Radiography student perceptions of a simulated clinical placement to enhance clinical placement capacity: A descriptive qualitative study

K. Brewer[*], C. Hawker, N. Chambara

School of Healthcare Sciences, Cardiff University, Heath Park Campus, Cardiff, CF14 4XN, United Kingdom

ABSTRACT

Introduction: Post-pandemic workforce demands in Wales have resulted in an increase in radiography students, causing an imbalance between student numbers and clinical placement learning opportunities. Simulation-based education (SBE) has been effectively implemented in several healthcare professions to replace clinical placement hours and enhance learning equity. This study aimed to address the limited scope of literature surrounding this approach within diagnostic radiography education in Wales, by exploring student perceptions of a Simulated Clinical Placement (SCP) package in one university radiography degree programme, to establish its acceptability as a replacement of clinical hours.
Methods: A qualitative descriptive design was selected to explore the value and factors influencing student perceptions of SCP. A focus group of eight students was formed to collect data, which was audio recorded, transcribed, coded and thematically analysed.
Results: Four themes were identified; preconceptions and prior experiences, SCP provision, learning conducive to confidently meeting professional standards, and role in clinical placement capacity. Student preconceptions and prior experiences were initially negative but evolved into enjoyment throughout package delivery. SCP provision influenced learning experiences, with all students reporting SCP enhanced confidence and skills supporting them in meeting required professional registration expectations. Students further reported most learning still occurred in clinical departments, and this was preferable to the SCP.
Conclusion: Overall, despite the SCP package being supportive to clinical learning, it was deemed insufficient to replace clinical placement hours, and should be a supplement, not a substitute. Additionally, simulation packages should only be adopted for accommodating already increased student numbers, not as a means of increasing cohort size.
Implications for practice: Clinical placements and simulation activities will progressively cohabitate, however with limited research and guidance, further exploration is required to establish the extent of this relationship for capacity management.

Introduction

Welsh diagnostic radiography workforce requirements have evolved due to unprecedented demands placed on imaging services, predominantly due to the COVID-19 pandemic.[1] Subsequently, diagnostic radiographers have been identified as a shortage occupation[2] with a post-pandemic Welsh vacancy rate of 7 %.[3] Efforts to mitigate workforce demands have seen commissioned undergraduate student enrolments on allied health professional courses, including radiography, increase by 11 % in Wales between 2019 and 2022.[4] As no diagnostic radiography apprenticeship scheme is currently available in Wales, undergraduate radiography students must participate in both academic and practice-based studies,[5] the latter being considered the gold standard for students to attain and develop competent clinical skills.[6] However, with increasing student numbers, and current clinical placement capacity being exceeded, there is a risk of industry partner fatigue, and a reduction in quality student supervisory and learning opportunities.[6] This poses an ongoing challenge of how and where students can be accommodated to complete this gold

standard clinical learning. The need to increase clinical placement capacity is ubiquitous within healthcare and a frequently implemented innovative solution is simulation-based education (SBE).[7] Within Wales, simulation is defined as a learning tool which supports development through experiential learning within a clinically replicated and safe environment. Students can learn from mistakes without posing a danger to patients, allowing them to analyse and respond to realistic situations, with the aim of developing or enhancing knowledge, skills, behaviour and attitudes.[8] SBE has been successful in supporting clinical placement capacity within diagnostic radiography education in England,[9] however no evidence exists for Welsh radiography programmes.

A Simulated Clinical Placement (SCP), a newly designed SBE blended activity package, was developed in one higher education institute (HEI) in Wales to meet placement capacity demands. The SCP is aimed at accommodating large cohorts of students to meet their clinical learning outcomes, whilst offering increased equity of clinical learning opportunities that might be achieved in clinical placements. Despite simulation being well established as a pedagogical approach, the SCP is a novel solution for replacing clinical hours, requiring evaluation, which has yet to be undertaken. This study aims to explore students' perceptions of the use of an SCP to determine if it sufficiently and effectively replaces clinical placement hours for final year radiography students.

SBE has been evidenced as a suitable partial replacement for clinical placement in nursing, therapeutic radiography, and other allied health professions.[6,10–13] Within the field of diagnostic radiography specifically, Partner et al.[9] evaluated the replacement of one week of clinical placement with SBE and evidenced increased student confidence, enhanced awareness of patient-centred care, and application of higher skill levels. Similarly, Kong et al.[14] found utilising SBE increased first-year radiography students' knowledge and confidence. Additionally, SBE enhances perceptions of self-efficacy, develops approaches to critical thinking[15] and provides transferable skills enhancing patient safety and communication abilities.[12,16,17] Despite a plethora of literature surrounding simulation, there is limited literature surrounding its use for replacing clinical hours within radiography more generally, despite its accelerated use post-pandemic for supporting radiography clinical placements.[18] A recent narrative review[19] identified only four studies using SBE activities as a replacement for radiography clinical activities, of which only two were related to diagnostic radiography, one occurring in Singapore[20] and one in the UK[9]; however, all four studies evidence positive outcomes for students. Although a role for simulation within diagnostic radiography education has been identified,[21] there is currently no definitive recommendation for the quantity of clinical placement that can be substituted. Beneficial experiences have been gained from 21 h to up to 2 years of SBE[9,10] or between 11 and 26 % of total clinical placement time,[13,22] with a multi profession consensus opinion indicating up to 30 % of clinical time can be replaced.[23] Further to this, no standard approach to providing SBE exists for diagnostic radiography students, with the majority of SBE being developed for sporadic use, or out of necessity.[24] In order to maximise the benefits of SBE, a strategic approach informed by prior research, student experience, placement provision, and regulatory body guidance, should be considered prior to embedding SBE into any radiography curriculum.[25]

Despite SBE being an established option to manage increased clinical capacity whilst ensuring quality, relevant experiences that complement and enhance clinical practice,[26] prior research is restricted to first-year radiography students' perceptions and experiences. This study aims to contribute to the evidence base required to strategise and build upon current literary findings by exploring final-year students' perceptions of participating in a newly designed SCP package, having previously completed 2 years of a prior package.

Methods

The SCP package

The SCP package is newly designed and replaces a total of 17 % of final year (Level 6) clinical hours, with students attending a single SCP week per clinical placement block. A prior package was delivered at level 5 (see supplementary file 1), however this contained self-directed study activities, with no direct facilitation. Effective SBE should be designed to reproduce real-world situations[27–29] build on conceptual frameworks, and be underpinned by theory,[30] therefore the new package was re-designed to meet the clinical module learning outcomes using the following:

- A conceptual framework for Virtual Reality (VR) use,[31] allowing students to use immersive VR equipment to perform x-ray examinations in a simulated, risk free environment, ultimately contributing to an assessed portfolio.
- A theoretical model for delivering patient centred care,[32] which was embedded into a simulated scenario, and utilised an audit tool to evaluate and reflect upon patient centred care provision for dementia sufferers.
- Browne and Philips' 5-stage scaffolded approach to integrating simulation into healthcare curricula,[33] whereby students engaged in online learning, attended a facilitated practical, participated in a facilitated simulation scenario, undertook further remote simulation utilising VR, and then returned to clinical practice to exercise skills learnt.
- A six phase internationally recognised simulation framework[34,35] providing a standardised approach to all simulation sessions by means of preparation, briefing, simulation, debriefing, reflection and evaluation.

Students participated in a blend of activities including self-directed study, briefings, facilitated simulation scenarios, debriefs, online quizzes, individual reflections, timed simulation scenario escape rooms, and immersive virtual reality simulation using Virtual Medical Coaching software. All reflective activities followed Gibbs reflective cycle,[36] and debriefs followed the PEARLS Healthcare Debriefing model,[37] with both frameworks being selected for their adaptability to different simulation activities[36,38] and familiarity due to use elsewhere in the programme. Face-to-face sessions were facilitated by clinical and academic lecturers, all of which were provided facilitator training and guidance documentation. Students were provided an electronic workbook to guide them through activities and this formed part of their clinical portfolio. A typical weekly timetable can be seen in Fig. 1.

Methods

To obtain a contextualised understanding of the value of the SCP package and whether students deem it an acceptable alternative to clinical placement, a qualitative design was adopted to allow for a rich understanding of how students feel about the SCP and explore the factors influencing their perceptions. A focus group method was utilised to identify a varied scope of opinions, permitting a substantial quantity of data to be collected in a short period of time.[39] Focus group participants were volunteers from a purposive sample of 89 final year (level 6) students enrolled on one undergraduate diagnostic radiography and imaging (DRI) degree programme, in a Welsh university. Final year students were selected due to limited research in this student population. Participants were passively

Figure 1. Level 6 SCP timetable.

recruited via an announcement on their virtual learning platform, and via a poster in the university clinical workspace. Students were provided with a participant information sheet and were required to email the researcher expressing an interest in participating. All prospective participants completed an electronic consent form, which was physically and verbally affirmed prior to data collection. It was outlined to all participants that contributions would be pseudo-anonymised and would not impact academic progression or clinical achievements, in order to minimise social desirability bias. Researcher subjectivity was minimised by the inclusion of peer review of research methods, data analysis and transcripts by two experienced qualitative researchers. One focus group was formed and met as demonstrated in the timeline in Fig. 2.

A focus group schedule (see supplementary file 2) was developed to guide discussion, with input from the programme team and informed by prior research.[9] The guide contained open ended questions to explore participants' perceptions and experiences of SCP, skill transferability, and its acceptability for replacing clinical placement hours, meeting the research aim. Following review by a Patient and Public Involvement (PPI) contributor, and pilot testing, no changes were recommended or made. Focus group meetings were solely facilitated, audio recorded and anonymously transcribed by the researcher ensuring no reasonable risk of participants being identified, with all transcripts being provided to the participants to check for accuracy and minimise researcher subjectivity. Transcribed data was inductively coded using NVivo12 software and subsequently thematically analysed using Braun and Clarke's framework.[40] Coding and theme generation were independently reviewed by two experienced qualitative researchers.
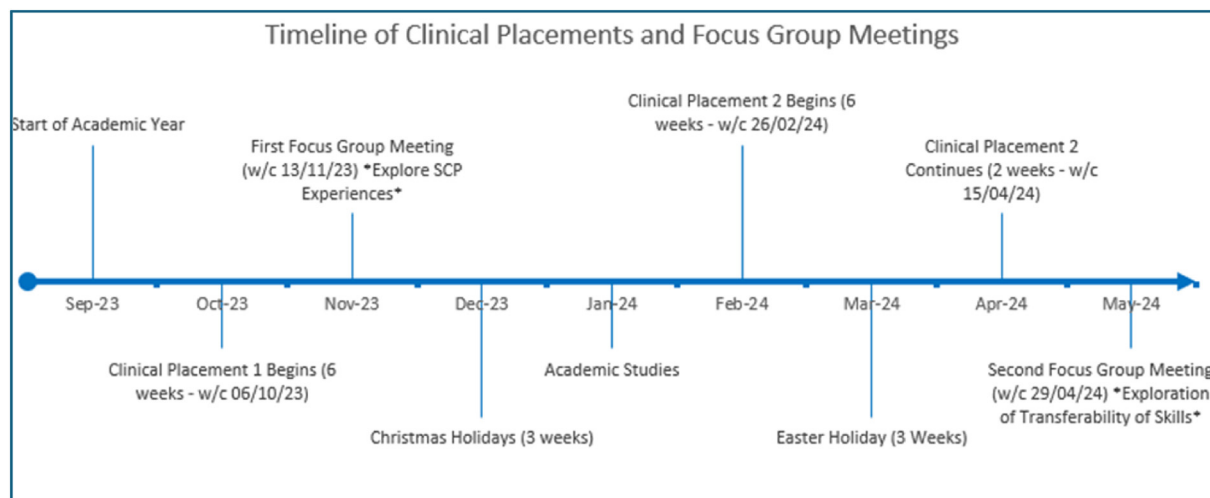

Figure 2. Timeline of clinical placements and focus group meetings.

To safeguard participants' well-being, rights, and dignity within the study, a favourable ethical outcome (REC1127) was obtained from the appropriate School Research Ethics Committee (SREC).

Results

A total of 8 students were recruited and participated in both focus group meetings. Four key themes were identified, which were refined through iteration and validated by peer review and a reflexive log. The themes are demonstrated in Fig. 3.

Preconceptions and prior experiences

Participants mostly held negative preconceived opinions regarding the replacement of clinical practice time using a simulation week due to the delivery of a prior restricted package, leading to shared feelings of low expectations, apprehension and uncertainty before the new SCP package was delivered.

"I think a lot of us have apprehension going into it because of the experience of [previous package], it wasn't well guided. It was a bit of a week off of placement" SCP2669.

The initial negativity changed throughout the SCP experience, with a positive consensus among the participants surrounding their enjoyment of the SCP week by the end of delivery, with activities being described as supportive for clinical placement, thought-provoking and fun.

"I think it was also really good because there was a nice balance between working through the scenarios and its actually helpful for clinical practice, and it's also fun for us" SCP2669.

Student participants applauded the balance between learning opportunities, and the activities being enjoyable, engaging and stimulating, ultimately feeling that the enjoyment meant they did not realise they were learning at the same time.

SCP provision

The provision of SCP had a varied influence on perception, with participants reporting that facilitation and realism of scenarios had the most significant impact on experience and learning. Students favoured facilitated sessions, as they allowed for additional learning opportunities, reflective debriefs, helped to inform student learning, and increased opportunities for staff to share real-world experiences.

"their experience can inform [learning] … they can tell their story of what happened after they see how you dealt with it" SCP3369.

Presence of a facilitator had a universally positive influence on participant experience; however it was raised that there was some inconsistency with facilitation approaches which resulted in inequitable learning opportunities for some students. Sessions not facilitated by staff, such as in the Virtual Reality (VR) suite, invoked feelings of ambiguity amongst participants.

"you can't tell if you're competent or not if no one is checking and saying if you're doing it correctly" SCP7776.

Students were provided with a workbook to guide them through the images to produce in the VR suite, however it was felt that accessible resources for comparing against 'gold standard' imaging examples, and the presence of a staff member as a 'point of contact', or as a virtual facilitator, would be beneficial.

Participants felt the SCP activities had a fairly low realism compared with clinical practice, particularly within the simulated scenarios. X-ray mannequins were used at times, to allow radiographs to be produced, which was felt to limit the opportunity to enhance communication skills.

"when you are dealing with a mannequin, you can't really talk to it like you would a real person in a clinical setting" SCP2669.

Additionally, students felt the virtual reality software was occasionally restrictive, as actions normally required in clinical environments were not always truly replicated.

"everything is already set up; it's not like real world … in VR you can expose without closing the door" SCP2266.

However, these limitations were not felt to restrict the learning opportunity and instead allowed students the opportunity to attempt more difficult radiographic projections focussing solely on positioning and technique, and further enhanced the variety of debrief discussion topics.

Learning conducive to confidently meeting professional standards

All students conveyed that the SCP package generally enhanced their confidence, with some reporting confidence increase surrounding a specific area of their clinical practice which aligned with benchmark expectations required for professional registration.[41,42] These areas predominantly included increased communication capability, enhanced capacity for working with others, and appreciation for reflective practice, however students also reported enriched radiographic technique knowledge as a result of VR, and improved capacity for patient and public care provision. The SCP further positively influenced confidence in clinical departments and subsequently, successful knowledge and skill transfer.

"I found the MRI [simulation escape room] useful … having prior knowledge of you know the form you have to fill out, I was able to go through that in depth with patients and have an understanding
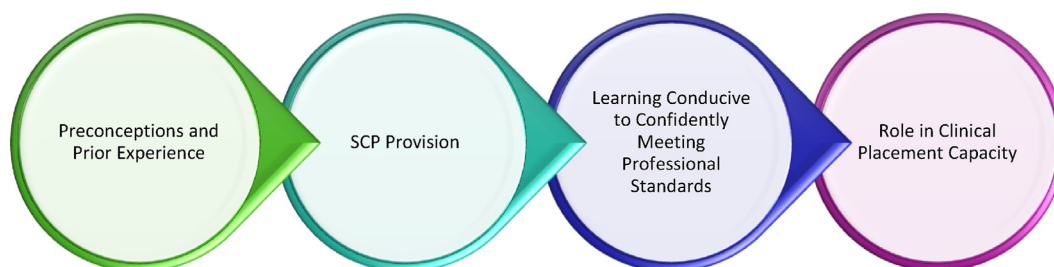

Figure 3. Four key themes identified during thematic analysis.

and be confident enough to do that because of that situation and scenarios that we all did" SCP2669.

Students demonstrated a positive unanimity regarding the transferability of knowledge and skills to their clinical placements, primarily as a result of reflection and debriefing.

Students further reported an improvement in their awareness, confidence and approach to communication, predominantly with carers of complex patients, ultimately helping them to provide a more holistic patient experience.

"One thing that really was emphasised was the [communication with] carers … it's so fast paced, they come in, you don't really utilise them, and you [X-ray] the patient, but they are a wealth of knowledge" SCP2669.

"Patient centred care definitely improved, just with the use of carers involvement" SCP2266.

Additionally, students also reported the SCP was an opportunity to meet and work with colleagues they may not otherwise work with, ultimately improving their adaptability to teamworking, principally their awareness of their specific role within a team.

"I thought that was a great balance of learning and fun, whilst also building a rapport and like teamwork with people you may not have encounter in lectures … you have to work with different people, and it's a skill that were gonna need of the workplace" SCP2669.

Within these groups, students were encouraged to complete regular reflections, in the form of debriefs, as well as independent reflections using Gibbs reflective model.[36] As a result, several students reported an increased appreciation of the value of meaningful reflective practice, with resulting positive influences on clinical practice.

"I think one big thing as well that the SCP week changed for me was my opinions on reflections … it's given me a new appreciation for that" SCP2669.

"[The action plan] allowed you to reflect on an area that I wanted to improve on … I've seen, like, a clear improvement with my paediatric work because the action plan … so that's directly sort of impacted my practice" SCP2669

Students were provided protected time to undertake group and individual debriefs, along with resources to support and monitor the reflection process.[36,37] These actions subsequently fostered a positive culture towards reflective practice. Ultimately, it was established that the SCP package was helpful for enhancing confidence and skills that are conducive to meeting professional standards.

Role in clinical placement capacity

Despite students reporting positive experiences and ample learning opportunities, the SCP package was not perceived to be a suitable replacement for their clinical placement hours, with many students reporting they still did most of their learning in the clinical department.

"I don't think it's a replacement for clinical experience. It's a useful adjunct to it. It's nice to have that time to do your reflections, to do the scenarios, do the escape rooms. It's nice to have some time to focus on what you're doing in practice, but it certainly doesn't replace it" SCP3359.

"I think it's an 'alright' substitute but you're never gonna be able to replace the value of time in a clinical space or clinical placement. That's where I have done most of my learning" SCP2669.

Subsequently, it was raised there is also a significant difference between using SCP as a coping strategy for increased cohort size, as was the case in this institute, and using SCP to enable further increased enrolments, with participants reporting that it should not be adopted for the latter.

"It's the difference between using [SCP] as a tool to increase, versus using it as a tool to cope with the increase, I think as a tool to cope with the increase, great, but as a tool to like to go 'Oh well, we can get even more people again', I'd say no" SCP3578.

It was felt that SCP was a suitable supplement to clinical placement learning and clinical hours, but could not replace the value of clinical time, and should only be used as a coping strategy, and not as a tool to acquire further increased student enrolments.

Discussion

SBE as a replacement of clinical placement hours, although innovative and employed in other professions, is still a novel issue within diagnostic radiography, with limited research and guidance on implementation and impact. Supporting the findings of this study, several studies evidence that simulation and immersive technologies are a beneficial tool for significantly enhancing students' clinical skills and confidence, particularly within radiography education,[21,25,43−45] however these studies were not all in relation to clinical replacement.

Recent findings by Chau, Arruzza and Johnson,[46] whose students endorsed the use of simulation as a complementary learning tool rather than a replacement of clinical hours, further support the findings of this research. Similarly, a study conducted by Larue, Pepin and Allard[7] established substituting clinical placement with simulation activities does not have a significant impact on clinical competency, confidence, and skills, even when 50 % of clinical time is replaced with simulation. However, when used as an adjunct to clinical placement, there were significant improvements in student capability, suggesting that simulation is more suitable as an adjunct, not a replacement, and that clinical placement experience is a significantly influential factor in developing confidence and skills. These findings also support the concept that the gold standard for practice-based learning is still in a real-world clinical environment,[6] aligning with the study findings that most students felt they still did most of their learning in the clinical departments. Despite research findings advocating the use of simulation as an adjunct to clinical learning, there are several studies within radiography that have contrasting findings.[9,12]

The lack of suitability for replacing clinical placement is contrary to findings by Ketterer et al.[12] who found partial replacements of clinical placements in therapeutic radiography practicable, and advantageous to the HEI and stakeholders, by reducing training burden on staff and students. Supporting this are findings by Partner et al.,[9] who established a simulation-based package to be a suitable replacement for one week of clinical placement, however this is one week less than the SCP package, and solely related to first year radiography students, whose expectations have not been negatively influenced by previous simulation packages. Participants of this study have experienced a varied provision regarding their clinical placements throughout their studies, including an unfacilitated simulation package and the current SCP package. This resulted in some participants feeling clinical time had been taken away from

them, rather than viewing the SCP package as a tool to enable equity in clinical placement learning opportunities. Negative sentiments, and lacking appropriate prior experiences, can make it more difficult to gain support for implementation of simulation packages.[47] As a result, implementing a simulation package from the start of an educational programme that does not replace clinical placement hours, may be influential in building positive experiences and emotions towards radiography simulation.

The SCP package was designed out of necessity to support an increase in commissioned student places, and provide equitable clinical learning opportunities, as are most simulated clinical placements.[48] However, there is a significant difference between using SBE interventions as a viable strategy for managing increased cohort size and using SBE to encourage increased student numbers. Adopting SBE placements have been evidenced as a suitable coping strategy,[9] however as a tool to acquire larger cohort sizes, it raises several concerns. Larger cohort sizes could result in increased group sizes for SBE activities and reduce the validity and effectiveness of the learning opportunities.[49] Additionally, some educational providers may use the scalability and flexibility of simulation, particularly immersive technologies, to acquire larger student cohorts to satisfy the high demand for radiography graduates, address workforce shortages, and generate significant supplementary revenue for HEI's where enrolled students pay annual tuition.[50] Although appealing, using simulation for these purposes requires careful consideration due to the numerous and varied challenges associated with implementing SBE, such as faculty commitment, training provision, facilitator expertise, and limited resources.[51] Additionally, finances are often a core and constraining factor in implementing SBE in many HEI's[19]. Furthermore, it has been suggested that using simulated placements as a coping strategy, and also as a means to intentionally increase student numbers cannot be accommodated simultaneously,[23] therefore establishing the true need for implementation of simulated placements will help to encourage safe and meaningful provision.

With conflicting findings regarding the use of SBE as a replacement of clinical hours within radiography, further investigation is needed to provide an evidence based strategy to integrate SBE into different radiography programmes when used for supporting placement capacity. There is currently no formal published direction on the quantity of clinical placement that can be replaced with SBE in Wales. The Health and Care Professions Council (HCPC), the radiography professional national regulatory body, provides flexibility for HEI's to deliver simulation where it is deemed effective for delivering quality clinical learning experiences and where quality of learning can be maintained.[5] However, there is no standard regarding using SBE for replacing clinical placement time, unlike nursing, where formal guidance on simulated practice learning is provided for HEI's who opt to implement SBE as a replacement of clinical placement time.[52,53] A focussed exploration of the quantity of clinical hours that can be completed with simulation activities would promote standardisation of practice amongst HEI's in keeping with the All Wales Simulation-Based Education and Training Strategy.[54] Whilst this strategy provides direction on standardising SBE delivery within healthcare, it does not provide guidance on replacing clinical placement time with simulation.

The use of SBE as a means of managing clinical placement capacity by replacing clinical hours is still a novel issue within diagnostic radiography, with limited research on the full extent of the impact this innovative solution may have on the future workforce, particularly in relation to skill transferability. A robust evaluation of simulated clinical placement learning and knowledge application in the clinical environment is required.[55] However, use of SBE as a means to develop and enhance clinical skills is well established in healthcare literature, therefore highlighting the need for an exploration of the relationship between SBE and student capacity management.

Study limitations

The study findings may have limited transferability to other HEI's as the SCP package was designed for one HEI's clinical placement learning outcomes, schedules, and facilities. Implementing an SCP package within other HEI's may require adaptions depending upon resources and clinical provision. Additionally, only a small sample of final year students participated, which may not be representative of all radiography students.

There is a possibility that participants were influenced by social desirability bias due to the researcher also being simulation lead for their programme, however efforts to mitigate this included pseudo-anonymising transcripts and verbatim quotes, gaining informed consent, and using participant information sheets to outline participation is entirely voluntary and will not influence their academic or clinical achievements in any way.

Conclusions

Overall, the SCP package was enjoyable and supportive to clinical learning, despite variations in facilitation and realism. The SCP package was successful in developing and enhancing confidence, and skills that are conducive to meeting the required standards for professional registration. Despite positive learning experiences, the SCP package was deemed insufficient to replace clinical placement hours, with many students doing most of their learning in the clinical departments. Subsequently, the SCP package should be used as a supplement, not a substitute, and only for accommodating already increased student numbers, not as a means to obtain larger student cohorts.

Ethical approval

To safeguard participants' well-being, rights, and dignity within the study, a favourable ethical outcome (REC1127) was obtained from the appropriate School Research Ethics Committee (SREC). The research was conducted following the Ethics Policy for Human Research, and in keeping with data protection legislation.

Conflict of interest statement

There is no conflict of interest declared.

Acknowledgements

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.radi.2025.102939.

References

1. The Royal College of Radiologists. *Clinical radiology census report*. 2021. https://www.rcr.ac.uk/sites/default/files/clinical_radiology_census_report_2021.pdf. [Accessed 29 May 2024].
2. Home Office. *Immigration rules appendix shortage occupation list*. 2022. https://www.gov.uk/guidance/immigration-rules/immigration-rules-appendix-shortage-occupation-list. [Accessed 28 May 2024].
3. The College of Radiographers. *Diagnostic radiography workforce UK census 2021*. 2021. https://www.sor.org/CMSPages/GetFile.aspx?guid=9dbc9e49-4b03-4e6c-83cf-bade28aef1bb&versionhistoryid=40703. [Accessed 29 May 2024].

4. Higher Education Statistics Agency. *What do HE Students study?*. 2023. https://www.hesa.ac.uk/data-and-analysis/students/what-study. [Accessed 28 May 2024].

5. Health and Care Professions Council. *Standards of education and training*. 2021. https://www.hcpc-uk.org/globalassets/resources/guidance/standards-of-education-and-training-guidance.pdf?v=637660865510000000. [Accessed 29 May 2024].

6. Roberts E, Kaak V, Rolley J. Simulation to replace clinical hours in nursing: a meta-narrative review. *Clin Simul Nurs* 2019;37:5−13. https://doi.org/10.1016/j.ecns.2019.07.003.

7. Larue C, Pepin J, Allard E. Simulation in preparation or substitution for clinical placement: a systematic review of the literature. *J Nurs Educ Pract* 2015;5(9):132−40. https://doi.org/10.5430/jnep.v5n9p132.

8. Hawker C, Diaz-Navarro C, Jones B, Mitra S, Cook SC, Bartholomew B. Developing an all-wales definition of simulation-based education. *Int J Healthc Simul* 2022;2:A40−1. https://doi.org/10.54531/INHM4618.

9. Partner A, Shiner N, Hyde E, Erret S. First year student radiographers' perceptions of a one-week simulation-based education package designed to increase clinical placement capacity. *Radiography* 2022;28:577−85. https://doi.org/10.1016/j.radi.2022.04.007.

10. Bogossian F, Cant R, Ballard E, Cooper S, Levett-Jones T, McKenna L, et al. Locating "gold standard" evidence for simulation as a substitute for clinical practice in prelicensure health professional education : a systematic review. *J Clin Nurs* 2019;28:3759−75. https://doi.org/10.1111/jocn.14965.

11. Chu E, Sheppard L, Guinea S, Imms C. Placement replacement: a conceptual framework for designing simulated clinical placement in occupational therapy. *Nurs Health Sci* 2019;21:4−13. https://doi.org/10.1111/nhs.12551.

12. Ketterer S-J, Callender J, Warren M, Al-Samerraie F, Ball B, Calder K-A, et al. Simulated versus traditional therapeutic radiography placements: a randomised controlled trial. *Radiography* 2020;26:140−6. https://doi.org/10.1016/j.radi.2019.10.005.

13. Soccio D. Effectiveness of mental health simulation in replacing traditional clinical hours in baccalaureate nursing Education. *J Psychosoc Nurs Ment Health Serv* 2017;55:36−43. https://doi.org/10.3928/02793695-20170905-03.

14. Kong A, Hodgson Y, Druva R. The role of simulation in developing clinical knowledge and increasing clinical confidence in first-year radiography students. *Focus Health Prof Educ: A Multi-Prof J* 2015;16:29−44. https://doi.org/10.11157/fohpe.v16i3.83.

15. Chui G. *Radiographer level of simulation training, critical thinking skills, self-efficacy, and clinical competence*. Dowling College; 2013. PhD Thesis, https://eric.ed.gov/?id=ED555818. [Accessed 29 May 2024].

16. Aura S, Jordan S, Saano S, Tossavainen K, Turunen H. Radiography transfer of learning: radiographers' perceptions of simulation-based educational intervention. *Radiography* 2016;22:228−36. https://doi.org/10.1016/j.radi.2016.01.005.

17. Shepherd C, McCunnis M, Brown L, Hair M. Investigating the use of simulation as a teaching strategy. *Nurs Stand* 2010;24:42−8. https://doi.org/10.7748/ns2010.05.24.35.42.c7751.

18. Short M, Giles E. Innovative strategies implemented by universities to support medical radiation science students during the COVID-19 pandemic. *J Med Radiat Sci* 2021;68:482−8. https://doi.org/10.1002/Fjmrs.558.

19. Jimenez Y, Gray F, Di Michele L, Said S, Reed W, Kench P. Can simulation-based education or other education interventions replace clinical placement in medical radiation sciences? A narrative review. *Radiography* 2023;29:421−7. https://doi.org/10.1016/j.radi.2023.02.003.

20. Tay Y, Sng L, Chow H, Zainuldin M. Clinical placements for undergraduate diagnostic radiography students amidst the COVID-19 pandemic in Singapore: Preparation, challenges and strategies for safe resumption. *J Med Imag Radiat Sci* 2020;51:560−6. https://doi.org/10.1016/j.jmir.2020.08.012.

21. Shiner N. Is there a role for simulation-based education within conventional diagnostic radiography? A literature review. *Radiography* 2018;24:262−71. https://doi.org/10.1016/j.radi.2018.01.006.

22. Nursing and Midwifery Council. *Standards for pre-registration nursing programmes*. 2023. https://www.nmc.org.uk/globalassets/sitedocuments/standards/2024/standards-for-pre-registration-nursing-programmes.pdf. [Accessed 6 November 2024].

23. Bridge P, Adeoye J, Edge C, Garner V, Sharp J. Simulated placements as partial replacement of clinical training time: a delphi consensus study. *Clin Simul Nurs* 2022;68:42−8. https://doi.org/10.1016/j.ecns.2022.04.009.

24. Shiner N. Time for simulation strategy? *J Med Radiat Sci* 2023;70:6−108. https://doi.org/10.1002/jmrs.685.

25. O'Connor M, Stowe J, Potocnik J, Giannotti N, Murphy S, Rainford L. 3D virtual reality simulation in radiography education: the students' experience. *Radiography* 2021;27:208−14. https://doi.org/10.1016/j.radi.2020.07.017.

26. Shiner N, Pantic V. An overview of the types and applications of simulation-based education within diagnostic radiography and ultrasound at two higher education institutions. *Imag Oncol* 2019:6−13. https://www.sor.org/getmedia/9552add0-39bd-41dc-aefc-e6525d2e5ec3/io_2019_lr.pdf_1. [Accessed 28 May 2024].

27. Buckley S, Hensman M, Thomas S, Dudley R, Nevin G, Coleman J. Developing interprofessional simulation in the undergraduate setting: experience with five different professional groups. *J Interprof Care* 2012;26:362−9. https://doi.org/10.3109/13561820.2012.685993.

28. Lonn L, Edmond J, Marco J, Kearney P, Gallagher A. Virtual reality simulation training in a high-fidelity procedure suite: operator appraisal. *J Vasc Intervent Radiol* 2012;23:1361−6. https://doi.org/10.1016/j.jvir.2012.06.002.

29. Patel R, Dennick R. Simulation based teaching in interventional radiology training: is it effective? *Clin Radiol* 2017;72:266.e7. https://doi.org/10.1016/j.crad.2016.10.014. 266.e14.

30. Shiner N. Can simulation impact on first year diagnostic radiography students' emotional preparedness to encounter open wounds on their first clinical placement: a pilot study. *Radiography* 2019;25:294−300. https://doi.org/10.1016/j.radi.2019.04.009.

31. Taylor B, McClean G, Sim J. Immersive virtual reality for pre-registration computed tomography education of radiographers: a narrative review. *J Med Radiat Sci* 2022;70:171−82. https://doi.org/10.1002/jmrs.657.

32. Hyde E, Hardy M. Patient centred care in diagnostic radiography (Part 1): a qualitative study of the perceptions of service users and service deliverers. *Radiography* 2021;27:8−13. https://doi.org/10.1016/j.radi.2020.04.015.

33. Browne E, Philips M. Developing a framework for the integration of skills and simulation: the 5-stage approach. *Int J Healthcare Simul* 2021;1:54. https://doi.org/10.54531/KYBT8535.

34. Jolly B, Nestel D, Sprick C. Module C2: training simulation educators. In: *NHET-Sim program*; 2012. http://www.nhet-sim.edu.au/. [Accessed 29 May 2023].

35. Health Education and Training Institute. *The SIM guide*. 2015. https://www.heti.nsw.gov.au/__data/assets/pdf_file/0009/509319/TheSimGuide_AlliedHealth_2017_waraheti_logo_V2.pdf. [Accessed 11 June 2023].

36. Gibbs G. *Learning by doing: a guide to teaching and learning methods*. Oxford Centre for Staff and Learning Development; 2013.

37. Bajaj K, Meguerdichian M, Thoma B, Huang S, Eppich W, Cheng A. The PEARLS healthcare debriefing tool. *Acad Med* 2018;93:336. https://doi.org/10.1097/ACM.0000000000002035.

38. Eppich W, Cheng A. Promoting excellence and reflective learning in simulation (PEARLS): development and rationale for a blended approach to health care simulation debriefing. *Simulat Healthc J Soc Med Simulat: J Soc Simul Healthc* 2015;10(2):106−15. https://doi.org/10.1097/SIH.0000000000000072.

39. Hennink M, Hutter I, Bailey A. *Qualitative research methods*. London: SAGE Publications; 2020.

40. Braun V, Clarke V. Using thematic analysis in psychology. *Qual Res Psychol* 2006;3:77−101. https://doi.org/10.1191/1478088706qp063oa.

41. Health and Care Professions Council. *Standards of conduct, performance and Ethics*. 2024. https://www.hcpc-uk.org/globalassets/resources/standards/standards-of-conduct-performance-and-ethics-2024.pdf. [Accessed 10 October 2024].

42. Health and Care Professions Council. *Standards of proficiency*. 2023. https://www.hcpc-uk.org/globalassets/resources/standards/standards-of-proficiency---radiographers.pdf. [Accessed 10 October 2024].

43. Warren J, Luctkar-Flude M, Godfrey C, Lukewich J. A systematic review of the effectiveness of simulation-based education on satisfaction and learning outcomes in nurse practitioner programs. *Nurse Educ Today* 2016;46:99−108. https://doi.org/10.1016/j.nedt.2016.08.023.

44. Halkett G, McKay J, Shaw T. Improving students' confidence levels in communicating with patients and introducing students to the importance of history taking. *Radiography* 2011;17:55−60. https://doi.org/10.1016/j.radi.2010.02.006.

45. Hustad J, Johannesen B, Fossum M, Hovland O. Nursing students' transfer of learning outcomes from simulation-based training to clinical practice: a focus-group study. *BMC Nurs* 2019;18. https://doi.org/10.1186/s12912-019-0376-5.

46. Chau M, Arruzza E, Johnson N. Simulation-based education for medical radiation students: a scoping review. *J Med Radiat Sci* 2022;69:367−81. https://doi.org/10.1002/jmrs.572.

47. Baayd J, Heins Z, Walker D, Afulani P, Sterling M, Sanders J, et al. Context matters: factors affecting implementation of simulation training in nursing and midwifery schools in north America, Africa and Asia. *Clin Simul Nurs* 2023;75:1−10. https://doi.org/10.1016/j.ecns.2022.10.004.

48. Beveridge J, Pentland D. A mapping review of models of practice education in allied health and social care professions. *Br J Occup Ther* 2020;83:488−513. https://doi.org/10.1177/0308022620904325.

49. Au M, Tong L, Li Y, Ng W, Wang S. Impact of scenario validity and group size on learning outcomes in high-fidelity simulation: a systematics review and meta-analysis. *Nurse Educ Today* 2023;121. https://doi.org/10.1016/j.nedt.2022.105705.

50. Acosta S, Lopez D. Enhancing radiography education through immersive virtual reality. *Radiography* 2024;30:42−50. https://doi.org/10.1016/j.radi.2024.09.054.

51. Al-Worafi YM. *Barriers of simulation research. Comprehensive healthcare simulation: pharmacy education, practice and research. Comprehensive healthcare simulation*. Cham: Springer; 2023. https://doi.org/10.1007/978-3-031-33761-1_43.

52. Nursing and Midwifery Council. *Simulated practice learning*. 2023. https://www.nmc.org.uk/standards/guidance/supporting-information-for-our-education-and-training-standards/simulated-practice-learning/. [Accessed 11 June 2023].

53. Nursing and Midwifery Council. *Simulated practice learning in pre-registration nursing programmes*. 2024. https://www.nmc.org.uk/globalassets/sitedocuments/simulated-practice-learning/reports/2024/evaluation-of-simulated-practice-learning-in-pre-registration-nursing-programmes.pdf. [Accessed 20 January 2025].

54. Health Education and Improvement Wales. *All Wales simulation-based education and training strategy for the healthcare workforce*. 2022. https://heiw.nhs.wales/files/all-wales-simulation-strategy-mg-draft-6pdf/. [Accessed 16 September 2024].

55. Kirkpatrick Partners. *The Kirkpatrick model*. 2024. https://www.kirkpatrickpartners.com/the-kirkpatrick-model/. [Accessed 14 February 2025].