

BMJ Open Effectiveness of a proficiency-based progression e-learning approach to training in communication in the context of clinically deteriorating patients: a multi-arm randomised controlled trial

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ABSTRACT

Objective To determine the effectiveness of proficiency-based progression (PBP) e-learning in training in communication concerning clinically deteriorating patients.

Design Single-centre multi-arm randomised double-blind controlled trial with three parallel arms.

Randomisation, setting and participants A computer-generated program randomised and allocated 120 final year medical students in an Irish University into three trial groups.

Intervention Each group completed the standard Identification, Situation, Background, Assessment, Recommendation communication e-learning; group 1 Health Service Executive course group (HSE) performed this alone; group 2 (PBP) performed additional e-learning using PBP scenarios with expert-determined proficiency benchmarks composed of weighted marking schemes of steps, errors and critical errors cut-offs; group 3 (S) (self-directed, no PBP) performed additional e-learning with identical scenarios to (PBP) without PBP.

Main outcome measures Primary analysis was based on 114 students, comparing ability to reach expert-determined predefined proficiency benchmark in standardised low-fidelity simulation assessment, before and after completion of each group's e-learning requirements. Performance was recorded and scored by two independent blinded assessors.

Results Post-intervention, proficiency in each group in the low-fidelity simulation environment improved with statistically significant difference in proficiency between groups ($p<0.001$). Proficiency was highest in (PBP) (81.1%, 30/37). Post hoc pairwise comparisons revealed statistically significant differences between (PBP) and self-directed (S) ($p<0.001$) and (HSE) ($p<0.001$). No statistically significant difference existed between (S) and (HSE) ($p=0.479$). Changes in proficiency from pre-intervention to post-intervention were significantly different between the three groups ($p=0.001$). Post-intervention, an extra 67.6% (25/37) in (PBP) achieved proficiency in the low-fidelity simulation. Post hoc pairwise comparisons revealed statistically significant differences between (PBP) and both (S) ($p=0.020$) and (HSE) ($p<0.001$). No statistically

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This is the first randomised controlled trial of a proficiency-based progression e-learning training and assessment programme investigating training in communication in the context of clinically deteriorating patients.
- ⇒ The research translated into e-learning performance outcomes that are objective, precise and robust measurement of performance.
- ⇒ Limitations are the single-centre design and the application in simulation to the undergraduate medical population only.

significant difference was found between (S) and (HSE) ($p=0.156$).

Conclusions PBP e-learning is a more effective way to train in communication concerning clinically deteriorating patients than standard e-learning or e-learning without PBP.

Trial registration number NCT02937597.

INTRODUCTION

Communication in a clinical setting is fraught with difficulties, with poor communication having serious ramifications for patient care. Numerous reports have consistently shown that many thousands of deaths each year in the USA are due to medical error.¹ The causes of errors are myriad, with one of the contributing factors being communication breakdown.^{1 2} Communicating about a clinically deteriorating patient is a vital time, with lack of formal training and policy on handover leading to difficulties with information transfer.³ While interventions to improve handover communication are useful,⁴ newly qualified doctors are ill-prepared for handover, with 73% of those

studied at the University of Florida⁵ failing in a practical handover examination. Gaining proficiency in the skill of communication handover is crucial to improving patient outcomes. Early warning scores (EWS) are designed to recognise early deterioration of a patient by categorising the EWS severity and prompting early and efficient communication with a structured communication tool such as Identification, Situation, Background, Assessment, Recommendation (ISBAR). The current standard for EWS and ISBAR training in the acute hospital sector in Ireland involves an e-learning programme that is mandatory for all healthcare professionals working in acute services.⁶ This e-learning programme does not use proficiency-based progression (PBP).

Proficiency refers to the development of a skill to a proficient level, with scaffolded exposure to the new skill in increasingly complex situations aiding learning and mastery.⁷ In a proficiency pathway, learning occurs via intermediate levels on the planned pathway^{8–10} that guide further instruction to enable movement from novice to proficiency.¹¹ When sufficiently detailed, properly integrated and used for remediation, feedback enables movement of the learner along this pathway.^{12–20} Research has consistently shown that proficiency in a desired parameter can be achieved in face-to-face simulation through the use of deliberate practice and predefined metrics subdivided into ‘steps’, ‘errors’ and ‘critical errors’.^{8 9 21–23} This has not yet been demonstrated in an e-learning environment.

Pervious research using a multi-arm randomised controlled trial²³ has investigated the use of face-to-face PBP training and education in ISBAR, using assessment metrics further differentiated by a modified Delphi panel of appropriate experts into three categories of ‘steps’, ‘errors’ and ‘critical errors’. A ‘step’ is a component of a task that should be performed. An ‘error’ is a component that should not be performed. A ‘critical error’ is a component that could jeopardise the overall outcome of the domain event if omitted, as opposed to the omission of a ‘step’ which would not be as serious. The ‘critical error’ category allows evaluation to focus on the presence of critical mistakes, allowing appropriate feedback to enable improved performance.^{8 9 21–23} The 2019 study²³ demonstrated that students trained on ISBAR using a face-to-face PBP simulation programme performed statistically significantly better in a simulated environment than students trained face-to-face using traditional methods.

The world is undergoing a digital revolution, increasingly driven by need in this pandemic time.^{24 25} E-learning has become a prominent component of the educational landscape.²⁶ The benefits of using technology for learning and instruction are widely noted.^{27 28} The attractiveness of virtual or e-learning methodologies in this technologically advancing age demanded an investigation of an e-learning PBP programme addressing training and assessment in ISBAR communication concerning a clinically deteriorating patient, using an e-learning weighted marking scheme of ‘steps’, ‘errors’ and ‘critical errors’. This has not been investigated previously in e-learning.

A multi-arm randomised controlled trial approach was adopted, replicating in this regard the approach of the original face-to-face 2019 study, with e-learning replacing simulation.

The primary aim of this research was to determine if a PBP e-learning programme for teaching communication concerning clinically deteriorating patients resulted in better performance compared with those trained using existing standard e-learning and e-learning with identical content to the PBP e-learning but without using PBP.

METHODS

Trial design

This is a single-centre multi-arm randomised double-blind controlled trial with three parallel arms, with trial registration with ClinicalTrials.gov ID: NCT02937597.

Participants

Eligible students were medical students in the 2016/2017 final medical academic year in University College Cork (UCC), Ireland who were scheduled to undertake EWS/ISBAR training as part of their undergraduate curriculum.

All groups

All consenting students first took part in a simulation involving an acutely deteriorating patient scenario case for assessment of their communication, consisting of an actor with a standardised script in a low-fidelity medical simulation suite, mimicking a patient whose condition was deteriorating. After a defined length of time with the patient, the students’ performance in communication concerning the clinically deteriorating patient via a simulated phone call using the ISBAR protocol was audio-recorded and analysed afterwards by two experienced independent assessors/raters, who were blinded to the study group allocations. The assessors recorded the individual ‘steps’, ‘errors’ and ‘critical errors’ for each student, and recorded who reached proficiency based on an expert-determined predefined benchmark. An extract from the simulation case metric’s scoring sheet, with weighted marking of steps, errors, critical errors and proficiency benchmark level, is shown in [figure 1](#). After completing the low-fidelity simulation case, each medical student then undertook their respective interventions of e-learning training and assessment.

One week after the first simulation exercise, all the involved medical students returned to the simulation suite. All were required to provide proof of completion of the Health Service Executive (HSE) e-learning training and any add-on e-learning training programme. They repeated the low-fidelity simulation on the same case used the week previously, with the same actors and standardised script. This was the last step in the trial for the students. The students’ performance of ISBAR communication was audio-recorded and analysed afterwards by the same two blinded independent assessors/raters. Risk

Irrelevant background <i>States fractured humerus 10 years ago</i>		Error if included	
States the situation States correct total EWS			Critical Error if Excluded
States the situation States blood in drain/ileostomy			Critical Error if Excluded
<i>Seeks a recommendation from recipient</i> Do you want me to do anything else/what would you recommend?	Step		
<i>Confirms recommendation by "repeat back"</i> You are coming to review the patient and you want me to get 2 units of blood from the blood bank and arrange a CT abdomen	Step		
Proficiency Steps > or equal to 8 and no more than one error AND no more than one critical error	Total steps count	Total error count	Total number of critical errors excluded

Figure 1 Extract from the simulation case metric's scoring sheet including the proficiency benchmark.

of harm was minimal to students in this study. Examination grades were not impacted by participation or non-participation.

HSE

The (HSE) group completed the standard national e-learning training and assessment for EWS and ISBAR. The HSE group (HSE) did no other e-learning training.

Proficiency-based progression

The (PBP) group completed the standard national e-learning training and assessment for EWS and ISBAR. The (PBP) group had, in addition, an add-on ISBAR PBP e-learning training and assessment programme. This add-on e-learning PBP programme translated into e-learning the four case scenarios and associated weighted marking of steps, errors and critical errors used in the face-to-face study by Breen *et al.*²³ The benchmarks of steps, errors, critical errors and proficiency were identical to those set by the experts for the face-to-face study, and specified the number of 'steps' that must be performed with each scenario assessment and set the limits on the number of 'errors' and/or 'critical errors' allowed for progression to the next assessment scenario. The use of multiple input Boolean triggers in Articulate Storyline 2 enabled automatic recognition in the PBP e-learning programme of the weighted marking components of steps, errors, critical errors and proficiency level. Each scenario represented intermediate levels on the path towards proficiency of the chosen domain skill of communication concerning clinically deteriorating patients, with scenarios increasing in complexity through the e-learning programme. The simplest case involved a patient with dehydration, the most complex related to respiratory failure and sepsis. Automatic feedback on performance, based on the answers chosen by the learner at various junctures, occurred immediately and throughout the e-learning scenarios. Technology offered immediate automatic feedback eliminating the need for a face-to-face instructor; they had access to feedback if desired via email. On assessment scenario completion, the learner

discovered if they had reached the required progression benchmark; if they had not, they were required to repeat the scenario; when they were proficient, they progressed to the next more complex assessment case scenario. No time limit was imposed; no limit was set on the number of attempts possible to reach proficiency. All four assessment scenarios required completion to the desired proficiency level to gain a certificate of completion of the add-on ISBAR PBP e-learning training and assessment programme.

Self-directed, no PBP

The (S) group completed the standard national e-learning training and assessment for EWS and ISBAR. The self-directed (S) group in addition had access to an e-learning programme with the same assessment scenario case content as the (PBP) group but without the PBP element. The (S) cohort did not have a focus through their assessment scenario cases on predefined metrics or PBP, they had access to feedback if desired via email. The students were advised to work through the cases themselves with a view to perfecting their ISBAR technique. No time limit was imposed. The (S) students ticked a box at the end of the four cases, stating they were satisfied that they could correctly use ISBAR for each of the four assessment scenario cases, at which point they were issued with a certificate of completion of their (S) e-learning programme.

Outcomes

The primary outcome was the ability to reach the proficiency benchmark on the standardised low-fidelity simulation assessment case following completion of each group's e-learning requirements. The secondary outcomes were the number of successfully completed steps, errors and critical errors performed by each group.

Sample size

A sample size of 81 participants (27 per group) would be sufficient to detect a medium within-between interaction effect ($f=0.25$)²⁹ in a repeated measures analysis of variance (ANOVA) with three groups, two time points, assuming a power of 80%, a level of significance of 0.05, a two-tailed test, correlations among repeated measures of 0 and a non-sphericity coefficient of 1. Allowing for a similar non-completion rate to that seen in the pilot of the 2019 study due to conflicting demands on students' curriculum and re-scheduling, 120 participants (40 per group) would be required to be recruited initially. The sample size calculations were performed using the G-Power V.3.1 program.³⁰

Randomisation and blinding

Subjects from final year medicine in UCC, Ireland were excluded from the study if they had undergone previous EWS/ISBAR training. One hundred twenty students from final year medicine in UCC, Ireland were randomly chosen by a computer-generated program (GraphPad QuickCals software package, www.graphpad.com/quickcals/)

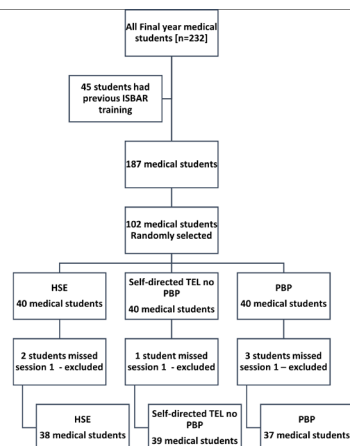


Figure 2 Consort diagram outlining selection, allocation, follow-up and analysis of medical student participants. ISBAR, Identification, Situation, Background, Assessment, Recommendation; PBP, proficiency-based progression; S, self-directed.

using a de-identified numbered list of remaining eligible medical students, obtained from the School of Medicine. The computer-generated program also categorised them randomly into one of three groups: (HSE), (PBP) and (S). The participants were not informed of the group to which they were allocated. Subjects were excluded from the study if (1) they had undergone previous EWS/ISBAR training, (2) did not consent to the study, (3) missed a simulation session or (4) did not complete their assigned e-learning courses prior to the second simulation session. This resulted in 45 students being excluded from trial involvement from the outset and 6 students being excluded during the trial (figure 2).

Statistical analysis

For baseline characteristics, categorical data were described using frequency and percentage (%); continuous data were described using the mean (SD) when the data were normally distributed and the median (IQR) otherwise.

Each of the two assessors/raters assessed the (1) number of 'steps' completed; (2) number of 'critical errors' made; (3) number of 'errors' made and (4) proficiency of the students, pre-intervention and post-intervention. Inter-rater reliability for the binary categorical variables (proficient: yes/no; made an error: yes/no) was assessed using Fleiss kappa statistic. Inter-rater reliability for the count variables (number of 'steps' identified, number of 'critical errors') was assessed using perfect agreement percentage between raters and the intraclass correlation coefficient (ICC), using a two-way, random effects model for single measures with absolute agreement. All statistical analysis was performed using IBM SPSS Statistics V.25.

For pre-intervention and post-intervention separately, Fisher's exact test was used to compare the percentage of participants (medical students) in each group demonstrating proficiency. If statistically significant, pairwise Fisher's exact tests were performed to identify which groups

were significantly different. To investigate if changes over time differed between the groups each participant was categorised as one of the following: (1) became proficient; (2) no change and (3) no longer proficient and Fisher's exact test was performed to compare changes between the three groups. If statistically significant, pairwise Fisher's exact tests were performed to identify which groups were significantly different.

To compare the number of 'steps' completed between the groups at pre-intervention and post-intervention, a one-way ANOVA was performed for each timepoint separately; if statistically significant, pairwise comparisons were performed using independent samples t-tests. To investigate if changes between pre-intervention and post-intervention differed by group, a linear mixed model was used. The fixed effects included in the model were group, time and the interaction of group by time. A statistically significant interaction would indicate that the change over time differed by group. Subject ID was included as a random effect in the model. The number of 'critical errors' was not normally distributed and therefore the non-parametric Kruskal-Wallis test was used to compare between the groups at each timepoint separately; if statistically significant, pairwise comparisons were performed using Mann-Whitney U tests. All statistical analysis was performed using IBM SPSS Statistics V.25. All tests were two-sided and a p value <0.05 was considered to be statistically significant.

Patient and public involvement

Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

RESULTS

Figure 3 outlines the experimental design and study flow indicating training interventions and assessment of the three groups of medical student participants. Analysis was by original assigned groups.

Baseline characteristics of the three groups are shown in table 1.

For pre-intervention, using the equation 'observation event agreements/total number of observations', the perfect agreement percentage between raters were 0.88, 0.90, 0.96 and 1 for number of steps, critical errors, errors and proficiency, respectively. Post-intervention perfect agreement percentage between raters were 0.95, 0.96, 0.99 and 1 critical errors, steps, proficiency and errors, respectively. With kappa, for pre-intervention, the agreement between the two raters was perfect (kappa=1.0) for proficiency, almost perfect (ICC (95% CI) 0.977 (0.966 to 0.984)) for 'steps' completed, almost perfect (ICC (95% CI) 0.990 (0.985 to 0.993)) for 'critical errors' made and substantial (kappa (95% CI) 0.884 (0.660 to 1)) on number of 'errors' made. For post-intervention, the agreement between the two raters was almost perfect (kappa (95% CI) 0.982 (0.948 to 1.000)) for proficiency,

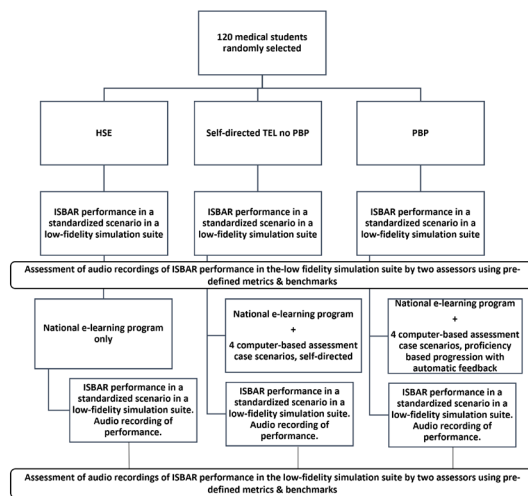


Figure 3 Experimental design and study flow indicating training interventions and assessment of the three groups of medical student participants. ISBAR, Identification, Situation, Background, Assessment, Recommendation; PBP, proficiency-based progression; S, self-directed.

almost perfect (ICC (95% CI) 0.994 (0.992 to 0.996)) for 'steps' completed, almost perfect (ICC (95% CI) 0.996 (0.994 to 0.997)) for 'critical errors' made and perfect (kappa=1.0) on number of 'errors' made.

Proficiency

The proficiency of each group pre-intervention and post-intervention is described in [table 2](#).

Pre-intervention (any e-learning or assessment), the proficiency demonstrated in each group was low (ranged from 5.3% to 13.5%) and no significant differences were found between the three groups ($p=0.419$). Post-intervention, the proficiency in each group as demonstrated in the low-fidelity simulation environment improved and there was a statistically significant difference in proficiency between the three groups ($p<0.001$). Proficiency was highest in the (PBP) group (81.1%, 30/37), followed by the (S) group (41.0%, 16/39) and lowest in the (HSE) group (31.6%, 12/38). Post hoc pairwise comparisons revealed statistically significant differences between the (PBP) group and both the (S) group ($p<0.001$) and the (HSE) group ($p<0.001$). A statistically significant difference was not found between the (S) group and the (HSE) group ($p=0.479$).

Changes in proficiency from pre-intervention to post-intervention for each group are described in [table 3](#).

Changes in proficiency were significantly different between the three groups ($p=0.001$). Post-intervention, an extra 67.6% (25/37) of participants in the (PBP) group achieved proficiency in the low-fidelity simulation environment compared with 38.5% (15/39) in the (S) group and 26.3% (10/38) in the (HSE) group. Post hoc pairwise comparisons revealed statistically significant differences between the (PBP) group and both the (S) group ($p=0.020$) and the (HSE) group ($p<0.001$). A

statistically significant difference was not found between the (S) group and the (HSE) group ($p=0.156$).

Number of 'steps' completed

Pre-intervention, there was not a statistically significant difference in the average number of 'steps' completed in each group ($p=0.684$). Post-intervention, the average number of 'steps' completed in the low-fidelity simulation environment improved in each of the groups and there was a statistically significant difference between the three groups ($p<0.001$). The average number of 'steps' completed was highest in the (PBP) group (mean (SD) 9.5 (1.2)), followed by the (S) group (mean (SD) 7.7 (1.8)) and the (HSE) group (mean (SD) 7.5 (1.6)). Post hoc pairwise comparisons revealed statistically significant differences between the (PBP) group and both the (S) group ($p<0.001$) and the (HSE) group ($p<0.001$). A statistically significant difference was not found between the (S) group and the (HSE) group ($p=0.532$).

In the linear mixed model, the interaction between group and time was statistically significant ($p<0.001$), indicating that the increase in 'steps' over time differed by group. For the (PBP) group, the mean number of 'steps' completed in the low-fidelity simulation environment increased from 6.6 (95% CI 6.1 to 7.1) pre-intervention to 9.5 (95% CI 9.0 to 10.0) post-intervention, a statistically significant increase of 2.9 'steps' (95% CI 2.3 to 3.6, $p<0.001$). For the (HSE) group, the mean number of 'steps' increased from 6.2 (95% CI 5.7 to 6.7) pre-intervention to 7.4 (95% CI 6.9 to 8.0) post-intervention, a statistically significant increase of 1.2 'steps' (95% CI 0.6 to 1.8, $p<0.001$). For the (S) group, the mean number of 'steps' increased from 6.4 (95% CI 5.9 to 6.9) pre-intervention to 7.7 (95% CI 7.2 to 8.2) post-intervention, a statistically significant increase of 1.3 'steps' (95% CI 0.7 to 1.9, $p<0.001$). The increase in the average number of 'steps' completed in the low-fidelity simulation environment between pre-intervention and post-intervention was 1.7 steps higher in the (PBP) group than the (HSE) group (95% CI 0.9 to 2.6, $p<0.001$). The increase was also 1.7 'steps' higher in the (PBP) group compared with the (S) group (95% CI 0.8 to 2.5, $p<0.001$). The change from pre-intervention to post-intervention was not significantly different between the (HSE) group and the (S) group ($p=0.869$).

Number of 'critical errors' made

Pre-intervention, there was not a statistically significant difference in the number of 'critical errors' between the three groups ($p=0.456$). Post-intervention, the median number of 'critical errors' in the low-fidelity simulation environment decreased in each group and there was a statistically significant difference between the three groups ($p<0.001$). The median number of 'critical errors' was lowest in the (PBP) group (median (IQR) 1 (0 to 2)) and post hoc pairwise comparisons revealed statistically significant differences between the (PBP) group and both

Table 1 Baseline characteristics between groups

	Group					
	(PBP) (n=37)		(HSE) (n=38)		(S) no PBP (n=39)	
	%	N	%	N	%	N
Age (years): median (IQR)	25	(23–27)	24	(23–26)	24	(23–25)
Gender						
Male	43.2	(16)	31.6	(12)	48.7	(19)
Female	56.8	(21)	68.4	(26)	51.3	(20)
Nationality						
Irish	56.8	(21)	55.3	(21)	71.8	(28)
Malay	21.6	(8)	21.1	(8)	15.4	(6)
Other	21.6	(8)	23.7	(9)	12.8	(5)
First language						
English	75.7	(28)	78.4	(29)	82.1	(32)
Malay	21.6	(8)	21.6	(8)	15.4	(6)
Other	2.7	(1)	0	(0)	2.6	(1)
Graduate						
Yes	51.4	(19)	36.8	(14)	30.8	(12)
No	48.6	(18)	63.2	(24)	69.2	(27)
Previous knowledge of ISBAR						
Yes	94.6	(35)	89.5	(34)	94.9	(37)
No	5.4	(2)	10.5	(4)	5.1	(2)
Previous experience using ISBAR						
Yes	48.6	(18)	47.4	(18)	61.5	(24)
No	51.4	(19)	52.6	(20)	38.5	(15)
Number of times used ISBAR						
0	51.4	(19)	52.6	(20)	38.5	(15)
<3 times	40.5	(15)	39.5	(15)	51.3	(20)
3–5 times	2.7	(1)	5.3	(2)	7.7	(3)
6–10 times	5.4	(2)	2.6	(1)	2.6	(1)
Reduced visual acuity						
No	56.8	(21)	44.7	(17)	56.4	(22)
Yes—corrected	40.5	(15)	55.3	(21)	43.6	(17)
Yes—not corrected	2.7	(1)	0.0	(0)	0.0	(0)
Colour blindness						
Yes	2.7	(1)	5.3	(2)	0.0	(0)
No	97.3	(36)	94.7	(36)	100	(39)
Reduced hearing						
No	100.0	(37)	100.0	(38)	97.4	(38)
Yes—corrected	0.0	(0)	0.0	(0)	0.0	(0)
Yes—not corrected	0.0	(0)	0.0	(0)	2.6	(1)

ISBAR, Identification, Situation, Background, Assessment, Recommendation; PBP, proficiency-based progression; S, self-directed.

the (S) group ($p=0.001$) and the (HSE) group ($p<0.001$). A statistically significant difference was not found between the (S) group and the (HSE) group ($p=0.626$).

Number of 'errors' made

No statistical tests were performed on the total number of 'errors' as the number of participants with 'errors'

Table 2 Proficiency of pre-intervention and post-intervention

	(PBP) (n=37)		(HSE) (n=38)		(S) (n=39)		P value*
	%	N	%	N	%	N	
Pre-intervention	13.5	(5)	5.3	(2)	7.7	(3)	0.419
Post-intervention	81.1	(30)	31.6	(12)	41.0	(16)	<0.001†

*From Fisher's exact test.

†Pairwise comparisons revealed statistically significant differences between the PBP group and both the HSE group ($p<0.001$) and the S group ($p<0.001$).

PBP, proficiency-based progression; S, self-directed.

pre-intervention or post-intervention was very low (two or one or none).

DISCUSSION

The ISBAR PBP e-learning training and assessment programme specifically targeted an area of healthcare known to be fraught with error, namely communication. Cases previously used successfully in a simulated training environment, using steps, errors and critical errors together with an expert-derived proficiency benchmark, were converted into a PBP e-learning training and assessment programme. The effectiveness of this ISBAR PBP e-learning training and assessment programme was demonstrated empirically through successful assessment of resulting performance in a follow-on face-to-face simulated environment. Those students trained to proficiency using the ISBAR PBP e-learning training and assessment programme, namely the (PBP) group, performed statistically significantly better in the subsequent simulated environment than those trained with e-learning when not using this approach. This was true in terms of the number of students reaching proficiency, the number of 'steps' completed and the number of 'critical errors' performed. While evidence already exists in relation to the use of PBP in a face-to-face simulated environment for communication skills acquisition using 'steps', 'errors' and 'critical errors',²³ this paper represents the first time that this novel assessment method has been used for communication skills acquisition in an e-learning environment. Recent research on PBP e-learning³¹ suggested that e-learning was effective in avoiding critical errors in

a surgical suturing and knotting task, but none of the involved trainees in that study demonstrated the proficiency benchmark. This is in contrast to this ISBAR PBP e-learning study, where 81% of the (PBP) group reached proficiency post the e-learning intervention. This paper thus advances the field of assessment, showing how technology can enhance education.

The main strength of this study is its rigorous and robust methodology in investigating the effectiveness of an ISBAR PBP e-learning training and assessment programme. The rigour of a randomised controlled trial was combined with well-defined assessment outcome measures. Due to the successful outcome of this research, the ISBAR PBP e-learning training and assessment programme is now an integral part of training in final year medicine in UCC for every future medical practitioner. More than 1000 individuals have, to date, completed this programme, with no change being required for this element of the medical curriculum when the COVID-19 pandemic hit; it continued to run uninterrupted.

Weaknesses of the study include the single-centre design and the application to the undergraduate medical population only. The use of only one discipline was inevitable as the e-learning programme developed was specifically developed for medical students; future work will make it more relevant for a nursing population also, very few changes will be needed to achieve this, with future research in this cohort then being possible. This study addresses level 2 learning of the Kirkpatrick evaluation model, demonstrating an increase in knowledge and skills in communicating in the event of a deteriorating

Table 3 Change in proficiency from pre-intervention to post-intervention

	(PBP) (n=37)		(HSE) (n=38)		(S) (n=39)		P value*
	%	N	%	N	%	N	
Became proficient	67.6	(25)	26.3	(10)	38.5	(15)	0.001†
No change	32.4	(12)	73.7	(28)	56.4	(22)	
No longer proficient	0	(0)	0	(0)	5.1	(2)	

*From Fisher's exact test.

†Pairwise comparisons revealed statistically significant differences between the PBP group and both the HSE group ($p<0.001$) and the S group ($p=0.020$).

PBP, proficiency-based progression; S, self-directed.

patient. Further research should address Kirkpatrick level 3, namely evaluation of the transfer of learning into the workplace. Thus, future research needs to investigate the use of this e-learning learning programme with qualified nurses and doctors and its impact on patient outcomes.

Medicine has moved to a competency-based rather than a time-based model; in competency-based education, progression is dependent on reaching a set standard irrespective of how long it takes.³² It allows students to work at the pace that suits them, thus allowing for autonomy and individualised learning.³³ The evidence from implementation of competency-based education is impressive.^{8 23 34–38} In medicine, the change to competency-based medical education^{39–43} and entrustable professional activities^{39 44–48} is progressing rapidly. Ideally, explicit evidence of competence should drive entrustment.^{39 44} This throws up challenges that include definition of competencies,⁴⁹ careful setting of the required milestones,^{50 51} pressure on staff, matching graduates to programmes when they graduate rather than at fixed times, financial implications,⁴⁵ institution resistance.³² The milestones set for proficiency benchmarks in these cases were validated through a modified Delphi expert panel.²³ They were transferred into an e-learning environment, where the incorporation of automatic feedback enabled progression through the training without the need for a face-to-face instructor.

CONCLUSION

In summary, this study shows that a PBP e-learning training and assessment programme is more effective in training in clinical communication in the event of a clinically deteriorating patient than the existing standard e-learning, and e-learning with identical content to the PBP e-learning but without using a PBP approach. Technology will inevitably form a bigger part of assessments in the future worldwide. Education and assessment are changing, and it is important to ensure that best practice underpins any newly developed e-learning assessments. Other exciting possibilities are inevitable in this technology-charged era of education. The future for education and e-learning is bright and exciting.

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