENA) to compare the internal structure, temporal co-occurrence patterns, and between-condition differences of students' epistemic networks under scaffolding and non-scaffolding conditions, with the aim of generating evidence-based recommendations to improve feedback quality in nursing education. The study addressed the following research questions:

RQ1 To what extent do metacognitive scaffolding contribute to better feedback quality and greater use of metacognitive strategies with GenAI-assisted peer feedback giving?

RQ2 If yes, why?

2 Method

2.1 Study design and context

This study implemented peer feedback giving tasks supported by metacognitive scaffolding. The scaffolding was designed to guide nursing students in applying metacognitive strategies – planning, monitoring, and evaluating-when providing feedback to peers within a GenAI-assisted learning environment. To examine the effectiveness of this approach, a quasi-experimental study was conducted in nursing clinical training. The study analysed how nursing students employed metacognitive strategies during the GenAI-assisted peer feedback giving tasks.

The study sample included 66 undergraduate nursing students from a large public open university in southern China (see Table 1). Participants were assigned to either an experimental group ($n = 32$) or a control group ($n = 34$). Both groups were taught by the same instructor, who had over ten years of experience in digital nursing education. Eligibility criteria included:

- 1 sufficient nursing knowledge relevant to the study context
- 2 successful completion of the Fundamentals of Nursing course with credit
- 3 demonstrated ability and willingness to participate peer feedback giving tasks.

The participants' ages ranged from 21 to 24 years ($M = 22.30$, $SD = 0.841$). All students reported prior experience with digital learning and peer feedback, though their use of GenAI tools such as chatbots for learning purposes was relatively limited. Notably, no statistically significant differences were identified between the two groups in terms of age, gender, peer feedback experience, or prior GenAI use.

2.2 Clinical case description

The clinical case focused on a 68-year-old female patient presenting with acute heart failure symptoms (see Figure 1). Students were required to identify two key aspects:

- 1 whether the peer's work provided a comprehensive account of both objective data, (e.g., vital signs, laboratory results) and subjective data (e.g., patient-reported symptoms and experiences)
- 2 whether abnormal data were accurately identified and appropriately analysed in relation to the patient's medical history.

They were tasked with completing peer feedback activities within a learning management system (Moodle), which provides access to instructor exemplars, rubric, peer work, and textbooks (Banihashem et al., 2025; Camarata and Slieman, 2020; Lipnevich et al., 2014; Vandermeulen et al., 2023), and prompts students to selectively draw on these resources

as needed. This case was selected because it aligns with nursing competencies and supports the development of clinical reasoning skills.

Table 1 Demographic information of participants in the study ($n = 66$)

Variable	Mean $\pm$ SD/frequency (%)	
	Experimental group ($n = 32$)	Control group ($n = 34$)
Age (years)	21.94 (± 0.669)	22.65 (± 0.849)
Gender		
Female	26(81.2%)	26(76.5%)
Male	6(18.8%)	8(23.5%)
Peer feedback experience		
Never	12.50%	17.6%
Rarely	50%	47.1%
Sometimes	18.8%	23.5%
Often	6.2%	5.9%
Always	12.50%	5.9%
Prior GenAI use frequency		
Never	12.50%	5.9%
Rarely	12.50%	23.5%
Sometimes	31.3%	41.2%
Often	31.3%	23.5%
Always	12.50%	5.9%

Figure 1 Example of GenAI-assisted peer feedback provided after clinical reasoning training in the LMS (screenshot of the Moodle) (see online version for colours)



2.3 GenAI-assisted peer feedback giving task

Following the case analysis, nursing students completed GenAI-assisted peer feedback giving task structured around metacognitive strategies (see Figure 2). The task aimed to enhance students' nursing plans and reasoning through peer feedback. The experimental

group completed the GenAI-assisted peer feedback giving task with metacognitive scaffolding, whereas the control group completed the same task without metacognitive scaffolding.

Figure 2 GenAI-assisted peer feedback giving task in the LMS (screenshot of the Moodle) (see online version for colours)



2.4 The metacognitive activities in Moodle

Metacognitive scaffolding was embedded in Moodle as multiple-choice forms (see Appendix A), with response options mapped to distinct dimensions of metacognitive strategies (Zheng et al., 2022). The multiple-choice format was adopted for its pedagogical and cognitive advantages:

- 1 it reduces cognitive load, allowing students to reflect without the pressure of writing open-ended answers
- 2 it provides structured guidance for using metacognitive strategies, helping students engage more purposefully in the feedback process
- 3 it enhances usability through its familiar format, making the task more accessible and engaging.

By selecting from options such as ‘completeness of objective data’ and ‘abnormal data analysis’, students were guided to identify two key aspects in the clinical case task. This process helped them clarify how to set appropriate goals within the peer feedback activity (see Figure 3).

2.5 Experimental procedure

This study adopted a three-week quasi-experimental design (see Figure 4). In week 1, the instructor introduced the goals of clinical reasoning training and the requirements of peer feedback. After a brief orientation on metacognitive strategies, Moodle operation, and GenAI-assisted feedback giving tasks, students practiced planning, monitoring, and evaluating during the clinical reasoning activity.

In week 2, students completed peer feedback tasks guided by metacognitive strategies (see Figure 5). During planning, they clarified task requirements and prepared feedback drafts with GenAI support (see Figure 6). In monitoring, they reviewed progress, aligned goals, and revised content and tone. In evaluating, they reflected on the process and

outcomes, considering how GenAI interactions influenced feedback quality. This activity lasted 120 minutes.

Figure 3 Example of metacognitive scaffolding in the LMS (screenshot of the Moodle) (see online version for colours)



Figure 4 Diagram of the experiment design (see online version for colours)

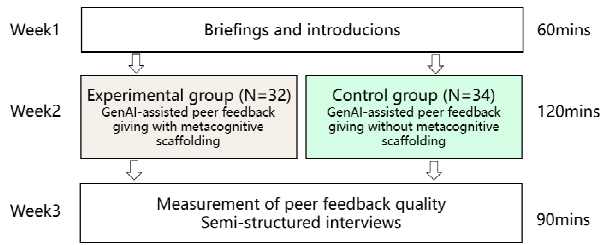
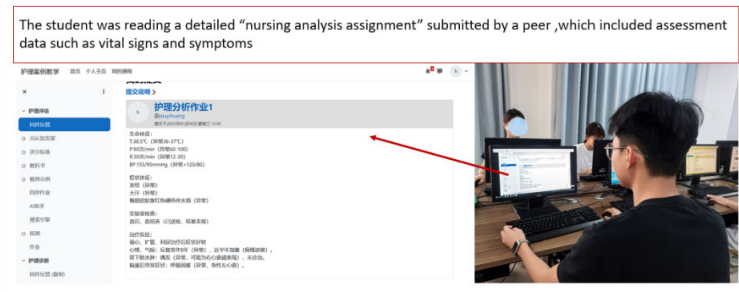
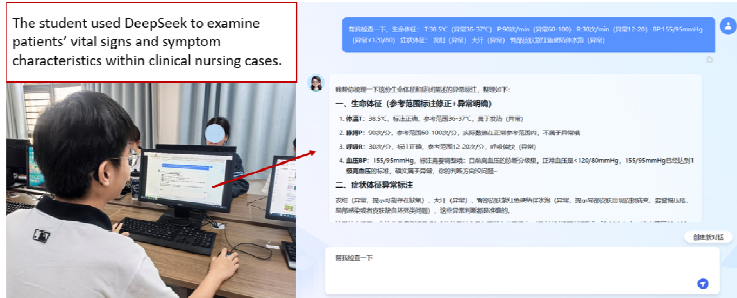


Figure 5 Screenshot of the student completed peer feedback task (see online version for colours)



In week 3, two nursing instructors independently rated the quality of peer feedback produced by both groups using the predetermined rubric. Additionally, a subset of 16 students drawn from both groups participated in semi-structured interviews to elaborate on their peer feedback experiences. These qualitative data served to complement and enrich the interpretation of quantitative results. This activity lasted 90 minutes.

Figure 6 Screenshot of student prepared feedback drafts with GenAI support (see online version for colours)



2.6 Data collection

To address the first research question, a coding scheme for evaluating students' peer feedback quality was developed, grounded in the Clinical Reasoning Rubric and informed by previous studies (Panadero and Lipnevich, 2022; Ramazanzadeh et al., 2023; Valero Haro et al., 2023). The feedback quality was characterised by three features: level of detail, comprehensibility, and tone (Lipnevich and Smith, 2022). Specifically, a score of 1 indicated no relevant feedback; 2 reflected feedback that was difficult to understand, lacked detail, or demonstrated an unprofessional tone; 3 indicated feedback that was clear and professional but lacked sufficient analytical depth; and 4 represented feedback that was detailed, easily comprehensible, professional in tone, and demonstrated rigor and attention to detail. The scores from these two variables were aggregated to represent the overall quality of peer feedback provided by each student.

Then, to address the second research question, this study employed a data triangulation approach, integrating multiple data sources to conduct a comprehensive and in-depth investigation of students' metacognitive strategy use during the peer feedback process. Specifically, the data sources comprised three layers:

- 1 Moodle logs: objective data were collected from the Moodle platform to record students' interaction patterns and time allocation.
- 2 Behavioural trace data: a combination of screen recording software (EV) and a keylogging tool (Spyrix Personal Monitor) was utilised to capture participants complete operational processes, keyboard inputs, and screen content.
- 3 Semi-structured interviews: grounded in the understanding that metacognitive strategies are typically held in working memory and can be effectively verbalised in the short-term (Fleiss et al., 2003), audio-recorded interviews were conducted to elicit students' metacognitive strategy use.

The coding scheme for analysing metacognitive strategies in GenAI-assisted peer feedback giving was developed in two stages. In first stage, established frameworks of metacognitive strategies (Bagga and McKee, 2024; Flavell, 1979; Ku and Ho, 2010) were examined and integrated into three core dimensions: planning, monitoring, and evaluating. These dimensions captured the metacognitive activities involved in feedback processes. In the second stage, two coders independently applied the scheme to pilot data,

and differences were discussed until agreement was reached. Moodle logs and behavioural trace data were organised in Microsoft Excel, highlighting reflective statements and observable actions related to metacognitive activities. Clear operational definitions and examples were provided to ensure coding consistency (see Table 2).

Table 2 Description and examples of the three dimensions and seven activities of metacognitive strategies

<i>Dimensions</i>	<i>Metacognitive activities</i>	<i>Description</i>
Planning	Setting goal (SG)	Clarifying task requirements and setting feedback goals.
	Making plan (MP)	Making plans about how to reach the goals, including selecting strategies and setting timelines.
	Executing strategy (ES)	Advancing and explaining feedback plans; coordinating conflicts.
Monitoring	Tracking (TK)	Tracking task progress and indicating comprehension status.
	Validating (VD)	Detecting errors and checking feedback coherence.
Evaluating	Review (RW)	Assessing the current solution and reflecting on feedback goals and progress.
	Revision (RN)	Adjusting feedback content, goals, plans, or strategies as needed.

Note: Detailed examples (including Moodle logs, behavioural trace data, and interview excerpts) for each activity are provided in Appendix B.

Subsequently, two experienced nursing lecturers independently coded all 1,676 data segments generated during the peer feedback giving tasks, using the coding scheme outlined in Table 2. Inter-rater reliability was calculated, yielding a Cohen’s kappa coefficient of 0.81, which exceeds the recommended threshold of 0.70 and indicates strong reliability (Fleiss et al., 2003). Following independent coding, the researchers reviewed the discrepancies, resolved conflicts through discussion, and reached consensus on all codes before proceeding with further analyses.

2.7 Data analysis

This study employed a Mann-Whitney *U* test to compare the experimental and control groups in terms of feedback quality. These two variables were selected because they represent key indicators of the effectiveness of peer feedback processes, particularly in contexts where GenAI may influence both the content and the depth of student interaction (Guo et al., 2024a).

A coding-and-counting method and descriptive statistical analysis was utilised to compare the distribution of metacognitive strategies between the experimental group and control group. ENA was applied to visualise structural relationships among three metacognitive dimensions (planning, monitoring, evaluating), capturing internal connections, temporal co-occurrence patterns, and group differences across seven codes.

Coded data segments were processed in the ENA Web Tool (<http://www.epistemicnetwork.org/>), treating activity codes as nodes and calculating co-occurrences within stanzas. A stanza size of four was set, meaning every four consecutive activities in Moodle logs and screen recordings constituted an analytical unit. ENA generated binary adjacency matrices per stanza (1 = co-occurrence, 0 = non-co-occurrence), aggregated into a global network where node connections reflected co-occurrence frequency (Shaffer et al., 2016). Dimension reduction retained two principal components (X-axis: maximum explained variance; Y-axis: second highest).

3 Result

The data presented in Table 3 indicate that Mann-Whitney U tests identified no significant difference emerged for the aggregated measure of overall feedback quality. Taken together, these results suggest that the metacognitive scaffolding aggregate feedback quality did not differ significantly between conditions in a short period of time.

Table 3 Differences in feedback quality by experimental group and control group

Variable	Groups	N	Mean rank	Sum of ranks	U	Wilcoxon W	Z value
Feedback quality	Experimental group	32	35.19	1,126	490	1,085	-0.717
	Control group	34	31.91	1,085			

Coded frequency analysis (Table 4) showed the experimental group produced more metacognitive strategy activities ($n = 1,236$) than the control group ($n = 440$), suggesting a positive effect on the overall frequency of metacognitive engagement. Z-tests (Table 2) found a significant group difference in monitoring (EG 28.64%, $n = 354$ vs. CG 21.82%, $n = 96$; $z = 2.77$, $p = 0.006$), indicating improved real-time monitoring. By contrast, no significant differences emerged for planning (EG 46.44%, $n = 574$ vs. CG 49.09%, $n = 216$; $z = -0.956$, $p = 0.339$) or evaluating (EG 24.92%, $n = 308$ vs. CG 29.09%, $n = 128$; $z = -1.713$, $p = 0.087$). Because counts miss temporal dynamics (Csanadi et al., 2018), we combined ENA with qualitative methods to examine co-occurrence patterns.

Figure 7 shows the centroid distribution and structural differences of metacognitive strategy networks in the experimental and control groups during peer feedback. In this visualisation, weaker connections were subtracted from stronger ones, with the resulting differences represented by both line colour and thickness. Specifically, blue lines indicate connections stronger in the experimental group, red lines indicate those stronger in the control group, and the thickness of each line reflects the magnitude of the coefficient (Csanadi et al., 2018). Each dot is a participant's network centroid. Each square is the group mean centroid in the two-dimensional ENA space. Dashed squares show 95% CIs. Blue marks the experimental group; red marks the control group. Node size shows activity frequency. Line thickness shows co-occurrence, or tie strength (Shaffer et al., 2016). The experimental network is more balanced. Its centroid is left of the Y-axis, closer to executing strategy (ES), tracking (TK), revision (RN), and validating (VD). The control centroid is right of the Y-axis, nearer to setting goal (SG), making plan (MP), and review (RW). The ENA model explained 24.1% of the variance on X and 27.7% on Y, which indicates moderate fit and captures key group differences. These patterns suggest

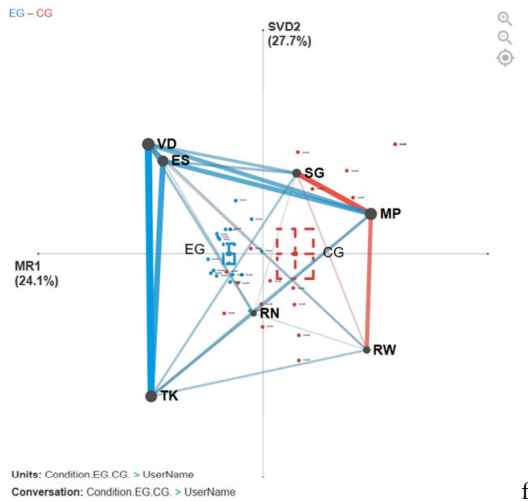
that scaffolding guided students toward a fuller pathway, with stronger execution and verification.

Table 4 Frequencies and distributions of metacognitive activities

Dimension	Metacognitive activities	Code	Experimental group (EG)		Control group (CG)		Z	p
			(F)	(%)	(F)	(%)		
Planning	Setting goal	SG	92	7.44%	48	10.91%	-0.956	0.339
	Making plan	MP	316	25.57%	122	27.73%		
	Executing strategy	ES	166	13.43%	46	10.45%		
Monitoring	Tracking	TK	214	17.31%	66	15.00%	2.773	**0.006
	Validating	VD	140	11.33%	30	6.82%		
Evaluating	Review	RW	206	16.67%	94	21.36%	-1.713	*0.087
	Revision	RN	102	8.25%	34	7.73%		

Note: * $p < 0.05$, ** $p < 0.01$.

Figure 7 Differential epistemic network of metacognitive strategy activities in the experimental and control groups (see online version for colours)



Note: Planning (SG = Setting goal, MP = Making plan, ES = Executing strategy), monitoring (TK = Tracking, VD = Validating), evaluating (RW = Review, RN = Revision).

A comparison of the two epistemic networks reveals clear structural differences (see Figure 8). The left network represents the EG (blue), and the right network represents the CG (red), allowing for a direct visual comparison of their distinct internal structures. The size of each node is proportional to the frequency of the corresponding activity, while the thickness of the connecting lines reflects the co-occurrence frequency of two activities, indicating the strength of their relationship (Csanadi et al., 2018). In the experimental group, the central nodes shifted toward ES, VD, and TK, with concentrated edge weights. This indicates that the experimental group significantly strengthened their metacognitive

activities along the ES-VD-TK chain, forming a more cohesive network structure. Such a pattern suggests that metacognitive scaffolding effectively guided students toward a more complete behavioural pathway, enhancing their capacity for task execution and strategy verification. By contrast, the control group's network remained centered on MP and RW, with connectivity largely confined to the planning dimension (e.g., MP→RW, MP→SG). This suggests that the control group's metacognitive activities were primarily concentrated in the planning dimension, without forming a closed loop of metacognitive strategy activities, resulting in a looser network structure. Collectively, the observed differences in node positioning and connection patterns underscore the positive impact of metacognitive scaffolding on students' metacognitive strategy activities.

Figure 8 A comparison of structural differences of epistemic networks of the experimental and control groups (see online version for colours)



These patterns were further substantiated by qualitative evidence. Analysis of task videos and Semi-structured interviews indicated that students in the experimental group, guided by scaffolding, more frequently monitored the progress of peer feedback giving tasks. They often advanced to subsequent phases even before fully resolving prior difficulties. For instance, Student G1 noted: “Because of the prompts from the metacognitive scaffolding, I was more proactive in checking the completion process of the feedback task, although it was a bit troublesome”. Student G3 echoed this view, stating that the scaffolding made him realise “There were many aspects I had previously overlooked”. Similarly, Student G4 commented: “I usually check my work as a habit, but if time allows, the strategies provided by the scaffolding are worth trying-especially when it suggests using AI to validate abnormal data, such as blood pressure or heartbeat counts”. In contrast, reflections from the control group were largely limited to planning. Student G7 remarked: “I usually don’t think about how much time the feedback task will take, nor do I check every step. Instead, I just focus on the requirements and try to complete the task”. Likewise, Student G10 explained: “It takes time for the AI to understand the requirements of the task, so I need to develop a plan and gradually design the questions until the task is finished”.

4 Discussion

We compared experimental and control groups on three dimensions: overall feedback quality, the frequency and distribution of metacognitive activities, and the epistemic network structure of metacognitive strategy use. This study gives multiple pieces of

evidence about the role of metacognitive scaffolding in GenAI-assisted peer feedback. The findings indicate that metacognitive scaffolding did not produce a significant improvement in overall feedback quality. One possibility is that both groups completed the peer feedback task with GenAI support. Table 1 shows no significant differences in peer feedback experience or prior GenAI use, suggesting comparable prompt skills and AI literacy across groups. Such similarity may have limited the incremental effect of scaffolding on final output quality. This interpretation aligns with prior work showing that GenAI-assisted feedback often increases textual consistency and can reduce between-group variance (Usher, 2025). Another factor concerns domain knowledge and sustained practice. Improvements in feedback quality commonly depend on deeper disciplinary knowledge and repeated practice, implying that metacognitive scaffolding alone may have limited influence on the cognitive dimension of feedback. Shin et al. (2023) similarly observed that when novices engaged in cognitively demanding tasks such as programming, even structured guidance produced constrained improvements in knowledge performance. A further explanation relates to feedback providers' self-efficacy. Prior studies show that students with lower self-efficacy are less likely to engage in deep reflection and tend to offer repetitive, surface-level comments that focus on language rather than diagnostic reasoning or evidence integration (Wei et al., 2024). To address this limitation, metacognitive scaffolding may be integrated with feedback literacy, clinical training, and exemplar-based calibration.

Although no significant differences were found in feedback quality, the experimental group demonstrated significantly higher levels of monitoring-related metacognitive activities. The frequencies and distributions of metacognitive activities (see Table 4) indicate that the experimental group generated 1,236 metacognitive activities, compared with 440 activities in the control group, suggesting that the intervention positively influenced the overall frequency of metacognitive activities. This increase was most pronounced in the monitoring dimension. Prior research has similarly shown that structured scaffolding can stimulate learners' self-regulatory behaviours in peer feedback processes (Nicol, 2021; Panadero and Lipnevich, 2022), which helps explain why the intervention affected monitoring more strongly. By contrast, we observed no clear group differences in planning and evaluating activities. One plausible explanation is that students without the support of scaffolding may have required additional time to interpret and understand requirements of the task (Camarata and Slieman, 2020; Xu et al., 2025). However, promoting more advanced evaluative practices may require continuous and sustained interventions.

Our ENA findings further visualised the structural differences in metacognitive strategy activities between the experimental and control groups. Notably, the experimental group demonstrated stronger interconnections among executing strategy (ES), tracking (TK), and validating (VD), whereas the control group exhibited higher connection coefficients among setting goal (SG), making plan (MP), and review (RW). These patterns indicate that scaffolding not only increased the frequency of strategy use but also enhanced the coherence among different strategies, guiding students to construct a more complete behavioural pathway across planning, monitoring, and validating. In particular, the strengthening of the ES-VD-TK chain (see Figure 7) highlights how scaffolding supported students in transitioning from the planning to monitoring and evaluating, thereby facilitating self-regulated learning. This aligns with prior research showing that metacognitive scaffolding helps learners integrate multiple strategies and sustain monitoring continuity throughout task completion (Li et al., 2023). By contrast,

the control group revealed stronger within-planning connections, (e.g., SG-MP, MP-RW), suggesting that without scaffolding, students often concentrated their efforts in the planning dimension while insufficiently activating monitoring and validation processes. Such reliance on preliminary planning is consistent with previous findings indicating that in the absence of scaffolding, learners tend to remain at the surface level of goal-setting and plan review, with limited engagement in deeper self-regulatory cycles (Li et al., 2023).

The findings of this study carry several important implications for nursing education. First, embedding metacognitive scaffolding into GenAI-assisted peer feedback can foster deeper engagement by encouraging students to actively monitor and regulate their learning processes in real-time. Second, the results underscore the need to evaluate peer feedback not only by outcome-oriented quality indicators but also through process-oriented measures. Third, although the intervention substantially enhanced monitoring strategies, its influence on planning and evaluation was limited. Finally, the observed role of metacognitive scaffolding in reshaping epistemic networks suggests its potential to reduce overreliance on GenAI and mitigate tendencies toward metacognitive laziness.

5 Conclusions

This study examined the multifaceted role of integrating metacognitive scaffolding into GenAI-assisted peer feedback giving. The intervention substantially increased the frequency and structural integration of monitoring strategies. ENA further revealed that metacognitive scaffolding supported the construction of more cyclical and coherent metacognitive regulation pathways. Overall, these results suggest that metacognitive scaffolding can help nursing students develop more integrated self-regulatory processes and offer practical guidance for instructional design in clinical training.

This study has several limitations. One limitation is the modest sample size, which limits the generalisability of the findings. Another limitation is that, although metacognitive scaffolding supported students' monitoring and validation efforts, the quality of feedback may still be affected by students' prompting skills and their GenAI literacy. A further limitation is the study's focus on nursing clinical training, while authentic and cognitively demanding may restrict the transferability of the findings to other disciplines or less-structured tasks. Future research should also seek to validate these results with larger and more diverse samples across institutions and nursing programs, as well as to explore hybrid models that integrate GenAI-assisted feedback with expert.

Acknowledgements

We would like to thank all the participants. This project is supported by 'Macao Polytechnic University Research Grant' (Approval No. RP/FCA-07-2025).

Declarations

During the preparation of this paper, the author utilised generative AI tools, (e.g., ChatGPT) for language polishing, grammar checking, and drafting/restructuring parts of the text. The author has thoroughly reviewed, verified, and modified all AI-generated content and assumes full responsibility for its academic accuracy and the final viewpoints. The AI served solely as an auxiliary tool, while the core ideas, research data, analysis, and conclusions were independently developed by the author.

The study protocol received full approval from the Institutional Review Board (IRB) of Macao Polytechnic University [Approval No:RP/FCA-07/2025]. Written informed consent was obtained before administering the survey. Participating students were promised that the information provided would remain anonymous.

The authors would like to declare that there is no conflict of interest in this study.

References

- Alemdag, E. and Yildirim, Z. (2022) 'Effectiveness of online regulation scaffolds on peer feedback provision and uptake: a mixed methods study', *Computers & Education*, Vol. 188, p.104574, <https://doi.org/10.1016/j.compedu.2022.104574>.
- Alfehaid, L.S., Qotineh, A., Alsuhebany, N., Alharbi, S. and Almodaimagh, H. (2018) 'The perceptions and attitudes of undergraduate healthcare sciences students of feedback: a qualitative study', *Health Professions Education*, Vol. 4, No. 3, pp.186–197, <https://doi.org/10.1016/j.hpe.2018.03.002>.
- Allison, J., Hwang, G-J., Mayer, R.E., Pellas, N., Karnalim, O., De Freitas, S., Ng, O-L., Huang, Y.-M., Hooshyar, D., Seidman, R.H., Al-Emran, M., Mikropoulos, T.A., Schroeder, N.L., Roscoe, R.D. and Sanusi, I. (2025) 'From generative AI to extended reality: multidisciplinary perspectives on the challenges, opportunities and future of educational computing', *Journal of Educational Computing Research*, Vol. 63, No. 6, pp.1327–1363, <https://doi.org/10.1177/07356331251359964>.
- August-Brady, M.M. (2005) 'The effect of a metacognitive intervention on approach to and self-regulation of learning in baccalaureate nursing students', *Journal of Nursing Education*, Vol. 44, No. 7, pp.297–304, <https://doi.org/10.3928/01484834-20050701-02>.
- Bagga, R. and McKee, A. (2024) 'Metacognition in oral health education: a pedagogy worthy of further exploration', *Medical Teacher*, Vol. 46, No. 7, pp.911–918, <https://doi.org/10.1080/0142159X.2023.2287399>.
- Banihashem, S.K., Kerman, N.T., Noroozi, O., Moon, J. and Drachsler, H. (2024) 'Feedback sources in essay writing: peer-generated or AI-generated feedback?', *International Journal of Educational Technology in Higher Education*, Vol. 21, No. 1, p.23, <https://doi.org/10.1186/s41239-024-00455-4>.
- Banihashem, S.K., Noroozi, O., Khosravi, H., Schunn, C.D. and Drachsler, H. (2025) 'Pedagogical framework for hybrid intelligent feedback', *Innovations in Education and Teaching International*, pp.1–17, <https://doi.org/10.1080/14703297.2025.2499174>.
- Barrot, J.S. (2023) 'Using ChatGPT for second language writing: pitfalls and potentials', *Assessing Writing*, Vol. 57, p.100745, <https://doi.org/10.1016/j.asw.2023.100745>.
- Camarata, T. and Slieman, T.A. (2020) 'Improving student feedback quality: a simple model using peer review and feedback rubrics', *Journal of Medical Education and Curricular Development*, Vol. 7, p.238212052093660, <https://doi.org/10.1177/2382120520936604>.

- Carless, D. and Boud, D. (2018) 'The development of student feedback literacy: enabling uptake of feedback', *Assessment & Evaluation in Higher Education*, Vol. 43, No. 8, pp.1315–1325, <https://doi.org/10.1080/02602938.2018.1463354>.
- Chang, C., Hwang, G. and Gau, M. (2022) 'Promoting students' learning achievement and self-efficacy: a mobile chatbot approach for nursing training', *British Journal of Educational Technology*, Vol. 53, No. 1, pp.171–188, <https://doi.org/10.1111/bjet.13158>.
- Chang, C-Y. and Su, W-S. (2025) 'The effect of a generative AI-based teaching strategy on building students' competency', *Journal of Nursing Education*, Vol. 64, No. 6, pp.346–355, <https://doi.org/10.3928/01484834-20250129-05>.
- Chang, C-Y., Wang, P-L., Li, C-J. and Hwang, G-J. (2024a) 'From empathy to quality long-term care: a generative AI-based art therapy approach based on the self-directed learning model', *Interactive Learning Environments*, pp.1–21, <https://doi.org/10.1080/10494820.2024.2443072>.
- Chang, C-Y., Yang, C-L., Jen, H-J. and Ogata, H. (2024b) 'Facilitating nursing and health education by incorporating ChatGPT into learning designs'.
- Church, D. and Carroll, M. (2023) 'How does metacognition improve decision-making in healthcare practitioners?', *Journal of Paramedic Practice*, Vol. 15, No. 3, pp.113–123, <https://doi.org/10.12968/jpar.2023.15.3.113>.
- Clynes, M.P. and Raftery, S.E.C. (2008) 'Feedback: an essential element of student learning in clinical practice', *Nurse Education in Practice*, Vol. 8, No. 6, pp.405–411, Elsevier BV, <https://doi.org/10.1016/j.nepr.2008.02.003>.
- Csanadi, A., Eagan, B., Kollar, I., Shaffer, D.W. and Fischer, F. (2018) 'When coding-and-counting is not enough: using epistemic network analysis (ENA) to analyze verbal data in CSCL research', *International Journal of Computer-Supported Collaborative Learning*, Vol. 13, No. 4, pp.419–438, <https://doi.org/10.1007/s11412-018-9292-z>.
- Darvishi, A., Khosravi, H., Sadiq, S., Gašević, D. and Siemens, G. (2024) 'Impact of AI assistance on student agency', *Computers & Education*, Vol. 210, p.104967, <https://doi.org/10.1016/j.compedu.2023.104967>.
- Dawson, P., Henderson, M., Mahoney, P., Phillips, M., Ryan, T., Boud, D. and Molloy, E. (2019) 'What makes for effective feedback: staff and student perspectives', *Assessment & Evaluation in Higher Education*, Vol. 44, No. 1, pp.25–36, <https://doi.org/10.1080/02602938.2018.1467877>.
- Er, E., Dimitriadis, Y. and Gašević, D. (2021) 'A collaborative learning approach to dialogic peer feedback: a theoretical framework', *Assessment & Evaluation in Higher Education*, Vol. 46, No. 4, pp.586–600, <https://doi.org/10.1080/02602938.2020.1786497>.
- Escalante, J., Pack, A. and Barrett, A. (2023) 'AI-generated feedback on writing: insights into efficacy and ENL student preference', *International Journal of Educational Technology in Higher Education*, Vol. 20, No. 1, p.57, <https://doi.org/10.1186/s41239-023-00425-2>.
- Fan, Y., Tang, L., Le, H., Shen, K., Tan, S., Zhao, Y., Shen, Y., Li, X. and Gašević, D. (2024) 'Beware of metacognitive laziness: effects of generative artificial intelligence on learning motivation, processes and performance', *British Journal of Educational Technology*, <https://doi.org/10.1111/bjet.13544>.
- Flavell, J.H. (1979) 'Metacognition and cognitive monitoring: a new area of cognitive – developmental inquiry', *American Psychologist*, Vol. 34, No. 10, pp.906–911, <https://doi.org/10.1037/0003-066X.34.10.906>.
- Fleiss, J.L., Levin, B.A. and Paik, M.C. (2003) *Statistical Methods for Rates and Proportions*, 3rd ed., Wiley-Interscience, Hoboken, N.J, <https://doi.org/10.1002/0471445428>.
- Gatrell, D., Mark, K., Au-Yeung, C. and Leung, K.Y. (2025) 'Using expansive learning to design and implement video-annotated peer feedback in an undergraduate general education module', *Education and Information Technologies*, Vol. 30, No. 3, pp.2999–3033, <https://doi.org/10.1007/s10639-024-12934-2>.

- Guo, K., Pan, M., Li, Y. and Lai, C. (2024a) 'Effects of an AI-supported approach to peer feedback on university EFL students' feedback quality and writing ability', *The Internet and Higher Education*, Vol. 63, p.100962, <https://doi.org/10.1016/j.iheduc.2024.100962>.
- Guo, K., Zhang, E.D., Li, D. and Yu, S. (2024b) 'Using AI -supported peer review to enhance feedback literacy: an investigation of students' revision of feedback on peers' essays', *British Journal of Educational Technology*, <https://doi.org/10.1111/bjet.13540>.
- Han, J-W., Park, J. and Lee, H. (2022) 'Analysis of the effect of an artificial intelligence chatbot educational program on non-face-to-face classes: a quasi-experimental study', *BMC Medical Education*, Vol. 22, No. 1, p.830, <https://doi.org/10.1186/s12909-022-03898-3>.
- Hattie, J. and Timperley, H. (2007) 'The power of feedback', *Review of Educational Research*, Vol. 77, No. 1, pp.81–112, <https://doi.org/10.3102/003465430298487>.
- Hwang, G-J., Xie, H., Wah, B.W. and Gašević, D. (2026) 'Presenting your AI in education research with rigor: the TEP-AIED model', *Computers and Education: Artificial Intelligence*, Vol. 10, p.100598, <https://doi.org/10.1016/j.caeai.2026.100598>.
- Järvelä, S., Nguyen, A. and Hadwin, A. (2023) 'Human and artificial intelligence collaboration for socially shared regulation in learning', *British Journal of Educational Technology*, Vol. 54, No. 5, pp.1057–1076, <https://doi.org/10.1111/bjet.13325>.
- Kasneci, E., Sessler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., Gasser, U., Groh, G., Günemann, S., Hüllermeier, E., Krusche, S., Kutyniok, G., Michaeli, T., Nerdel, C., Pfeffer, J., Poquet, O., Sailer, M., Schmidt, A., Seidel, T., Stadler, M., Weller, J., Kuhn, J. and Kasneci, G. (2023) 'ChatGPT for good? On opportunities and challenges of large language models for education', *Learning and Individual Differences*, Vol. 103, p.102274, <https://doi.org/10.1016/j.lindif.2023.102274>.
- Ku, K.Y.L. and Ho, I.T. (2010) 'Metacognitive strategies that enhance critical thinking', *Metacognition and Learning*, Vol. 5, No. 3, pp.251–267, <https://doi.org/10.1007/s11409-010-9060-6>.
- Lee, M. and Evans, M. (2019) 'Investigating the operating mechanisms of the sources of L2 writing self-efficacy at the stages of giving and receiving peer feedback', *The Modern Language Journal*, Vol. 103, No. 4, pp.831–847, <https://doi.org/10.1111/modl.12598>.
- Lerchenfeldt, S., Mi, M. and Eng, M. (2019) 'The utilization of peer feedback during collaborative learning in undergraduate medical education: a systematic review', *BMC Medical Education*, Vol. 19, No. 1, p.321, <https://doi.org/10.1186/s12909-019-1755-z>.
- Li, T., Fan, Y., Tan, Y., Wang, Y., Singh, S., Li, X., Raković, M., Van Der Graaf, J., Lim, L., Yang, B., Molenaar, I., Bannert, M., Moore, J., Swiecki, Z., Tsai, Y.-S., Shaffer, D.W. and Gašević, D. (2023) 'Analytics of self-regulated learning scaffolding: effects on learning processes', *Frontiers in Psychology*, Vol. 14, p.1206696, <https://doi.org/10.3389/fpsyg.2023.1206696>.
- Lipnevich, A.A. and Smith, J.K. (2022) 'Student – feedback interaction model: revised', *Studies in Educational Evaluation*, Vol. 75, p.101208, <https://doi.org/10.1016/j.stueduc.2022.101208>.
- Lipnevich, A.A., McCallen, L.N., Miles, K.P. and Smith, J.K. (2014) 'Mind the gap! Students' use of exemplars and detailed rubrics as formative assessment', *Instructional Science*, Vol. 42, No. 4, pp.539–559, <https://doi.org/10.1007/s11251-013-9299-9>.
- Loda, T., Erschens, R., Nikendei, C., Zipfel, S. and Herrmann-Werner, A. (2020) 'Qualitative analysis of cognitive and social congruence in peer-assisted learning – the perspectives of medical students, student tutors and lecturers', *Medical Education Online*, Vol. 25, No. 1, p.1801306, <https://doi.org/10.1080/10872981.2020.1801306>.
- Molenaar, I. (2022) 'Towards hybrid human-AI learning technologies', *European Journal of Education*, Vol. 57, No. 4, pp.632–645, <https://doi.org/10.1111/ejed.12527>.
- Molenaar, I., Van Boxtel, C.A.M. and Sleegers, P.J.C. (2010) 'The effects of scaffolding metacognitive activities in small groups', *Computers in Human Behavior*, Vol. 26, No. 6, pp.1727–1738, <https://doi.org/10.1016/j.chb.2010.06.022>.

- Mollick, E. and Mollick, L. (2023) *Assigning AI: Seven Approaches for Students, with Prompts*, arXiv [online] <https://doi.org/10.48550/ARXIV.2306.10052>, <https://arxiv.org/abs/2306.10052> (accessed 23 June 2026).
- Nelson, M.M. and Schunn, C.D. (2009) 'The nature of feedback: how different types of peer feedback affect writing performance', *Instructional Science*, Vol. 37, No. 4, pp.375–401, <https://doi.org/10.1007/s11251-008-9053-x>.
- Nicol, D. (2021) 'The power of internal feedback: exploiting natural comparison processes', *Assessment & Evaluation in Higher Education*, Vol. 46, No. 5, pp.756–778, <https://doi.org/10.1080/02602938.2020.1823314>.
- Noroozi, O., Banihashem, S.K., Biemans, H.J.A., Smits, M., Vervoort, M.T.W. and Verbaan, C-L. (2023) 'Design, implementation and evaluation of an online supported peer feedback module to enhance students' argumentative essay quality', *Education and Information Technologies*, Vol. 28, No. 10, pp.12757–12784, <https://doi.org/10.1007/s10639-023-11683-y>.
- Noroozi, O., Biemans, H. and Mulder, M. (2016) 'Relations between scripted online peer feedback processes and quality of written argumentative essay', *The Internet and Higher Education*, Vol. 31, pp.20–31, <https://doi.org/10.1016/j.iheduc.2016.05.002>.
- Panadero, E. and Lipnevich, A.A. (2022) 'A review of feedback models and typologies: towards an integrative model of feedback elements', *Educational Research Review*, Vol. 35, p.100416, <https://doi.org/10.1016/j.edurev.2021.100416>.
- Ramazanzadeh, N., Ghahramanian, A., Zamanzadeh, V., Valizadeh, L. and Ghaffarifar, S. (2023) 'Development and psychometric testing of a clinical reasoning rubric based on the nursing process', *BMC Medical Education*, Vol. 23, No. 1, p.98, <https://doi.org/10.1186/s12909-023-04060-3>.
- Shaffer, D.W., Collier, W. and Ruis, A.R. (2016) 'A tutorial on epistemic network analysis: analyzing the structure of connections in cognitive, social and interaction data', *Journal of Learning Analytics*, Vol. 3, No. 3, pp.9–45, <https://doi.org/10.18608/jla.2016.33.3>.
- Shin, Y., Jung, J., Zumbach, J. and Yi, E. (2023) 'The effects of worked-out example and metacognitive scaffolding on problem-solving programming', *Journal of Educational Computing Research*, Vol. 61, No. 6, pp.1312–1331, <https://doi.org/10.1177/07356331231174454>.
- Steiss, J., Tate, T., Graham, S., Cruz, J., Hebert, M., Wang, J., Moon, Y., Tseng, W., Warschauer, M. and Olson, C.B. (2024) 'Comparing the quality of human and ChatGPT feedback of students' writing', *Learning and Instruction*, Vol. 91, p.101894, <https://doi.org/10.1016/j.learninstruc.2024.101894>.
- Tu, Y.F. and Lu, Y.C. (2025) 'Trends of generative AI applications in educational settings', *International Journal of Mobile Learning and Organisation*, Vol. 19, No. 4, pp.442–467, <https://doi.org/10.1504/IJMLO.2025.149024>.
- Urban, M., Děchtěrenko, F., Lukavský, J., Hrabalová, V., Svacha, F., Brom, C. and Urban, K. (2024) 'ChatGPT improves creative problem-solving performance in university students: an experimental study', *Computers & Education*, Vol. 215, p.105031, <https://doi.org/10.1016/j.compedu.2024.105031>.
- Usher, M. (2025) 'Generative AI vs. instructor vs. peer assessments: a comparison of grading and feedback in higher education', *Assessment & Evaluation in Higher Education*, pp.1–16, <https://doi.org/10.1080/02602938.2025.2487495>.
- Valero Haro, A., Noroozi, O., Biemans, H.J.A., Mulder, M. and Banihashem, S.K. (2023) 'How does the type of online peer feedback influence feedback quality, argumentative essay writing quality and domain-specific learning?', *Interactive Learning Environments*, pp.1–20, <https://doi.org/10.1080/10494820.2023.2215822>.
- Vandermeulen, N., Van Steendam, E., De Maeyer, S. and Rijlaarsdam, G. (2023) 'Writing process feedback based on keystroke logging and comparison with exemplars: effects on the quality and process of synthesis texts', *Written Communication*, Vol. 40, No. 1, pp.90–144, <https://doi.org/10.1177/07410883221127998>.

- Wan, T. and Chen, Z. (2024) 'Exploring generative AI assisted feedback writing for students' written responses to a physics conceptual question with prompt engineering and few-shot learning', *Physical Review Physics Education Research*, Vol. 20, No. 1, p.010152, <https://doi.org/10.1103/PhysRevPhysEducRes.20.010152>.
- Wang, T., Zheng, J., Tan, C. and Lajoie, S.P. (2023) 'Computer-based scaffoldings influence students' metacognitive monitoring and problem-solving efficiency in an intelligent tutoring system', *Journal of Computer Assisted Learning*, Vol. 39, No. 5, pp.1652–1665, <https://doi.org/10.1111/jcal.12824>.
- Wei, W., Cheong, C.M., Zhu, X. and Lu, Q. (2024) 'Comparing self-reflection and peer feedback practices in an academic writing task: a student self-efficacy perspective', *Teaching in Higher Education*, Vol. 29, No. 4, pp.896–912, <https://doi.org/10.1080/13562517.2022.2042242>.
- Wong, B.S.H. and Shorey, S. (2022) 'Nursing students' experiences and perception of peer feedback: a qualitative systematic review', *Nurse Education Today*, Vol. 116, p.105469, <https://doi.org/10.1016/j.nedt.2022.105469>.
- Xu, W., Dong, X. and Ouyang, F. (2025) 'The effects of three scaffoldings on computer-supported, robot-assisted collaborative programming in higher education', *International Journal of Human-Computer Interaction*, Vol. 41, No. 8, pp.4987–5002, <https://doi.org/10.1080/10447318.2024.2356399>.
- Yao, Y., Sun, Y., Zhu, S. and Zhu, X. (2025) 'A qualitative inquiry into metacognitive strategies of postgraduate students in employing CHATGPT for English academic writing', *European Journal of Education*, Vol. 60, No. 1, p.e12824, <https://doi.org/10.1111/ejed.12824>.
- Yoong, S.Q., Wang, W., Chao, F.F.T., Dong, Y., Goh, S.H., Chan, Y.S., Lim, S., Seah, A.C.W., Wu, X.V. and Zhang, H. (2023) 'Using peer feedback to enhance nursing students' reflective abilities, clinical competencies and sense of empowerment: a mixed-methods study', *Nurse Education in Practice*, Vol. 69, p.103623, Elsevier BV, <https://doi.org/10.1016/j.nepr.2023.103623>.
- Yu, Q. and Schunn, C.D. (2023) 'Understanding the what and when of peer feedback benefits for performance and transfer', *Computers in Human Behavior*, Vol. 147, p.107857, <https://doi.org/10.1016/j.chb.2023.107857>.
- Zeb, H., Younas, A., Rasheed, S.P. and Sundus, A. (2020) 'Lived experiences of male nurse educators: an interpretive phenomenological inquiry', *Journal of Professional Nursing*, Vol. 36, No. 3, pp.134–140, <https://doi.org/10.1016/j.profnurs.2019.10.005>.
- Zhai, C., Wibowo, S. and Li, L.D. (2024) 'The effects of over-reliance on AI dialogue systems on students' cognitive abilities: a systematic review', *Smart Learning Environments*, Vol. 11, No. 1, p.28, <https://doi.org/10.1186/s40561-024-00316-7>.
- Zheng, J., Lajoie, S.P., Wang, T. and Li, S. (2023) 'Supporting self-regulated learning in clinical problem-solving with a computer-based learning environment: the effectiveness of scaffoldings', *Metacognition and Learning*, Vol. 18, No. 3, pp.693–709, <https://doi.org/10.1007/s11409-023-09352-z>.
- Zheng, L., Zhen, Y., Niu, J. and Zhong, L. (2022) 'An exploratory study on fade-in versus fade-out scaffolding for novice programmers in online collaborative programming settings', *Journal of Computing in Higher Education*, Vol. 34, No. 2, pp.489–516, <https://doi.org/10.1007/s12528-021-09307-w>.

Appendix A

<i>Scaffolding type</i>	<i>Condition</i>	<i>Forms</i>	<i>Content</i>
Planning scaffolding	- When nursing students do not know how to set goals - After reading the peer-feedback task	Multiple-choice questions	1 When providing feedback on a nursing assessment assignment, which of the following goals should serve as core objectives? (Select up to 2) - Evaluate completeness of objective data documentation - Evaluate completeness of subjective data documentation - Assess accuracy in identifying and analysing abnormal data - Assess accuracy in analysing patient-reported data
			2 When developing a feedback plan for a nursing assessment, which steps/strategies should be included? (Select up to 3) - Clarifying objectives and task breakdown - Detailed time allocation strategy - Professional discussion with AI assistant - Structured feedback design - Feasibility evaluation and timely adjustment
Monitoring scaffolding	- When nursing students check latest progress - If no activity for 10 min - After 10 min of task enactment	Multiple-choice questions	After completing feedback, which self-checks should you perform? (Select up to 4) - Confirm clear labelling of all data omissions - Verify integration of abnormal signs with patient history - Validate textbook citation accuracy - Review feedback tone for constructiveness - Ensure actionable improvement suggestions - Check for anticipation of potential complications - Assess clinical logic consistency

Appendix A (continued)

<i>Scaffolding type</i>	<i>Condition</i>	<i>Forms</i>	<i>Content</i>
Evaluating scaffolding	• When average score did not meet expected outcome • When nursing students reflect on the peer-feedback process	Multiple-choice questions	1 For this task, what problems or difficulties did you encounter? (Select up to 3) - a Insufficient feedback comprehensiveness - b Unprofessional or inconsistent feedback tone - c Challenges evaluating goal attainment - d Misinterpretation of grading criteria - e Poor time management and task progression control - f Inadequate documentation of operational issues - g Lack of resource support or external guidance 2 Which statements accurately describe your approach in this feedback task? (Select up to 3) - a Clearly identified strengths and explained their value - b Provided detailed, actionable improvement suggestions - c Used a respectful, constructive tone - d Directly addressed assignment requirements without digressing - e Motivated peer toward improvement - f Offered practical revision pathways rather than vague directives

Appendix B

Table B1 Description and examples of the three dimensions and seven activities of metacognitive strategies

<i>Dimensions</i>	<i>Metacognitive activities</i>	<i>Description and examples</i>
Planning	Setting goal (SG)	Clarifying task requirements and setting feedback goals. • Moodle logs: mapped to course/workshop view events indicating the student read the task page (e.g., 'The user with id '8' viewed the 'workshop' activity with course module id '20'.') • Behavioural trace data: the student first opened the task notification in Moodle and carefully reviewed the assignment instructions, which required providing peer feedback on peers' nursing assessment. After reading the instructions, the student paused and highlighted the part emphasising the identification of abnormal data. • Semi-structured interviews: "I read the teacher's task note; I will focus on abnormal data and link it to the patient."
	Making plan (MP)	Making plans about how to reach the goals, including selecting strategies and setting timelines. • Moodle logs: mapped to resource (rubric) views and local draft/note saves indicating planning (e.g., 'The user with id '8' viewed the 'resource' activity with course module id '13'.') • Behavioural trace data: the student opened the Moodle task, divided the feedback process into smaller steps (reading the case, reviewing peer's work, comparing with rubric), and allocated approximate time for each stage before drafting structured comments. • Semi-structured interviews: "I split the task into reading, reviewing and drafting, and set time for each part."
	Executing strategy (ES)	Advancing and explaining feedback plans; coordinating conflicts. • Moodle logs: mapped to assess_submission/submission_assessment events representing completed peer assessment (e.g., 'The user with id '8' assessed the submission with id '16' for the user with id '10' in the workshop with course module id '20'.') • Behavioural trace data: the student consulted the nursing textbook and applied the rubric to score the peer's work. She referred to teacher-provided exemplars, then used the GenAI chatbot to verify ranges of vital signs and locate relevant textbook chapters to support her feedback. • Semi-structured interviews: "I graded the peer using the rubric and wrote structured comments."
Monitoring	Tracking (TK)	Tracking task progress and indicating comprehension status. • Moodle logs: mapped to submission_view or resource_view events where the student inspects peer files or case materials (e.g., 'The user with id '8' viewed the 'resource' activity with course module id '22'.').

Table B1 Description and examples of the three dimensions and seven activities of metacognitive strategies (continued)

<i>Dimensions</i>	<i>Metacognitive activities</i>	<i>Description and examples</i>
Monitoring	Tracking (TK)	• Behavioural trace data: the student checked the peer's assignment against the case details, such as whether the size of the pressure ulcer blister was recorded. She also verified the accuracy of textbook citations to ensure comprehension and alignment with medical standards. • Semi-structured interviews: "I check whether blister size and other details are recorded and whether citations match the textbook."
	Validating (VD)	Detecting errors and checking feedback coherence. • Moodle logs: mapped to resource_view of teacher comments/textbook and subsequent draft edits (e.g., 'The user with id '8' viewed the 'resource' activity with course module id '9''). • Behavioural trace data: the student examined whether the peer's feedback aligned with the rubric requirements. She then cross-checked the statements with the textbook to verify accuracy and consistency • Semi-structured interviews: "I compared my comments with the rubric and the textbook and corrected inaccuracies."
Evaluating	Review (RW)	Student assessing the current solution and reflecting on feedback goals and progress. • Moodle logs: mapped to survey_submission/survey_saved or reflection-note events indicating review/reflection (e.g., 'The user with id '8' has saved the submission with id '3''). • Behavioural trace data: the student first consulted textbooks and rubrics to confirm her understanding, then referred to teacher examples for modelling. After forming initial ideas, she used the GenAI chatbot to optimise analysis, especially linking patient history with current symptoms and identifying relevant references. • Semi-structured interviews: "I reviewed exemplars and noted remaining uncertainties in the reflection form."
	Revision (RN)	Adjusting feedback content, goals, plans, or strategies as needed. • Moodle logs: mapped to url_view or external_tool_launch and subsequent draft updates/resubmissions (e.g., 'The user with id '8' viewed the 'url' activity with course module id '12''). • Behavioural trace data: the student revised her feedback drafts by asking the GenAI chatbot to polish unclear expressions, highlight task priorities, and check grammar. She adjusted her wording and structure based on AI suggestions, ensuring clarity and alignment with task requirements. • Semi-structured interviews: "I used AI to polish unclear wording, then updated and re-submitted the draft."