Journal of Radiotherapy in Practice

Journal of Radiotherapy in Practice (2016)
15, 5–14 © Cambridge University Press 2016
doi:10.1017/S1460396915000527

Guest Editorial

Radiotherapy educational research: a decade of innovation

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(Received 12 October 2015; revised 25 October 2015; accepted 27 October 2015)

INTRODUCTION

Radiotherapy education has always been a rapidly moving and exciting field of practice. It has had to keep pace with rapid technological developments and evolving roles in both clinical and academic environments. The increasing impact and relevance of educational research on the profession and training is reflected in the introduction of a new 'educational note' format for JRP submissions. This editorial presents the context for this development by summarising the key factors influencing the changing face of radiotherapy education globally along with some thoughts regarding future directions in pedagogy and educational research.

Although this editorial focusses mainly on pre-registration education and training, it must be acknowledged from the outset that the development and extension of the professional workforce is also proving a rich source of radiotherapy education opportunities. The widespread adoption of advanced practice programmes around the world has reflected the move in the profession towards role extension for therapy radiographers. The various developments discussed in this article are equally valid for both continuing professional development (CPD) and formal further education. The recent audit from Probst et al.[1] clearly outlines the need for higher education institutions (HEIs) to help support this by providing post-graduate training opportunities and publication support for radiotherapy professionals. Optimising the workforce and delivering effective training are essential to ensure that tomorrow's workforce can help fulfil the UK 'vision for radiotherapy'[2] and equivalent international targets. Equally important is ensuring that practitioner-led research directly leads to widespread changes in practice; social media networks, local evidence-based practice champions and strong support from practitioner-led academic journals such as JRP can play a major role in facilitating this.

Published evidence over the last decade highlights the dramatic change in both radiotherapy clinical practice and education with clear parallels between clinical and academic development. Both the clinical department and the radiotherapy classroom have been transformed by developments in technology, visualisation and simulation, whereas academic curricula and clinical practice have been enriched by a commitment to reflective practice and patient involvement. Furthermore, both have had to keep pace with restructuring and upskilling of the workforce and embrace the power and challenges of collaboration. The published evidence addresses these issues in several key themes such as patient involvement, personal skills, technological advances, technology-enhanced learning, simulation and pedagogy. Clearly, the potential scope of this article is vast and rather than detail the full raft of educational issues and innovations, the aim of this piece is to provide an overview of these main themes arising in radiotherapy education research in order to define the context for the new submission format.

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PATIENT INVOLVEMENT

Patients (more recently known as 'service users') have formed an integral component of successful clinical training since the early days of medicine. Historically, contact with patients was confined to clinical practice, but now many health professions have responded to a call for greater patient involvement[3] across all aspects of pre-clinical training. A key benefit of engaging patients in the academic environment is that it changes the dynamic and constraints of the professional–patient relationship and allows students to ask questions that they perhaps would not feel comfortable asking in clinical departments.[4] Published benefits of involving patients in the medical education classroom are considerable and include value to both students and patients; a recent discussion paper[5] eloquently summarised the rationale and current status of patient involvement. Published impact of this includes increased empathy,[6] improved engagement[4,7] and reduced use of jargon.[8] From an educational perspective, the involvement of patients is frequently reported as helping to bridge the theory–practice gap in nursing,[9,10] radiography[11] and mental health.[12]

Patients can be involved in student medical education via a variety of different mechanisms. Towle's comprehensive review[13] outlined a detailed taxonomy for classifying these different levels of patient engagement with medical education programmes. These levels range from 'Level 1' where patient details are used as the focus of teaching activities to 'Level 6' where patients are involved in policy and curriculum planning at institution level. Recent research into patient involvement in radiotherapy education has been limited with a recent discussion paper[5] only locating four published papers. Unsurprisingly, within this limited evidence base, current publications mostly evidence Levels 3 and Level 4 where patients share experiences[14] or help with teaching or evaluating students.[15] Outcomes from research in this field predominantly relate to the impact of the interventions on the quality of student experience. It is clear that more in-depth evaluation and publication relating to patient involvement is sorely needed. In particular, it would be interesting to see extension of the evidence base across the full range of Towle's taxonomy along with some evidence quantifying its specific value for student professional practice and the long-term impact on the patient experience.

PERSONAL SKILLS

The modern curriculum embeds a range of activities and teaching that aims to nurture development of reflective practice, emotional intelligence (EI) skills and resilience. Reflection was first postulated as a valuable professional development tool in the late 1980s[16] and slowly gained in popularity, featuring as the focus of debate in one of the first JRP editions in 1999.[17] It dramatically increased in prevalence and importance to radiotherapy in the 2000s when mandatory recording of CPD activities became a common professional body requirement.[18] The modern practitioner is required to maintain a reflective portfolio and evidence reflection on their practice. Formal integration of reflective learning and portfolio development outcomes into educational curricula has therefore been widely introduced to help prepare students for future reflective practice. Reflection brings an additional academic skill to the traditional blend of explanation, evaluation and literature skills.

Teaching and assessment[19] of reflective practice rationale, theory and models is now only one component of personal skills development. Research[20] links reflective practice to self-awareness elements of EI. EI abilities are evidently deemed as valuable to health professionals with a recent publication suggesting that they should be core competencies[21] and proposing a link with success and resilience.[22] Increasing interest in possible development of EI is evident from recent longitudinal tracking results.[23] A variety of techniques have been reported as beneficial for developing personal skills throughout the student learning journey including narrative journaling,[20] EI training[24] and interprofessional workshops.[25] Although evidence supports the value of EI for health professionals, the topic is fraught with controversy. The multifactorial nature of professional development presents a challenge in identifying the exact role of EI. Furthermore, debate continues concerning its

https://doi.org/10.1017/S1460396915000527 Published online by Cambridge University Press

classification as a trait or ability and the extent to which its elements can be measured and improved. Reflection on the other hand suffers from a lack of evidence supporting its value to clinical practice, but is easier to measure with some useful developed reflective marking models.[26] It is commonly accepted that reflection, EI, empathy and resilience are increasingly vital skills for today's radiotherapy graduates. There is a real need for stronger evidence concerning the value and roles of these potentially valuable educational outcomes as well as pedagogical theories to support their effective development within the modern curriculum.

CLINICAL TECHNOLOGY ADVANCES

Radiotherapy clinical practice has undergone rapid technological development over the last decade with advances including multimodality imaging,[27] a range of image-guided radiation therapy (IGRT) technology,[28] volumetric arc therapy (VMAT)[29] and proton therapy.[30] Not only have these developments outpaced those in many other professions, but the different uptake rates have created a uniquely diverse range of clinical environments. This presents a challenge not only to clinical staff but also to educators who must ensure that students are well equipped to engage with new technology and embrace a rapidly evolving environment. In order to respond to these changes, radiotherapy education has had to ensure that students are both prepared to use new equipment and equipped with the necessary skills to adapt to future change.

The first of these requirements is supported by the 10-year vision document,[2] which clearly states the importance of aligning curricula with changes in practice. This necessitates horizon scanning,[31] understanding of current practice[32] and active engagement with manufacturers, research teams and professional bodies. In terms of skills development, the evidence base clearly shows that technological innovation such as IGRT increasingly demands much greater clinical decisionmaking from therapy radiographers.[33] Although sound decisionmaking must be informed by clinical experience, it is important that students develop core understanding of the process and requirements as well as an enquiring and critical mind. An additional challenge arises when judging the extent to which students should be immersed in emerging specialised technology that they may not encounter for years after qualification. Linked with this are the inevitable situations that may occur when students gain experience in technology such as VMAT planning that their clinical mentors may not have. Students have the luxury of devoted time to study and engagement with the emerging evidence base; hectic clinical schedules restrict this opportunity for most practitioners. It is, therefore, essential that education continues to not only provide for students but also help identify and assist with addressing skills gaps in the workforce arising from technique and technology development.[34]

The second element of radiotherapy education relating to technological advances is change management. With such a dynamic environment and the constant need for training in techniques[35] and equipment,[36] it is vital that students gain transferable skills and aptitudes. These include cognitive tools to evaluate new technologies and evidence, decision-making skills, the emotional capacity to reflect on their own development needs and a thirst for continuous learning. It is also important to ensure that introduction of teaching into new developments is not at the expense of interpersonal skills training and that core understanding from more basic technology is still retained.

The vision for radiotherapy[2] document reiterates the value of collaboration with regards to research and innovation. Although current research is clearly focussed on implementation of new technology, greater understanding of human factors and response to change is equally important and further research into how best to future-proof radiotherapy graduates is urgently required. Collaborative quantitative research into technological development should be partnered with qualitative research into how best to equip radiotherapy educators, students and the wider workforce for knowledge transfer and adaptability. In particular, it would be interesting to determine the optimal level of decision-making skills required by graduates and how best to ease the transition to clinical decision-making. It would also be useful to quantify the

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extent to which pre-registration understanding and skill development with complex technology or techniques is retained post-qualification.

TECHNOLOGY-ENHANCED LEARNING

It is not only clinical equipment that has been subject to rapid development, technology has revolutionised our everyday communication and knowledge transfer processes. Mobile technology and the rapid explosion of Internet resources have enabled instantaneous communication and access to an overwhelming range of facts, images and ideas. The learner of today has grown up with digital technology and generally has unparalleled access to information; in 2009, 82% of UK learners had home access to the Internet.[37] Different terms for the modern cohort have been proposed including Generation Y,[38] the Net Generation[39] or Millennial students.[40] These students typically have high levels of Internet and social media use. It is important to acknowledge that modern radiotherapy cohorts embrace a particularly diverse range of learners from school age to mature students; a broad-brush adoption of a single-learning style should be avoided. It is also important to distinguish between e-communication and e-learning; a 2012 study[41] indicated that face-to-face communication was still preferred by students in the United States and Norwegian Universities, whereas a study[42] into Year 1 English students' engagement with technology highlighted the distracting nature of social media. Despite this, technology impacts positively on student learning[43] and can facilitate a range of pedagogical strategies; chiefly that of 'blended' learning with its mixture of traditional and electronic learning tools. A recent meta-analysis[44] neatly summarised the challenges of unravelling the multiple factors impacting on student learning and identified a need for more rigorous primary research into blended learning benefits.

Despite the limited evidence base, it is fair to say that educational institutions have eagerly embraced the efficiency gains[45] and pedagogical power of digital communication technology. Modern radiotherapy students enjoy access to rich virtual learning environments providing them with immediate access to resources, assessment and feedback mechanisms, mobile learning facilitation and a raft of communication options. Today's classroom is significantly different from that of 10 years ago with recent developments increasing student access to and control of resources.

Figure 1 comprises four scenes illustrating how technology has impacted on the learning environment and shifted the 'focus of learning' from the lecturer towards the student cohort. Scenes 1 and 2 show how technology has expanded the focus from the lecturer alone to a combination of the lecturer and online learning resources. Scene 3 illustrates the recent trend of shifting from a tutor-centred learning environment towards a 'flipped classroom'.[46] The flipped classroom model draws on the rich availability of knowledge by providing students with resources via remote access before attendance at student-led seminars. This changes the focus of teaching time from knowledge provision to facilitating clinical application of knowledge and development of high-level academic skills. Scene 4 represents the current growth of mobile learning, with increasing use of independent learning and online resources facilitating individual learning. The focus of learning here is diffuse with each student experiencing their own blend of learning. Although the academic here is depicted in the office gazing wistfully at the students, it is unlikely that personal interaction will disappear from the radiotherapy academic environment. The emerging role of the tutor coordinating and facilitating remotely will need supplementing with personal contact to ensure development of interpersonal skills.

The nurturing of independent learning skills, however, should particularly benefit the future radiotherapy graduates and equip them for evidence-based practice and lifelong professional development. Further independent learning is facilitated by e-learning technology to support placement-based distance learning with both pre-registration students and post-graduate clinical staff[47] reporting high levels of satisfaction. E-learning has developed a unique role in the support of clinical learning with students able to access reflective portfolio and learning resources while in the clinical environment; this enables rapid capturing of reflection-in-action as well as optimising placement time.

https://doi.org/10.1017/S1460396915000527 Published online by Cambridge University Press

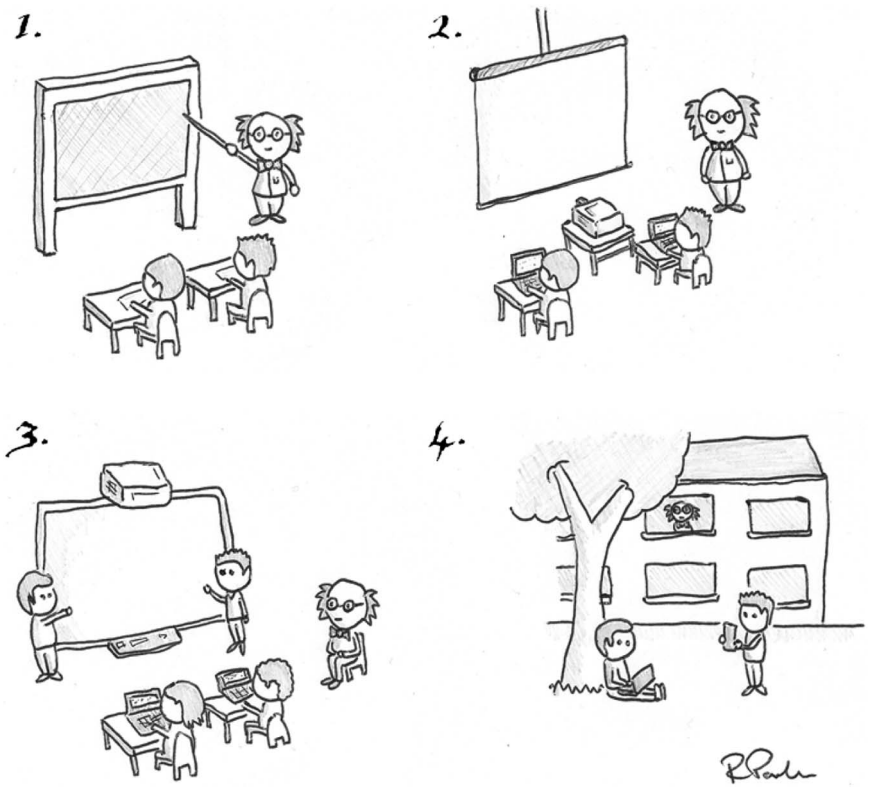

Figure 1. The evolution of the radiotherapy classroom.

The fusion of technology and traditional teaching methods can clearly help to cater for increasingly diverse cohorts[44] while nurturing enquiry-based independent learning. The increased potential for facilitation of independent learning and provision of flexible resources to suit a range of learning styles is of particular interest to radiotherapy education. In particular, e-learning is transforming traditional teaching into more personalised education with different resources and formats available for individual learners. This tailored approach mirrors the clinical drive towards personalised radiotherapy[48] and further research into how best to manage and optimise this would be useful.

An interesting offshoot of technology-enhanced learning has been the use of Open Access education, including Massive Open Online Courses, social network learning and online journal clubs. The future role of these is controversial and they bring a new series of challenges and opportunities to radiotherapy education. Although Open Access education has been seen as a temporary whim or even a threat to traditional educational models in some quarters, it does have great potential for collaborative learning, generating debate and sharing ideas; an essential aspect of helping to drive change.

Current educational research suggests that the increasing dependence on mobile technology will lead to drastically different pedagogical approaches[49] as seen in Figure 1 (Scene 4) and it will be interesting to see how this impacts on students' collaborative learning development. It is clear that the increasingly collaborative nature of the upcoming 'iGeneration' or 'Generation Z'[38] is going to radically change the face of radiotherapy education. It is important that academic and clinical educators prepare to embrace and support this new generation in academia and also that we prepare our clinical departments for forthcoming patients from Generation X.

SIMULATION

In health profession training, 'simulation' implies use of technology or techniques to replicate

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aspects of clinical practice and allow students to develop valuable skills in a safe environment. This allows for training in potentially complex procedures that were previously limited to 'in at the deep end' experiences on patients who desperately need the procedure to be performed correctly. Simulation is not a new educational tool in radiotherapy. Students have long been prepared for clinical practice through activities and equipment in academia; this ranges from simple communication role playing to use of non-clinical treatment planning systems. Simulation in radiotherapy has recently undergone a transformation, thanks to the introduction of virtual reality (VR) simulation.

VR simulation in radiotherapy demands replication of a 'whole-room' and the 'Virtual Environment for Radiotherapy Training' (VERT) software[50] continues to support pre-clinical radiotherapy training.[51] In the clinical environment, use of simulation in busy clinical departments has allowed some students to make good use of machine down time or practice for specific patient encounters without impacting on workflow. It is clear, however, that VERT's real strength lies in acquisition of technical and dosimetry evaluation skills as opposed to direct knowledge transfer. Carter et al.[52] failed to determine benefit for anatomy teaching, although this could possibly have been attributed to pedagogical technique. One of the criticisms of VERT-based simulation in radiotherapy has been the failure to deliver the promised expansion of clinical training capacity. VERT is certainly a valuable addition to clinical placement learning but users still lack the evidence base to support its use as a 'placement'.

It should also be noted that simulation encompasses a broad range of learning tools. In addition to technical skills development, simulation activities and equipment offer students opportunities to hone other essential radiotherapy skills. Research into a range of simulation systems is vibrant and extensive, covering a range of relevant skill acquisition opportunities. Studies have demonstrated the relative value of VR and simulation training over traditional methods for acquisition of interpersonal communication skills,[53] practical infection control skills[54] and nursing clinical skills.[55] Simulation is an ideal addition to and preparation for clinical practice, but given the wide range of potential factors, identifying the specific impact of this on student skills and patient outcomes is challenging. Much of the research relating to simulation reports qualitative outcomes based on student satisfaction and engagement; typically based on small cohorts. Published data is also largely restricted to conference presentations, with relatively few formal peer-reviewed articles contributing to the evidence base. More widespread high-quality evidence is urgently needed to establish the wider impact of simulation on student learning and, ultimately, patient experience.

VR simulation technology, in particular, is rapidly evolving, being heavily influenced by the lucrative gaming industry. There is great current interest in VR headsets to increase sense of embodiment and thus effect behaviour change.[56] Simulations such as Ball's dementia simulator[57] highlight the potential value of vastly increased immersion in more realistic virtual clinical environments. Indeed one author[58] has heralded VR headsets as 'redeeming' VR in higher education. Fundamental work establishing best practice in pedagogical guidelines and a move towards a more standardised approach to evaluation of VR-based resources should yield valuable data and help prepare the academic community for future developments in this space.

LIMITATIONS OF THE EVIDENCE BASE

One of the most commonly voiced maxims in radiotherapy concerns how small a world it is. The relatively small number of practitioners compared with other professions can be a challenge when seeking research funding or establishing a strong publication profile. The effect is also felt in academia with radiotherapy class sizes frequently dwarfed by those of other health science professions. Much of the evidence base concerning education in radiotherapy is therefore characterised and somewhat thwarted by small cohort sizes. The review of evidence revealed a mean cohort size of 42 (minimum = 1, maximum = 227) and a median of 24. Most (58%) of the cohort sizes were <40 with 25% being 40–80 and

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only two papers with cohorts over 100. This contrasts starkly to papers relating to education in nursing where cohorts numbering over 100 are commonplace[59–61] with correspondingly high statistical power.

Radiotherapy and academia both have a long tradition of independent development based around single institutions. The faces of both these environments are changing, however, with a growing enthusiasm for collaborative working and resource sharing, including the national radiotherapy dataset,[62] standardisation of practice[63] and audit of practice.[32] The true strength of collaboration in radiotherapy educational practice and research, however, lies in collaboration between multiple academic institutions and clinical departments as encapsulated by the UK Academic Health Science Networks.[2] There are certainly challenges to HEI collaboration,[64] including knowledge sharing and intellectual property issues, and it is clear that widespread adoption of collaborative practice will require a culture shift from resource guarding to resource sharing and an institutional-level commitment to collaboration in educational development. The benefits, however, include enriched skill mix, increased reliability of findings, higher quality published output, and a louder voice and stronger presence in the professional environment. More widespread endorsement of collaborative publication and projects at both editorial and institutional level is to be encouraged.

It should also be noted that much of the current evidence base in radiotherapy education consists of conference presentations and posters with few of these being written up as peer review articles. Although these formats are useful, when compared with other professions there is a real need for high-quality primary evidence that can be used to inform practice and drive change. The rapid rate of change in radiotherapy education means that expanding this evidence base should be a key priority.

CONCLUSION

It must be remembered that the primary objective of radiotherapy education is not simply to develop the best possible therapy radiographers but to improve patient experience and outcomes.

Radiotherapy education is a fundamentally important aspect of modern radiotherapy and, as this piece has demonstrated, mirrors clinical practice closely. Both academic and clinical worlds are transforming into reflective and patient-centred yet technological environments. The need to maintain pace with educational and clinical technology as well as the increasing diversity of students and clinical staff calls for a more collaborative approach. Against this backdrop of collaboration is the move towards personalised education and student-directed learning strategies.

What can be deduced from the evidence base and current strategic directions are a number of trends and innovations that are currently impacting on radiotherapy education and these form the base of the 'innovation and tools pyramid' in Figure 2. The next level up summarises the necessary enabling tools that will enable these to achieve the secondary and primary objectives towards the top of the pyramid. Research relating to collaborative implementation and evaluation of innovations along with the associated pedagogy is vital and it is the evolution and evaluation of these enabling tools that especially needs published support from research findings to ensure effective implementation and achievement. Firmer evidence in relation to these research directions will support the ultimate aim of radiotherapy education of not only improving student learning but making a definitive positive impact on the experiences and outcomes of our patients.

It can be seen that many of these themes parallel current clinical research and strategy; it is vitally important that this continues and that education remains a core and mutually supportive aspect of radiotherapy in practice. Although this brief overview cannot do justice to any of these areas it is hoped that it will stimulate ideas for new 'educational note' submissions and in turn that this new format will facilitate wider research and publication of radiotherapy education findings. JRP has always enjoyed a strong educational focus and I hope that the new

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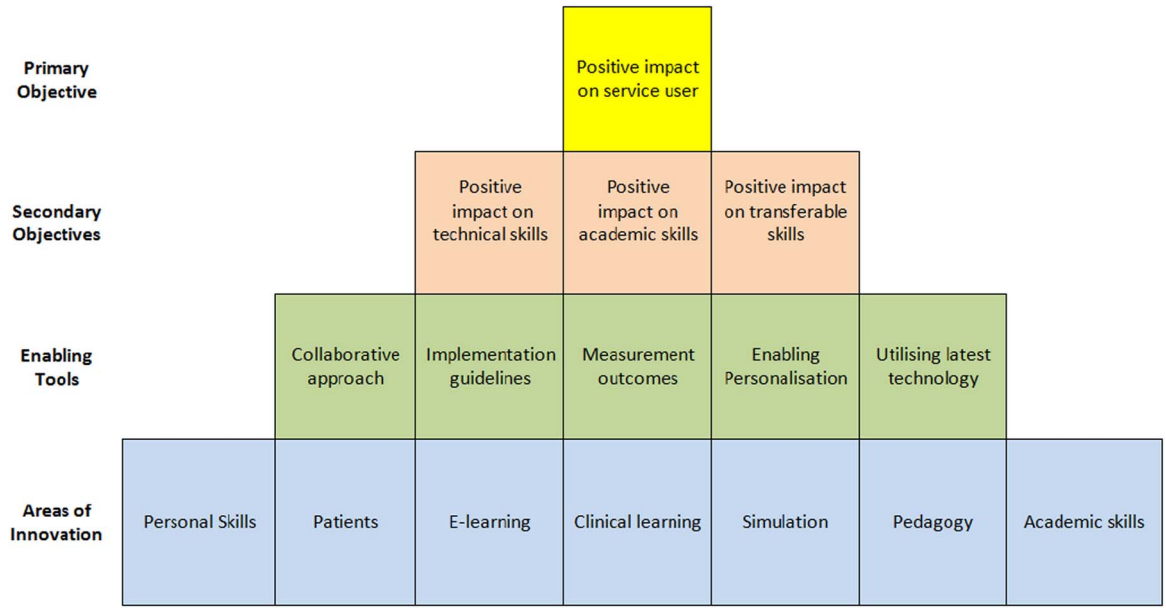

Figure 2. Radiotherapy education innovation and tools pyramid.

submission format will not only encourage dissemination of educational case studies and original pedagogical research, but also facilitate practice sharing of both pre-registration and post-graduate educational initiatives that will further training within the profession globally. The future awaits us and at JRP we await your educational innovation findings.

Acknowledgements

The author wishes to acknowledge the invaluable expertise and insight provided by Professor Heidi Probst and the artistic skills of Richard Parker.

Financial Support

None.

References

1. Probst H, Harris R, McNair H A, Baker A, Miles E A, Beardmore C. Research from therapeutic radiographers: an audit of research capacity within the UK. Radiography 2015; 21 (2): 112–118.
2. NHS England. Vision for radiotherapy (2014–2024). London: NHS, 2014.
3. Francis R. Report of the Mid Staffordshire NHS Foundation Trust Public Inquiry. London: The Stationery office, 2013.
4. Henriksen A H, Ringsted C. Learning from patients: students' perceptions of patient-instructors. Med Educ 2011; 45 (9): 913–919.
5. Hill G, Thompson G, Willis S, Hodgson D. Embracing service user involvement in radiotherapy education: a discussion paper. Radiography 2014; 20 (1): 82–86.
6. Gidman J. Listening to stories: valuing knowledge from patient experience. Nurse Educ Pract 2013; 13 (3): 192–196.
7. Stickley T, Stacey G, Pollock K, Smith A, Betinis J, Fairbank S. The practice assessment of student nurses by people who use mental health services. Nurse Educ Today 2010; 30 (1): 20–25.
8. Thomson D, Hilton R. An evaluation of students' perceptions of a college-based programme that involves patients, carers and service users in physiotherapy education. Physiother Res Int 2012; 17 (1): 36–47.
9. Carpenter R. Using story theory to create an innovative honors level nursing course. Nurse Educ Perspect 2010; 31 (1): 28–30.
10. Turnbull P, Weeley F M. Service user involvement: inspiring student nurses to make a difference to patient care. Nurse Educ Pract 2013; 13 (5): 454–457.
11. Bleiker J, Knapp K M, Frampton I. Teaching patient care to students: a blended learning approach in radiography education. Radiography 2011; 17 (3): 235–240.
12. Perry J, Watkins M, Gilbert A, Rawlinson J. A systematic review of the evidence on service user involvement in interpersonal skills training of mental health students. J Psychiatr Ment Health Nurs 2013; 20 (6): 525–540.

13. Towle A, Bainbridge L, Godolphin W et al. Active patient involvement in the education of health professionals. Med Educ 2010; 44 (1): 64–74.
14. Williamson K, White E, Pope E, Mundy L. Learning from patients—an example of service user involvement in radiotherapy education. Clin Oncol 2009; 21 (3): 253–255.
15. Bridge P, Pirihi C, Carmichael M. The role of radiotherapy patients in provision of student interpersonal skills feedback. J Radiother Pract 2014; 13 (2): 141–148.
16. Schon D. Educating the Reflective Practitioner. San Francisco, CA: Jossey-Bass Publishers, 1987.
17. Newnham J. To reflect or not? Reflective practice in radiation therapy. J Radiother Pract 1999; 1 (1): 109–116.
18. The College of Radiographers. A Strategy for Continuing Professional Development. London: SCoR, 2003.
19. Brackenridge S A. Perceptions of reflective practice among recent Australian radiation therapy graduates. Radiographer 2007; 54: 18–23.
20. Smith J. Emotional intelligence and professional education: the use of narrative journaling. Int J Learn 2009; 16 (7): 81–92.
21. Codier E, Codier D. Do emergency nurses have enough emotional intelligence? Emerg Nurs 2015; 23 (3): 26–29.
22. Libbrecht N, Lievens F, Carette B, Côté S. Emotional intelligence predicts success in medical school. Emotion 2014; 14 (1): 64–73.
23. Carmichael M, Bridge P, Harriman A. Emotional intelligence development in radiation therapy students; a longitudinal study. J Radiother Pract 2015 (In Press).
24. Fletcher I, Leadbetter P, Curran A, O'Sullivan H. A pilot study assessing emotional intelligence training and communication skills with third-year medical students. Patient Educ Couns 2009; 76: 376–379.
25. Flowers L K, Thomas-Squance R, Brainin-Rodriguez J E, Yancey A K. Interprofessional social and emotional intelligence skills training: study findings and key lessons. J Interprof Care 2014; 28 (2): 157–159.
26. Findlay N, Dempsey S, Warren-Forward H. Validation and use of the Newcastle Reflective Analysis Tool: a three-year longitudinal study of RT students' reflective journals. Reflect Pract 2010; 11 (1): 83–94.
27. Guden M, Ceylan C, Berberoglu K et al Contribution of PET-CT to staging, gross tumour volume definition, planning and response assessment in IMRT for nasopharyngeal carcinoma. J Radiother Pract 2011; 10 (4): 272–282.
28. Qi X S, Wu S, Newman F, Li X A, Hu A Y. Evaluation of interfraction patient setup errors for image-guided prostate and head-and-neck radiotherapy using kilovoltage cone beam and megavoltage fan beam computed tomography. J Radiother Pract 2013; 12 (4): 334–343.
29. Maungwe P, Chamunyonga C. A dosimetric retrospective planning study comparing volumetric arc therapy (VMAT) and stereotactic body radiotherapy (SBRT) treatment plans for non-small cell lung cancer (NSCLC). J Radiother Pract 2015; 14 (3): 260–267.
30. Bridge P. Does the photon have a future? An overview of potential benefits associated with hadron therapy. J Radiother Pract 2004; 4 (1): 25–32.
31. RANZCR. Techniques and technologies in radiation oncology—2011 Horizon Scan. RANZCR, 2011. http://www.ranzcr.edu.au/organisation/faculty-radiation-oncology/899-faculty-publication. Accessed on 12th November 2015.
32. Bridge P, Dempsey S, Giles E et al Practice patterns of radiation therapy technology in Australia: results of a national audit. J Med Radiat Sci 2015 (In Press).
33. Waldon A, Plank A, Middleton M. Analysis of online and offline head and neck image-guided radiation therapy. J Med Imaging Radiat Sci 2014; 45 (2): 79–84.
34. Hoskin P J, Bhattacharya I S. Protons and more: state of the art in radiotherapy. Clin Med 2014; 14 (suppl): s61–s65.
35. Sale C, Batson A. Implementing results of a change process at the Andrew Love Cancer Centre—the axillary technique. Radiographer 2011; 58 (3): 12–20.
36. Amols H I. New technologies in radiation therapy: ensuring patient safety, radiation safety and regulatory issues in radiation oncology. Health Phys 2008; 95 (5): 658–665.
37. Eynon R. Harnessing technology: the learner and their context; how young people use technologies outside formal education. Survey Report. Coventry: Becta, 2009.
38. Horowitz B. After Gen X, Millennials, what should next generation be? USA Today, 2012. http://usatoday30.usatoday.com/money/advertising/story/2012-05-03/naming-the-next-generation/54737518/1. Accessed on 12th November 2015.
39. Tapscott D. Grown Up Digital: How the Net Generation is Changing Your World. New York, NY: McGraw-Hill, 2009.
40. Howe N, Strauss W. The next 20 years; how customer and workforce attitudes will evolve. *Harvard Business Review*, 2007. http://hbr.org/2007/07/the-next-20-years-how-customer-andworkforce-attitudes-will-evolve/ar/1. Accessed on 12th November 2015.
41. Robinson S, Stubberud H A. Communication preferences among university students. Acad Educ Leadersh J 2012; 16 (2): 105–113.
42. Jones C, Healing G. Net generation students: agency and choice and the new technologies. J Comput Assist Learn 2010; 26 (5): 344–356.
43. Tamim R M, Mohammed H B, Bernard R M, Borokhovski E, Abrami P C, Schmid R F. What forty years of research says about the impact of technology on learning: a second-order meta-analysis and validation study. Rev Educ Res 2011; 81 (1): 4–28.

44. Bernard R M, Borokhovski E, Schmid R F. A meta-analysis of blended learning and technology use in higher education: from the general to the applied. J Comput High Educ 2014; 26 (1): 87–122.
45. Bridge P, Appleyard R M. A comparison of electronic and paper-based assignment submission and feedback. Br J Educ Technol 2008; 39 (4): 644–650.
46. Phillips C R, Trainor J E. Millennial students and the flipped classroom. J Bus Educ Lead 2014; 5 (1): 102–112.
47. Probst H, Eddy D, Doughty J. Integrating e-learning into postgraduate radiotherapy and oncology education: a case study. E-Learning 2009; 6 (4): 363–371.
48. Ree A H, Redalen K R. Personalized radiotherapy: concepts, biomarkers and trial design. Br J Radiol 2015; 88 (1051): 1–13.
49. Vazquez-Cano E. Mobile distance learning with smartphones and apps in higher education. Educ Sci Theory Pract 2014; 14 (5): 1505–1520.
50. Bridge P, Appleyard R M, Ward J W, Philips R, Beavis A W. The development and evaluation of a virtual radiotherapy treatment machine using an immersive visualisation environment. Comput Educ 2007; 49 (2): 481–494.
51. Flinton D. Competency based assessment using a virtual environment for radiotherapy. Proc Comput Sci 2013; 25: 399–401.
52. Carter P J, Birak K S, Magias D, Hulse M A, Willis S J. The effectiveness of the Virtual Environment Radiotherapy Training (VERT) system as a teaching tool for anatomy. The First Annual Cyberpsychology Conference (ACPC), 19 September, Leicester: De Montfort University, 2013.
53. James J, Sim J, McDonald M, Ryan T. Using second life for health professional learning: informing multidisciplinary understanding. Int J Mod Educ Forum 2012; 1 (1): 24–31.
54. Luctkar-Flude M, Pulling C, Medves J et al Development and evaluation of an interprofessional simulation-based learning module on infection control skills for prelicensure health professional students. Clin Simul Nurs 2014; 10 (8): 395–405.
55. Mosalanejad L, Shahsavari S, Sobhanian S. The effect of virtual versus traditional learning in achieving competency-based skills. Turk Online J Distance Educ 2012; 13 (2): 69–75.
56. Kim S Y, Prestopnik N, Biocca F A. Body in the interactive game: how interface embodiment affects physical activity and health behavior change. Comput Hum Behav 2014; 36: 376–384.
57. Ball S, Bluteau P, Clouder L, Adefila A, Graham S. myShoes: an immersive simulation of dementia. Proceedings of the European Conference on e-Learning, 2015: 16–23.
58. Waters J K. Could Oculus Rift redeem virtual reality in higher ed? Campus Technology Magazine 2014; 28 (3): 8–10.
59. Harris M A, Pittiglio L, Newton S E, Moore G. Using simulation to improve the medication administration skills of undergraduate nursing students. Nurs Educ Perspect 2014; 35 (1): 26–29.
60. Cunico L, Sartori R, Marognolli O, Meneghini A M. Developing empathy in nursing students: a cohort longitudinal study. J Clin Nurs 2012; 21: 13–14.
61. Rush S, Firth T, Burke L, Marks-Maran D. Implementation and evaluation of peer assessment of clinical skills for first year student nurses. Nurse Educ Pract 2012; 12 (4): 19–26.
62. Hoskin P J, Forbes H, Ball C, Riley D, Cooper T. Variations in radiotherapy delivery in England—evidence from the national radiotherapy dataset. Clin Oncol 2013; 25 (9): 531–537.
63. Haviland J S, Owen J R, Dewar J A et al The UK Standardisation of Breast Radiotherapy (START) trials of radiotherapy hypofractionation for treatment of early breast cancer: 10-year follow-up results of two randomised controlled trials. Lancet Oncol 2013; 14 (11): 1086–1094.
64. Siska J, van Swet J, Pather S, Rose D. From vision to reality: managing tensions in the development and implementation of an international collaborative partnership programme for institutional change and sustainable development in inclusive education. Int J Inclus Educ 2013; 17 (4): 336–348.

https://doi.org/10.1017/S1460396915000527 Published online by Cambridge University Press