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Research

Evaluating the Effectiveness of Structured Self-Evaluation of Video Recorded Performance for Peripheral Intravenous Catheter Insertion: A Mixed Method Randomized Control Trial

Orlaith Hernon, RGN, RCN, RNT, BSc, PgDip, MSc[1]*, Edel McSharry, RN, RNT, BNSc, MSc, EdD[2], Andrew J. Simpkin, BA, PhD[3], Naomi Davies, RN, BSc, PgDip, MHSc[1], Iain MacLaren, BSc (Hons), PhD[4], Peter J. Carr, RN, BSc, MMedSc, PhD[1]

[1] *School of Nursing and Midwifery, University of Galway, Co. Galway, Ireland*
[2] *School of Nursing, Health Science and Disability Studies, ATU St Angela's, County Sligo, Ireland*
[3] *School of Mathematical and Statistical Sciences, University of Galway, Co. Galway, Ireland*
[4] *Centre for Excellence in Learning and Teaching, University of Galway, Co. Galway, Ireland*

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ABSTRACT

Background: The learning and demonstration of a clinical procedure is a fundamental aspect of any nursing program. One common invasive clinical procedure is peripheral intravenous cannulation.
Aim: This study aimed to evaluate an innovative teaching approach of self-evaluating video-recorded performance for final year undergraduate nursing students.
Methods: Guided by Ericsson's deliberate practice theory, a single-center, nonblinded, 2-group, mixed method randomized control trial was designed to provide students with more simulated practice opportunities.
Results: There was no significant difference in average knowledge, performance and attitude scores between the control and intervention groups at follow-up. However, both control and experimental group separately, improved significantly in their average knowledge, performance, and attitude scores from baseline to follow-up. Qualitative responses were positive from students regarding additional practice sessions and the intervention.
Conclusions: The findings of this study demonstrate that more simulated practice sessions and self-evaluating video-recorded performance are promising teaching strategies that can be implemented to improve educational outcomes and to increase students' satisfaction with their learning.

Introduction

A fundamental goal for new graduate nurses is to provide safe, high quality nursing care (Stone et al., 2020). This is achieved in part by teaching clinical psychomotor skills which is an essential component of the undergraduate nursing curriculum. Students should be practically and theoretically prepared for their roles (Francis and O'Brien, 2019), and this is achieved by using several teaching strategies. Performing nursing skills correctly supports patient safety and quality of care initiatives. Therefore, it is essential that clinical skills are taught with the most up-to-date knowledge regarding the subject in tandem with opportunities to master the skill. It is accepted that nurse educators prepare students with the correct skills to ensure clinical competency is achieved (Chao et al., 2021), however, it can be difficult for nurse educators to develop the appropriate teaching approaches to improve the performance of nursing skills (Chuang et al., 2018). There are many clinical skills in which nursing students are expected to learn and become proficient in, such as urinary catheter insertion or nasogastric tube insertion. The focus of this research study relates to the insertion of a peripheral intravenous cannula/catheter (PIVC) a new skill introduced into the undergraduate curriculum in Ireland. Acknowledged as a vascular access device, it is the most widely used invasive device in healthcare (Berndt & Steinheiser 2019) but acknowledged as one of the most stressful clinical skills for nursing students to learn (Marchionni et al., 2021). Furthermore, it is considered difficult to learn and perform (Ravik et al., 2017), with literature noting that many nurse graduates and nursing students lack confidence in their vascular access knowledge and skills (Ray et al., 2022; Hunter et al., 2018).

*Corresponding author.
E-mail address: orlaith.hernon@universityofgalway.ie (O. Hernon).

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In 2020, theoretical and practical content regarding PIVCs was introduced into the undergraduate nursing and midwifery curriculum in Ireland. To date it consists of a blending learning program incorporating e-learning with students allocated opportunities to practice the skill in a simulated environment in a higher education institution (Health Service Executive [HSE] (Office of the Nursing and Midwifery Services Director), 2020). Given the recent introduction of this common clinical skill into the curriculum and notwithstanding the aforementioned risks it was considered prudent to evaluate our educational approach. Specifically, one potential teaching method, that is student self-evaluation of their own videoed performance inserting a PIVC by using a task specific checklist. Strand et al. (2017) found that video recording to be essential in learning clinical skills. The use of the camera improved elements such as self-assessment, reflection, and psychomotor performance. Substantial volumes of evidence were synthesised to date on various digital approaches (Hernon et al. 2023a; Hernon et al. 2023b) and a previous evaluation study demonstrated that students wanted more simulated practice opportunities (Hernon et al. 2024). As a result of this work, a study was designed to evaluate video technology which incorporated more simulated practice into students PIVC education. The theoretical framework underpinning this research and analysis is Ericsson's deliberate practice theory (Ericsson et al., 1993). The goal of deliberate practice is to enhance performance. It is a structured activity that is developed to improve weaknesses (Ericsson et al., 1993).

The purpose of this study was to evaluate the effectiveness of structured self-evaluation of individual students' video recorded performance, specifically focusing on nursing students' PIVC knowledge, attitude (including confidence) and performance. Additionally, the research team wanted to know if extra simulated practice impacted students' educational outcomes. By ensuring all students received additional simulated practice sessions this allowed the research team to evaluate the intervention more closely.

The research question is: *Does formal structured self-evaluation of videoed performance have a positive impact on nursing students' peripheral intravenous cannulation knowledge, attitude, including confidence and performance?*

The methods which include additional background and study justification was registered by publishing the study protocol (Hernon et al. 2023c).

Methods

Trial Design

This study was a single-center, nonblinded, 2-group, pre-test and post-test, mixed method randomized control trial (RCT) (Hernon et al. 2023c). The reporting of the study followed the CONSORT (Consolidated Standards of Reporting Trials) 2010 checklist (Schulz et al., 2010).

Study Participants and Setting

Study participants included final year nursing students from one university in Ireland. Simulated practice sessions were performed in person in a simulation center equipped with an audio and high-resolution visual equipment and access to CAE LearningSpace simulation management platform (CAE Healthcare, 2024). To adequately power this study a sample size calculation identified the number of students required in each group. A previous evaluation study reported that students achieved an average knowledge score of 7.2 out of 15 (SD=2.4) in a knowledge, attitudes, and practices (KAP) survey in relation to venepuncture and peripheral intravenous cannulation (Hernon et al. 2024). A sample size of n=46 students (i.e., 23 in each group) was required to find a 25% increased score in the intervention group (i.e., an average score of 9). This was calculated for 80% power with an alpha of 0.05 under a one-sided hypothesis for a 2-sample t-test.

Students were invited to participate in this study and, if willing to participate, signed the study consent form after completing curriculum content. Study participation was optional. Students consented to the research study which included consenting to the recording of their performance and post-performance feedback (audio and visual). Once consented, students were provided with a study number and were then randomized into their respective groups. Participants were randomly assigned to either the control or experimental group using simple randomization via Excel. This sequence was decided on prior to consenting and can be noted in the published protocol (Hernon et al. 2023c). The randomization process was implemented by the primary researcher. Considering students were either randomized to self-evaluating their video recorded performance or not self-evaluating their video recorded performance it was not possible to blind students or the researchers. However, the outcomes assessors were blinded to the intervention groups.

Study Interventions

The intervention of interest for this RCT was the pedagogical strategy of video-modelling or students self-evaluating their own video recorded simulation practice. Both the experimental and control group received extra simulated practice sessions. However, the experimental group viewed their own video-recorded performance after their practice session and evaluated their performance using a task specific checklist. Overall, the timeframe for the study spanned a 6-month period.

Study Outcomes

The primary outcome in this study was the students' knowledge level of the skill of PIVC insertion. Secondary outcomes included their procedural competence, attitudes (such as confidence) and practices in the clinical environment, as well as their feedback on their performance of the skill and of the intervention. All outcomes were measured using several data collection instruments.

Data Collection Tools

Knowledge, Attitudes, and Practices (KAP) Survey

The survey instrument underwent face and content validity to evaluate the knowledge, attitudes, and practices of students in relation to PIVC and venepuncture and was used in an earlier study (Hernon et al. 2024). The previous version of the survey focused on both PIVC and venepuncture, for this RCT the survey (Supplemental material 1) was shortened to focus on PIVC only. The survey was completed twice by both the experimental and control groups - before and after the students completed the two study specific practice sessions. The survey aimed to capture the students' knowledge, attitudes, and practices regarding the skill. The knowledge portion of the survey included twelve questions. A score of 1 was awarded if the question was answered correctly, if a question was answered incorrectly or not answered no score was given for that question. In relation to attitudes, the subjective attitudes of students towards the skill were captured in this portion of the survey. A total of 13 questions considered the students' subjective attitudes in relation to the skill. Students were asked using a Likert scale of 0-10 how they felt regarding a statement. Students were mainly questioned on their confidence levels in relation to the skill, but they were additionally asked for their opinions on the level of importance or the risk which was associated with the skill. A score of 0 was considered negative depicting students feeling not confident or feeling the skill was low risk or

of low importance whereas scoring a 10 on the scale depicted a positive attitude. No score was given if a question was not answered or answered negatively (reported 5 or less) on the Likert scale. Answers scoring 6 or above were deemed a positive response and were given a score of 1. A positive attitude considered students feeling confident or feeling that the skill was important and appreciated its risk. Finally, the survey included 20 questions aimed to capture students' practices in relation to performing the skill and the training they received. Questions throughout the survey were framed as both closed and open-ended questions.

Clinical Outcomes Survey

All participating students were asked to complete the clinical outcomes survey (Supplemental material 2). This survey aimed to further evaluate students' practices in relation to the skill but in the clinical environment. Students were asked to complete the survey for every opportunity they had in the clinical environment to perform the skill of PIVC insertion regardless of that opportunity being successful or unsuccessful. Both closed and open-ended questions were used in the survey to capture students' experiences.

Task-Specific Checklist

The task-specific checklist was adapted from the procedural step-by-step process in the national guiding framework for PIVC training (Health Service Executive (Office of the Nursing and Midwifery Services Director), 2017) (Supplemental material 3). This checklist was used previously by the researcher in an earlier study evaluating nursing students simulated performance (Hernon et al. 2024). Students performed the simulated procedure on a low-fidelity PIVC task-trainer which provided flashback when the 'vein' was punctured. Each student's recorded procedural performance was evaluated by the researcher using this task-specific checklist. This evaluation was completed once all study procedures were performed. The same checklist was used by students in the experimental group, who watched the same video and evaluated their own performance. The students in the experimental group evaluated their own recorded performances directly after their simulated attempt. The highest score achievable was 28.

Student Feedback

Short, focused interviews with three key feedback questions were asked. Directly after the students completed their simulated procedure each student, in the simulation setting, was asked to reflect on how they felt their performance went, what they would do differently and how they felt about getting these self-directed practice opportunities. Students were asked these questions in an interview style which were recorded. The experimental group were asked for their feedback on the intervention this was collected through open-ended questions after completing the task analysis checklist.

The pre KAP survey was disseminated in January 2023 and the survey was completed by participating students before they performed their first study specific simulated practice session in February 2023. Remaining students then performed their second study specific simulated practice session in May 2023 and were then asked to complete the post KAP survey. The clinical outcomes survey was made available to students to complete throughout the study after their first simulated practice session. The students second practice session was combined with an objective structured clinical examination (OSCE) on the skill. A breakdown of the study design is demonstrated in the published protocol (Hernon et al. 2023c).

Data Analysis

The quantitative data gathered were first analyzed using descriptive statistics and graphical summaries. The outcomes of interest such as the knowledge, performance and attitude score were analyzed and are presented in this paper as initially showing the average pre- and post-scores for each measure. To investigate the efficacy of the intervention, an analysis of covariance (ANCOVA) model was used to formally analyse the between-group difference. The follow-up scores are treated as the outcome in a linear regression model with binary group set as the key predictor, while adjusting for the baseline scores. Finally, to investigate whether students improved from the pre and post KAP (approximately 4 months) or from the first to the second practice session (approximately 3 months), a paired t-test was performed in both control and experimental groups. The p-value deemed to be statistically significant was <0.05. Content analysis was conducted on data gathered from open-ended questions and short, focused interviews. The analysis focused on manifest content, this approach focuses on what the text says, adding structure and is often presented as categories (Graneheim & Lundman, 2004; Kleinheksel et al., 2020). Categories consider a descriptive level of content and is seen as a representation of the manifest content (Graneheim & Lundman, 2004). Initially data was coded, thereafter simple descriptive categories were applied to the students' responses.

Ethical Considerations

Ethical approval was provided for this study by both the university ethics committee (reference number 2022.08.007) and the partnering hospital ethics committee (reference number C.A. 2891).

Results

All students (n=69) in the class were invited to participate in this study, 58 students consented into the study. However, the research team report a 22% attrition rate with 45 students (21 experimental and 24 control) included in the study analysis (See Fig. 1 CONSORT flow diagram). Although, 45 students completed both simulated practice sessions, this paper reports complete KAP survey data on 43 students (pre KAP survey) and 40 students (post KAP survey), 38 students provided complete pre and post KAP survey data. The effectiveness of the intervention on students' PIVC knowledge, performance, and attitude and the between group difference is presented as an ANCOVA model see Table 1. Scores of nursing students' knowledge, performance, and attitude in both groups and differences between the pre and post-test evaluations was completed using paired t-test and the average pre- and post-scores for each of the outcomes are presented in Table 2.

Most students, 74% (n=28), improved their knowledge score from pre to post KAP, especially in the control group. To evaluate the between group difference using the ANCOVA model, the average difference in follow-up knowledge score was 0.25 higher in the control group compared to the experimental group, but this difference was not statistically significant (95% CI −1.01 to 1.50, p= .695). Using a paired t-test there was a significant improvement in knowledge score for both groups. The experimental group knowledge score increased by 1.56 (95% CI 0.27, 2.85; p=.021) and the control groups score increased by 1.55 (95% CI 0.85, 2.25; $p<.001$).

The secondary outcomes of this study included (1) the students' procedural competence, (2) the students' attitudes, including their confidence, (3) their practices in the clinical environment and (4) their feedback regarding their performance of the skill and of the intervention. For the between group difference using the ANCOVA model, the average difference in follow-up performance score was 1.88 lower in the control group compared to the experimental group, but this was not statistically significant (95% CI -3.88 to 0.12, p= .065) (Table 1). Using a paired t-test a significant improvement was observed in the performance score for both groups (control 95% CI 2.18, 5.24; $p<.001$, experimental 95% CI 3.42, 7.24; $p<.001$) (Table 2).

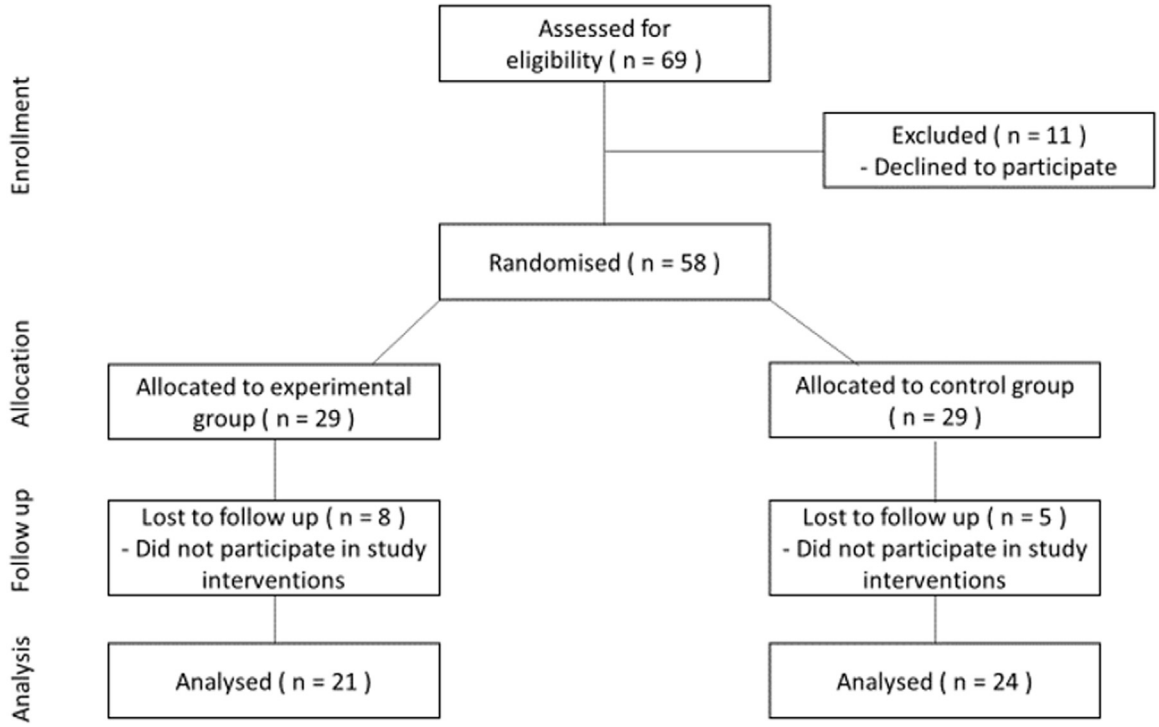

Fig. 1. CONSORT flow diagram.

Regarding attitudes the between group difference using the ANCOVA model, the average difference in follow-up attitude score was 0.22 lower in the control group compared to the experimental group, but this was not statistically significant (95% CI −1.46 to 1.03, p= .728) (Table 1). Using a paired t-test, to investigate whether students improved from pre to post KAP, there was a significant improvement in attitude scores for both control (95% CI 1.81, 3.59; p<.001) and experimental (95% CI 1.78, 5.00; p<.001) groups (Table 2).

Students self-reported the number of opportunities they had in practice to perform the skill on a patient. This was collected in interview form after their simulated practice session and via the clinical outcomes survey. During their second practice session, a grouped sum of 209 opportunities were reported by students. The mean number of opportunities was 4.64 and the range of opportunities per student varied from no opportunities to thirteen opportunities.

There were 86 clinical outcomes surveys completed by students throughout the study period. More specifically, 12 students in the control group accounted for 35/86 reports and 17 students in the experimental group accounted for 51/86 reports. Out of the 86 attempts reported by students, 77.9% (n=67) reports were noted to be supervised by nurses with 19.8% (n=17) supervised by doctors the remaining 2.3% (n=2) were noted to be observed by 'other'. Out of the 86 reports of PIVC insertions 72% (n=62) were deemed successful, with 55% (n=47) successful on the first attempt. For both control and experimental groups, the first-time insertion success rate was 57% (n=20) and 53% (n=27) respectively. Via the clinical outcomes survey students reported how confident they felt before, during and after each attempt using a Likert scale from 0-10, ranging from low to high confidence. The mean scores and standard deviation (mean [SD]) of students' confidence before (5.16 [2.11]), during (5.52 [2.09]) and after the procedural attempt (6.65 [2.62]) demonstrated that the students' confidence increased as they performed the procedure.

Table 1
Analysis of covariance (ANCOVA) model results, comparing groups at follow-up while adjusting for baseline. The 'Control Group' estimate shows the mean difference in score compared to the intervention group, e.g., negative values show the intervention group was higher at follow-up, compared to control.

Outcomes	Predictors	Estimates	95% CI	p
Knowledge				
	(Intercept)	4.54	2.34 – 6.75	<0.001
	Control Group	0.25	-1.01 to 1.50	0.695
	Pre knowledge	0.42	0.03 – 0.81	0.034
Performance				
	(Intercept)	16.89	11.17 – 22.61	<0.001
	Control Group	-1.88	−3.88 to 0.12	0.065
	First performance	0.13	−0.28 – 0.55	0.520
Attitude				
	(Intercept)	8.31	6.40–10.22	<0.001
	Control Group	-0.22	−1.46 to 1.03	0.728
	Pre attitude	0.33	0.11–0.56	0.005

The e-learning module provided by the national health authority (Health Service Executive, 2018) advises students that ideally, the PIVC should be performed on the most distal aspect of cephalic or basilic veins in the forearm. The KAP survey asked the participant which anatomical/vein location they were advised was the most appropriate for PIVC during their teaching instruction. In both pre and post KAP surveys most students (n=25) responded with the antecubital fossa, with only n=9 answering the forearm. Additionally, students were asked where in their professional experience (not to be confused with television) have they observed most PIVCs to be placed. Again, most students (pre KAP survey n= 25, post KAP survey n=22) reported the antecubital fossa with less students reporting the forearm in the pre KAP n=9 and post KAP survey n=4. Using the clinical outcomes survey students were asked where they attempted to insert the PIVC. From the image (images obtained and adapted from shutterstock.com) in Fig. 2. the colors denote the area where students clicked representing where they inserted the PIVC. The red spots indicate more clicks therefore from this image more attempts were on the back of the hand and the antecubital fossa with less clicks noted on the forearm.

Every student (n=45) provided feedback regarding their experiences after the simulated performance. The videos were approximately

Table 2
Paired t-test—students, in each group, change over time (positive values imply improvement).

	Experimental group (n=21)				Control group (n=24)			
	Pre score M (SD)	Post score M (SD)	*p*	95% CI	Pre score M (SD)	Post score M (SD)	*p*	95% CI
Knowledge	5.35 (1.73)	6.53 (2.20)	0.021	0.27, 2.85	5.61 (1.78)	7.19 (1.86)	< 0.001	0.85, 2.25
Unknown (missing data)	N=1	N=2			N=1	N=3		
Performance	13.33 (2.89)	18.7 (3.4)	< 0.001	3.42, 7.24	13.04 (2.01)	16.8 (3.2)	< 0.001	2.18, 5.24
Attitude	7.35 (2.76)	10.74 (1.94)	< 0.001	1.78, 5.00	8.00 (2.73)	10.76 (2.10)	< 0.001	1.81, 3.59
Unknown (missing data)	N=1	N=2			N=1	N=3		

M = mean, SD = standard deviation

10 minutes in length and included the student simulating the PIVC procedure, which was followed by a short, focused interview. For these qualitative responses codes were decided on as they emerged from the data. Responses gathered from student feedback were collated and grouped into descriptive categories. Students' experiences were collected regarding (1) how the performance went, (2) what they would do differently for their next attempt at the skill and (3) how they felt about the practice sessions. The experimental group were asked for their feedback on the intervention.

A) How the performance went

In relation to how the students perceived their performance, nine categories were evident in the data. Interestingly, the same categories were noted in both the February and May time points. This section is presented in table format to accommodate to word count limits, see Table 3. This table provides a list of categories alongside their explanation and supporting quotes to illuminate students' perceptions.

B) Do anything differently

The areas where students reported they would do something differently included asepsis, preparation, the tourniquet, flushing the cannula and dressing the cannula. These categories were identified in both the first and second practice session.

C) Opinion on self-directed/ practice sessions

Students' opinions were transcribed and grouped into recurring concepts, these included that the sessions are and would be *helpful, good, makes up for the lack of ward opportunities, helps with procedural flow* and *helps with nerves*. Insights included students wanting *more simulated practice opportunities* and that it *was good to practice on a manikin instead of a patient* however they noted that completing the skill on a manikin was *different to a patient.* These opinions or concepts were from both the first and second practice sessions however a few more were identified from the second practice session. These included that the sessions *helped with familiarity of equipment*, that it was *different to how things are done on the ward* but that they can *appreciate the benefits of self-directed opportunities*.

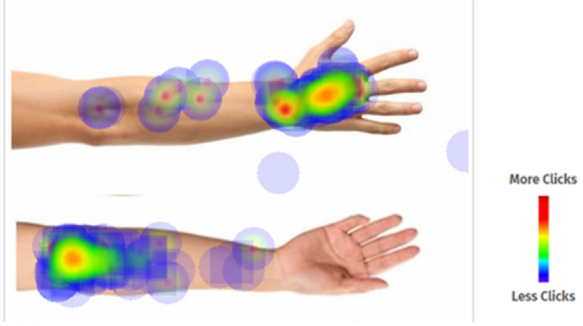

Fig. 2. Where students inserted PIVC.

The experimental group were asked how they felt about the self-evaluation approach and using the checklist to watch their performance. Their feedback was requested using open-ended questions. After the first practice session in February most responses were positive towards the intervention; "very useful, allowed me to identify faults in technique that I wouldn't have noticed otherwise" (Student T) and "good to realize what mistakes you have made and what to be mindful of the next time" (Student AA). However, there were a few negative comments; "struggled to keep up with the video when answering questions" (Student AH) and it was "difficult to watch video and answer questions at same time" (Student AI). After their second practice session students were asked again how they found the intervention. There were no negative comments noted at this timepoint; "I included a few more steps than last time e.g., aspirate the vein" (Student Y) and "I think that rewatching over my IVC attempt has helped me see the areas where I need to improve and to learn from any mistakes that I made" (Student F). The issues reported in the first session appeared to have been appeased in the second session "much easier to keep up with and analyse this time around and much easier to see faults in my practice" (Student AH).

Discussion

This study provides important insights in how student knowledge and performance, for PIVC insertion, can be improved. We have identified that more simulated performance is requested and required. Additionally, we identify that evaluating the effectiveness of student performance with video technology to support teaching approaches is a promising technology. Each group improved significantly in their average knowledge, performance, and attitudes scores from baseline to follow-up. However, as this study used a RCT design the educational outcomes of the intervention and control group were compared. There was no significant difference in average improvement between these groups across any of the study outcomes. However, it can be concluded that both extra simulated practice sessions and simulated practice sessions combined with self-evaluating videoed performance can be used to effectively improve knowledge, performance, and attitude in the clinical psychomotor skill of PIVC insertion. Additionally, there were positive responses from students in both groups regarding the additional practice sessions and specifically from the experimental group regarding the intervention.

The benefits of self-evaluating video recordings are reported in the literature. Video provides students with immediate feedback on their performance on the skill and it may help in transitioning from theory to practice. Furthermore, students feel more self-confident and safer in their performance (Strand et al., 2017). Tudor et al. (2019) found that those who completed video-assisted self-debriefing improved their performance similarly to those with standard debriefing from faculty with Cheng et al. (2014) also reporting that video-assisted debriefing has comparable outcomes to non-video assisted debriefing. Considering the wider literature and the findings

Table 3
How the performance went.

Category name	Explanation with supporting quotes
Happy (enough)	Students claiming that they were '*happy (enough)*' with their performance declaring that they were "happy enough with how it went" (Student A) with some students in May noting their improvements since the last simulation session, "better than the last time" (Student Y).
Not good	The '*not good*' category was identified whereby students expressed that they felt their performance went "very badly" (Student J) or "not great" (Student C).
Forgot steps	Another category included students expressing that they '*forgot steps*' regarding the procedural order, this was a particularly large category after the February practice session. Statements such as, "didn't get my steps right" (Student P) or "I think I did the steps in the wrong order sometimes but I'm not sure" (Student G) were reported.
Feelings	Students also expressed their '*feelings*' in their responses, the feelings expressed appeared to be more negative than positive. Students felt like they were "panicked" (Student AL) and "nervous" (Student AD). Students referred to their confidence levels, "I'm so glad I haven't done it on a patient yet because I'm not confident" (Student M). Empathy towards the 'patients' or the manikin/simulator was also evident, "the poor patients" (Student S).
Simulator vs patient	Students reported that performing the skill on a simulator in a simulated environment differed from performing the skill on a patient in the clinical environment, "very different when it's a manikin and not a person" (Student A). For some it appeared easier to complete the skill on a patient "I find it's much easier to do it on a real person" (Student AK). Although some issues were in relation to the fidelity of the simulation, being able to practice in a simulated environment was beneficial "looking back on it now, I know I made a load of mistakes, but I'd rather make the mistakes here rather than on a patient so I'm glad I got the opportunity" (Student Q).
Different process in the clinical environment	It was reported by some students that the process in the simulated environment was different to what they normally observe or use. Some differences were noted with equipment or how to apply particular elements, "sometimes the nurses on the ward they will, like all of them have a different way of putting the dressing on so I never know what is the best way to dress the cannula" (Student AA). It was also noted that some of the steps were not observed in the clinical environment "in practice, now I know from an examination point of view the aspiration is quite important but in practice I haven't seen that done much and I don't think I've ever done it myself in actual practice" (Student AH).
Familiarity with equipment	Students alluded that they were unfamiliar with the equipment used to perform the skill "and with the ones I did on the ward they didn't have this (extension set). It was just a bung, I hadn't done it with the extension so I was a bit confused on where to put it but I figured it out in the end" (Student AB). It was evident that students needed to "get more used to the equipment" (Student AN).
Long time since training/revision needed	The first and last simulated practice the students had until the study specific sessions was in November 2022. Some students noted that there was a significant difference in time between November and the next practice session in February, "I find it hard to remember from November, it's definitely a long time" (Student P). Students also reported needing to revise on the skill "to brush up on it" (Student AL).
Focusing on the flashback	One particular step from the procedural process which was frequently reflected on by students included the flushing and the 'flashback'. Getting the flashback or flushing was a positive for the students, "it flushed for me, so I was happy with that as soon as I saw flashback" (Student AK). On the opposite end students were also disappointed when they didn't get flashback, "obviously getting flashback would be good" (Student Z).

from this study, self-evaluating video performance may need to be incorporated into the standard clinical skills training of nursing programs. We suggest this approach should be adopted and evaluated in schools/simulation laboratories that have high resolution cameras and a learning technology resource such as CAE LearningSpace (CAE Healthcare, 2024).

The value of simulation has been articulated in these findings hence increasing the student exposure to simulation could be considered as an additional component within the current curriculum guidelines. Although it cannot replace clinical practice, in lieu of clinical practice opportunities educators may need to ensure students are receiving more than one simulated practice session. As typically, reassessing students in the clinical skills laboratory is the exception and not the rule or the norm (Gonzalez & Sole 2014). In this study, for procedural competency the maximum score achievable to students using the task specific checklist was 28. The students received their simulated practice as part of their standard curriculum in November. The average pre-scores (from their study specific simulated practice in February) of both experimental (13.33) and control (13.04) was less than 50% of the maximum score. Additionally, subsequent exposure increased the final procedural scores of the experimental (18.7) and control (16.8) group. This finding is supported by work from Gonzalez and Sole (2014) who suggest that being checked off on a skill using simulation once is not enough to become competent and retain skills.

Ericsson's deliberate practice theory guided this study. Deliberate practice does not generate monetary rewards, but it does have associated costs with the use of educator's resources and training settings. There is a resource constraint with deliberate practice, it requires available time and energy for the students and access to educational resources such as training facilities and trainers (Ericsson et al., 1993). Therefore, how much practice is enough must be questioned, as cost is to be considered. Specifically, economical cost of educator's time and training resources and environmental costs of the consumables being used for practice. Based on these findings more deliberate self-practice is required but caution is required with this approach as a significant number of consumables are required and this will challenge sustainable development goals and agendas and so the research team suggest other newer technologies such as augmented or mixed reality be tested. Further research considerations focusing on environmental and economic costs may include investigating if more consumables are used in simulated practice and students become more proficient will less consumables be used in the clinical environment. Furthermore, educators may evaluate the use of

technology to improve the simulated practice activities so that they can make the training more efficient and reduce the number of practice sessions or equipment required in practice sessions. Future research should continue to design and research the impact of teaching approaches, guided by educational theory, to develop an effective standardized approach to teaching clinical skills.

Limitations

There were some limitations noted in this study. In relation to retention, difficulties were identified with students who were working in the clinical environment and getting the time to leave the practice setting to perform the psychomotor aspect of the study. The sample size is a limitation, however the number of students in the class was small to begin with. Generalizability is limited in this RCT due to the number of participants and as it only included one university. This study reports missing KAP survey data (38 students provided complete pre and post KAP survey data), this was due to participants incorrectly adding their study numbers to the online survey platform, which made identification impossible. This study duration was 6 months, from participant consent to final survey. The study included a pre KAP survey followed by two practice skills sessions and finally a post KAP survey. While each group increased in their educational outcomes and with extra practice performance, it could be presumed that this would increase further overtime, it would be useful to do a longitudinal study. The participating students were in the final year of their four-year degree program, where the teaching of this skill is delivered, and hence it was not possible to do a more longitudinal study. To further assess the value of this intervention future research using a similar methodology should consider following the students as they transition from undergraduate to postgraduate. Finally, this study reports positive feedback in relation to the simulation sessions and participation in this research study. However, the potential exists that those who did not participate in the research may have altering views.

Conclusion

This study provides data which may be helpful for nurse educators when developing and designing teaching approaches for clinical skills training. Specifically, it will be valuable for PIVC insertion for nursing students. An interesting finding of this study was the impact additional simulated practice had on the control groups educational outcomes. This study has shown that both teaching strategies may help develop a better education program around PIVC practice. Self-evaluation of video-recorded performance is an innovative, technological teaching method which may be beneficial to use alongside current learning strategies. The insights and recommendations from this study can help other researchers and/or educators design their programs of study. The findings of this study demonstrate that more simulated practice sessions and self-evaluating video-recorded performance are both effective teaching strategies to improve educational outcomes and to increase students' satisfaction with their learning. Future research on innovative teaching strategies for undergraduate nursing students performing PIVC insertion should include environmental impact, economic costs, and clinical outcomes.

Registration

The protocol for this RCT was published in an open access trial methodology journal (Hernon et al. 2023c).

Declaration of competing interest

Dr Peter Carr is clinical advisor for Flomatrix a company that has designed a novel peripheral intravenous catheter and is clinical advisor for VeinTech a company that has designed a vein detecting technology.

All other authors declare no conflicts of interest.

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Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.teln.2024.06.007.

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