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User evaluation of clinical simulation-based learning developed by FORCE (Framework for Online Radiographer Clinical Education)

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ABSTRACT

Introduction: The FORCE initiative, funded by the EU, was created in response to the COVID-19 pandemic's impact on radiography education. It offers a virtual learning environment (VLE) filled with clinical simulation scenarios targeting Diagnostic Imaging, Nuclear Medicine, and Radiotherapy. These scenarios are designed to provide open-access, simulation-based learning (SBL) resources that help radiography undergraduates engage in problem-based learning across relevant clinical knowledge and professional awareness. This study presents the results of an online survey aimed at evaluating the FORCE VLE and SBL resources to guide future development.

Methods: The survey targeted academic and clinical staff in Radiography and student Radiographers. It was based on the Course Experience Questionnaire (CEQ) and modified to include topics relevant to online learning, using a five-point Likert Scale (LS). The questionnaire consisted of four sections: research information and consent; socio-demographic data; LS-based questions on case structure, content, interactivity, technical aspects, multimedia quality, and overall experience; and open-text responses.

Results: Of the 407 invited participants, 109 (27 %) responded, with 77 % being students and 23 % clinical or academic radiographers from 13 countries. English proficiency was reported by 76 % of respondents. The median LS was consistently 4 across all categories, indicating high satisfaction. Content analysis of 159 open-text comments revealed 139 positive opinions on the SBL resources.

Conclusion: The FORCE VLE SBL resources were highly regarded for their interactivity, applicability, and support in consolidating knowledge and enhancing patient care. Suggestions for improvement were minor, mainly focusing on navigation and specific content preferences.

Implications for practice: Expanding the availability of online SBL cases could enhance Radiographer education and promote inclusivity across the field.

Introduction

As well as precipitating a global health crisis, the COVID-19 pandemic had international impact on clinical training schedules for student radiographers, and reinforced the need for alternate learning options within radiography curricula.[1] In 2020, in response to the impact of COVID-19 upon education, the European Union [EU] (under Erasmus + Key Action 2) issued a grant call seeking "Partnerships for Digital Education Readiness".[2] A successful bid led to the initiation of the FORCE project.

FORCE (Framework for Online Radiographer Clinical Education) is an EU grant-funded collaboration between Radiography staff in eight European higher education institutions. Between May 2021 and December 2023, the FORCE team developed a virtual learning

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environment (VLE) in Moodle which is hosted on the collaborative Digicampus platform (https://digicampus.fi/). The VLE is populated with clinical simulation scenarios, each with specific learning outcomes, and addressing examinations in Diagnostic Imaging (DI), Nuclear Medicine (NM), and Radiotherapy (RT). Each simulation comprises video footage of the simulated examination, overlaid and interspersed with textual learning content and interactive, problem-based learning material. Collaboration with Virtual Medical Coaching®/Skilitics® has enabled the DI simulations to be enhanced by the addition of a FORCE project version of 2D virtual simulation of the radiographic techniques.

The aim of the FORCE VLE and clinical simulations is to provide open-access simulation-based learning resources for radiography undergraduates to engage individually with problem-based learning across a range of clinically relevant knowledge and professional awareness. To our knowledge, similar open-access, interactive, simulation-based learning resources for radiography learners globally are not currently widely available. The FORCE VLE moved to open access in October 2023, and has been publicised through social media and at international conferences. Users log in to the VLE using their existing Google password – a feature needed to facilitate anonymous tracking of progress and to give feedback on the 2D virtual simulation elements. Readers can access the FORCE VLE via the QR code displayed as Fig. 1:

Literature review

Simulation-based learning

Technology developments and the increasing requirement to improve trainees' performance during complicated tasks are leading to new developments to assist the training of health care workers. One of these approaches is simulation-based learning (SBL). SBL facilitates delivery of a real-world experience that can be related to clinical practice. Both technical and social competencies can be acquired using simulation.[3] Evidence suggests that compared to traditional education of health care students, SBL using virtual patients is at least as effective at improving knowledge, and more effective at improving skills such as clinical reasoning, procedural skills, team skills, task completion and reflection.[4] Evidence also suggests that training and assessment based on simulation improve observance of best practice and can improve clinical outcomes, leading to eventual reductions in the cost of health care[3,5].

Figure 1. QR code to log in to VLE.

Simulation in radiography education

The education of health care professionals demands a large element of clinical training involving patients. The trend towards SBL is somewhat influenced by challenges in clinical placement provision, with radiography being no exception.[5] These challenges include issues related to the use of patients for learning purposes, such as ensuring patient privacy, ethical issues,[6] potential risks to ionising radiation[7] and challenges from patients' physical and behavioural limitations.[8] In simulation, learning and assessment are both safe and effective.[9,10] Actual patients can be uncomfortable or anxious, and simulation can deliver similar patient behaviour.[6] Furthermore, simulations can be structured to exactly fit training requirements by including specific conditions, situations, and complications: this facilitates harmonised training across all learners, as well as repetitive use with reliability and duplicability.[11] SBL safeguards patients from potential risks during skills practice, and guarantees that trainees have had some practice before managing patients. SBL is therefore particularly useful in circumstances where the real scenario is impractical due to risks, ethical constraints, availability or financial limitations. If SBL improves the diagnostic skills of health care professionals, then it has the potential to reduce errors.[11] SBL is clearly a valuable pedagogical approach for diagnostic radiography education.[4]

Structure of clinical simulation-based learning

To be effective, SBL must replicate the main thinking processes of actual clinical tasks. While some simulations are developed to be as realistic as possible, others replicate only the main features of the simulated scenario. Irrespective of the design or difficulty, SBL must provide instant feedback to trainees about their questions, decisions and actions, thereby guiding the thinking processes and clinical reasoning that the learner develops.[11,12] Adding interactive and immediately responsive feedback adds to the time-consuming nature of developing SBL material for radiography students, making this type of educational development challenging for individual staff and institutions. These design and development challenges underpin the overall aim of the FORCE project: to make SBL resources widely and freely available to radiography trainees.

This article presents the results of an online survey directed at users of the FORCE VLE since the open access launch. The aims of the survey were to gather user evaluation of various aspects of the VLE and SBL and to use this evaluation feedback to inform future development.

Methods

Survey strategy

Survey participants were academic and clinical staff in radiography, and student radiographers in training, who of their own choice logged into the FORCE VLE during the survey period. Following their use of the FORCE VLE, an e-mail was sent to each user, inviting them to complete a linked online evaluation questionnaire. The questionnaire was developed from the established Course Experience Questionnaire (CEQ),[13,14] with adaptations to suit evaluation of online learning material. Responses were downloaded

from SurveyMonkey® for analysis. Participants consented to have their responses aggregated to identify consensus opinions on the FORCE resources. Ethical approval to conduct the survey was granted (approval number LS-C-23-243-Matthews) in University College Dublin, Ireland: the lead partner in the FORCE project.

Questionnaire

The established Course Experience Questionnaire is a reliable and validated evaluation tool.[14] In its original form, the CEQ does not address technical considerations with online learning material: these topics were added to the questionnaire by members of the FORCE team using the same five-point Likert scale as in the pre-validated CEQ. The face validity of the refined questionnaire was internally reviewed and approved without any changes by the academic leads from each FORCE partner institution. In a small pilot study, the questionnaire was completed by 20 students in two of the partner institutions. No changes were made to the questionnaire.

There were four main sections:

1) Information about the research and consent, and instructions for completion;
2) Questions with drop-down menus to gather socio-demographic and professional information about respondents, and to identify how many cases the respondent had considered and for how long;
3) Questions requiring a Likert Scale (LS) response ranging through strongly disagree (LS = 1), disagree (LS = 2), neutral (LS = 3), agree (LS = 4) to strongly agree (LS = 5). These questions addressed: a) case structure and content; b) questions and interactivity; c) technical e-learning and navigation; d) multimedia quality; and e) overall experience.
4) Questions requiring open text response to allow respondents offer further information and to give opinions of strengths and limitations of the clinical simulations and VLE.

The questionnaire can be viewed as a supplementary file

Survey administration

From October 2023 to June 2024, 407 users logged in to the FORCE VLE: these users represent the survey population. At log in, a user must record their e-mail address: this is necessary for the operation of the VLE. Information on the log in page explains that an invitation to the survey will be e-mailed to all users. The invitation was accompanied by an information sheet about the research, and a link to the online questionnaire. Volunteer participants were asked to engage with simulated cases of their own choosing before completing the questionnaire. A consent form was incorporated into page one of the questionnaire. Each user decided independently whether to complete the survey or not: participation was thus voluntary, with the option to exit the questionnaire at any time without reason or repercussion.

Analysis

Response data were extracted to an Excel spreadsheet. Descriptive statistics were applied to socio-demographic data and Likert scale responses. Open text responses were subject to content analysis according to Braun and Clarke[15] in order to establish recurrent opinions and establish any themes. No textual content was assigned to more than one theme.

Results

From the 407 invited participants, 109 answered the questionnaire, representing a 27 % response rate. None of the questions were compulsory, hence the total number of respondents varies slightly across some questions.

Socio-demographic and professional data

Both student and radiographer respondents were drawn from a range of years of experience, presented in Fig. 2.

While the majority of participants' current country of practice reflects the countries involved in the FORCE project, see Fig. 3, these

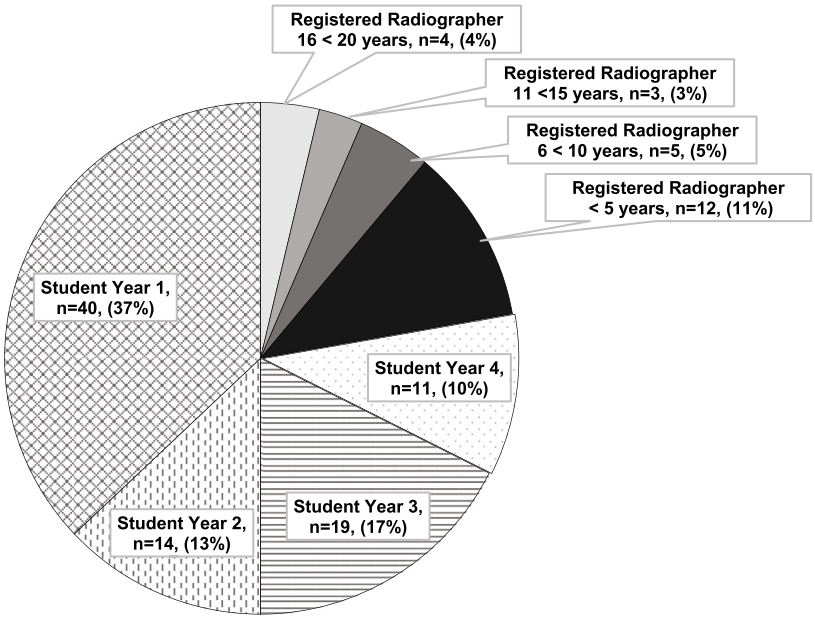

Figure 2. Participant categories and years of experience in radiography.

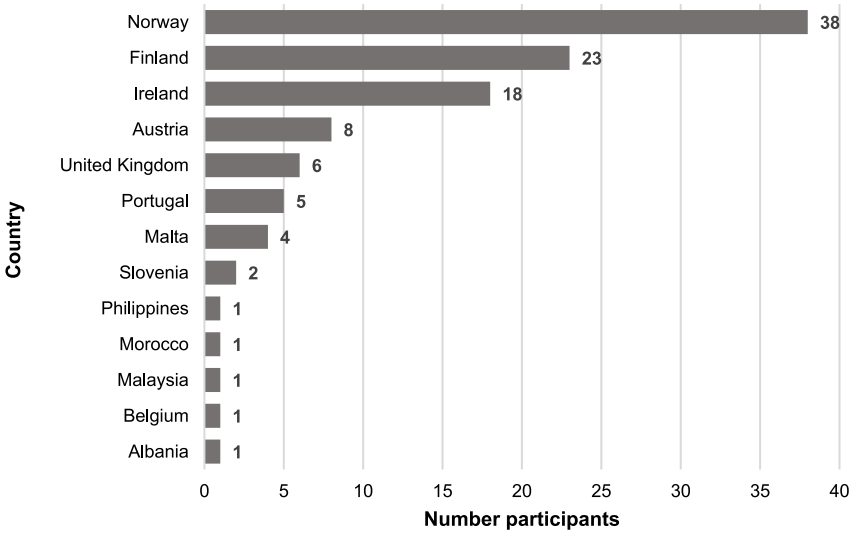

Figure 3. Participants country of practise.

participants were not necessarily associated with one of the partner institutions.

All except five participants reported fluency in English at intermediate level or better, with 76 % (n = 82) considering themselves fluent, advanced or native speakers, shown in Fig. 4.

Participants reviewed cases in each of Diagnostic Imaging, Image Interpretation Nuclear Medicine, and Radiotherapy, as shown in Fig. 5.

While the time reported to review a case varied (Fig. 6), a majority of participants (59 %, n = 63) reported a case time of between 30 and 60 min, which was the target of the project team. The time spent on any case was not significantly associated with either the type of case or whether the participant was a student or a radiographer.

Likert scale opinions on aspects of the SBL resources and FORCE VLE

Mean and median Likert scores from participants' opinions of various aspects of the SBL resources and FORCE VLE are presented in Figs. 7–11.

Open text opinions on aspects of the SBL resources and FORCE VLE

After each Likert scale question and in open ended questions about the FORCE VLE overall, participants offered a total of 159

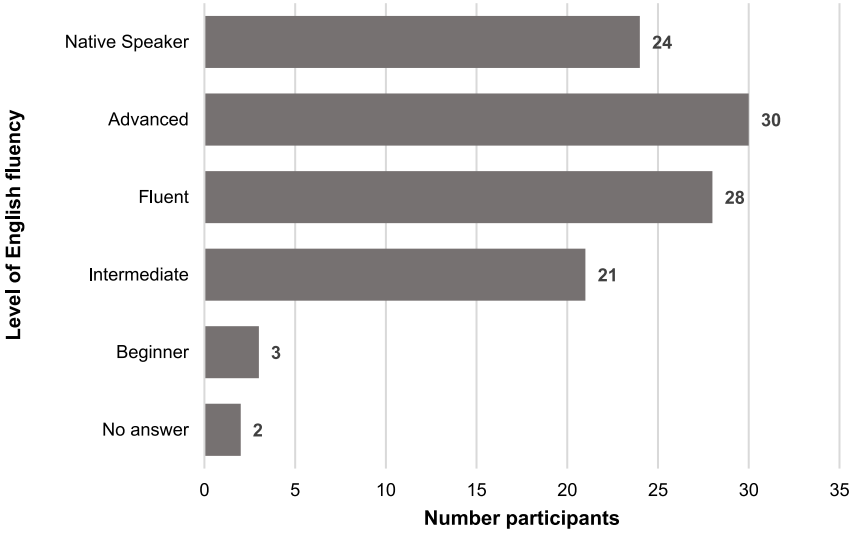

Figure 4. Participants language level.

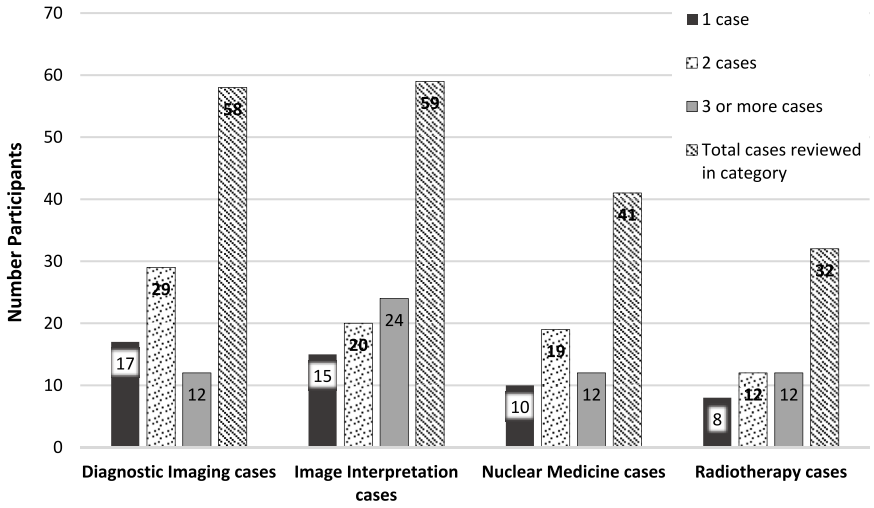

Figure 5. Number of cases studied by all participants.

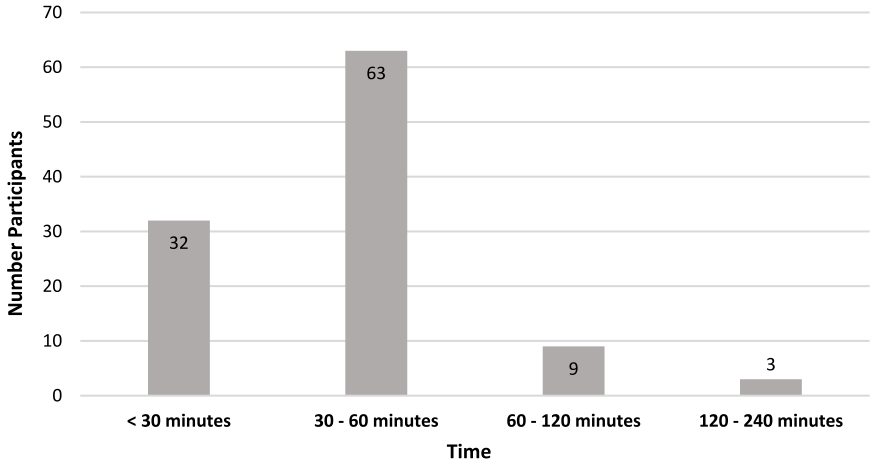

Figure 6. Time spent reviewing an individual case.

open text comments. Content analysis identified 139 separate opinions in the comments that were summarised and grouped into themes as presented in Table 1.

Participants suggestion for other topics to be included in FORCE are summarised in Table 2.

Discussion

Participant demographics

The response rate was quite low at 27 %, raising consideration of the potential for sample bias in the results: for example it could be that only users who were very satisfied with the FORCE VLE completed the questionnaire. However, both students (77 %) and clinical or academic radiographers (23 %) from 13 countries returned the questionnaire, allowing a range of perspectives to be garnered from the responses. Furthermore, the survey was open for nine months, and comparison of responses between earlier and later responders showed repetition of opinions, suggesting that on the open text responses data saturation was achieved across the many positive and fewer negative comments. Comparison of opinions was not attempted between students versus radiographers, or across different countries of practice, because each participant may have studied different cases, thus making a direct comparison invalid. Similarly, comparison of opinions was not attempted between participants who studied cases in different modalities, for example Diagnostic Imaging against Radiotherapy, because of the potential confounding effects of participants being from different countries or being some students and some radiographers. A much larger survey would be needed to generate sufficient participants in the various possible subgroups to facilitate such comparisons. While this may be deemed a limitation of the current work, the results do provide an overall and straightforward understanding of how the FORCE VLE and SBL content are appreciated by users to date.

Language considerations

FORCE SBL is delivered in English with subtitles, and during development the FORCE team had some concerns about whether a

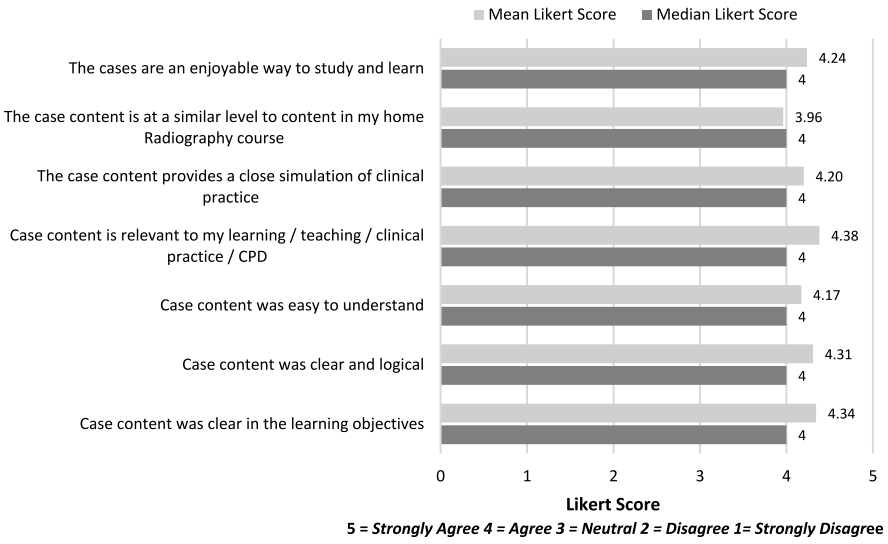

Figure 7. Opinions on case structure and content.

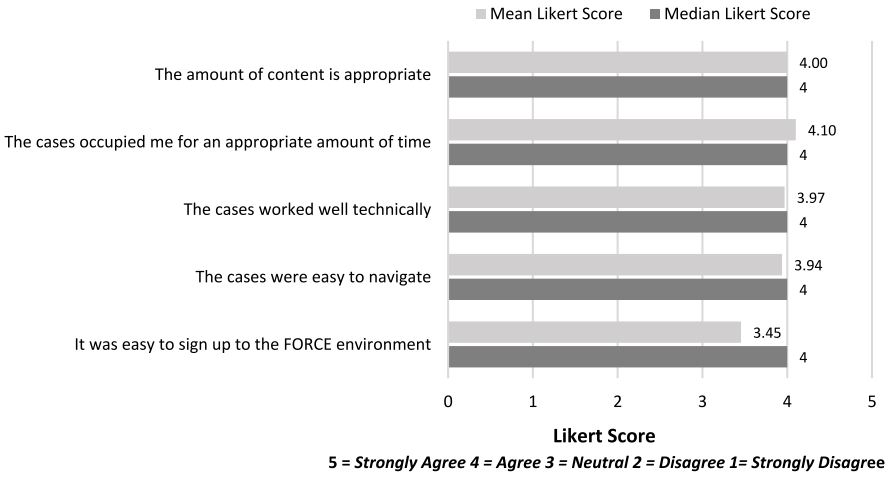

Figure 8. Opinions on technical elements and navigation.

solely English language resource would prove attractive internationally. In the current survey, 76 % of respondents considered themselves fluent or native speakers, and only two open comments from non-English speakers (Participants 55 and 60) expressed an opinion that a native language resource would be preferable. However, subtitles were reported as particularly useful: *"Our students sometimes had issues with understanding native English speakers because of their accents and quick pronunciation. Subtitles help a lot"* (Participant 55, academic lecturer). Positively, two other open comments highlighted "*a unique possibility for non-English speakers to learn medical language and vocabulary*" (Participant 53, radiography lecturer) in a way that *"can possibly broaden our career path"* (Participant 110, year one radiography student).

Duration of SBL resources

During development, the FORCE team had aimed for a completion time of under 1 h to study a complete case, and had tested this completion time with volunteer students in one of the consortium universities. The planned completion time was substantiated in the survey where 59 % of participants spent between 30 and 60 min on any single case. Evidence suggests that learners prefer multiple short duration engagements in online learning and hence each of the cases was broken down into sections that the learner could choose to study in isolation or at separate times. Participant 9, an academic lecturer, appreciated being able to "*look at the information in bitesize chunks and choose which areas you wanted to focus on".*

Likert scores for aspects of SBL resources

Likert scores from participants' opinions of various aspects of the SBL resources and FORCE VLE showed a high level of satisfaction, with a consistent median Likert Score of 4 (equating to agreement with a positive aspect) across all questions. Results indicate that the SBL resources are fit for purpose.

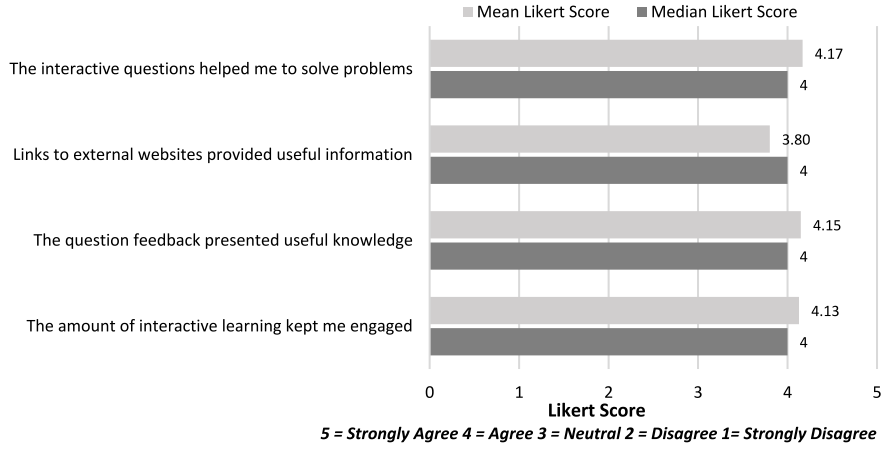

Figure 9. Opinions on interactivity.

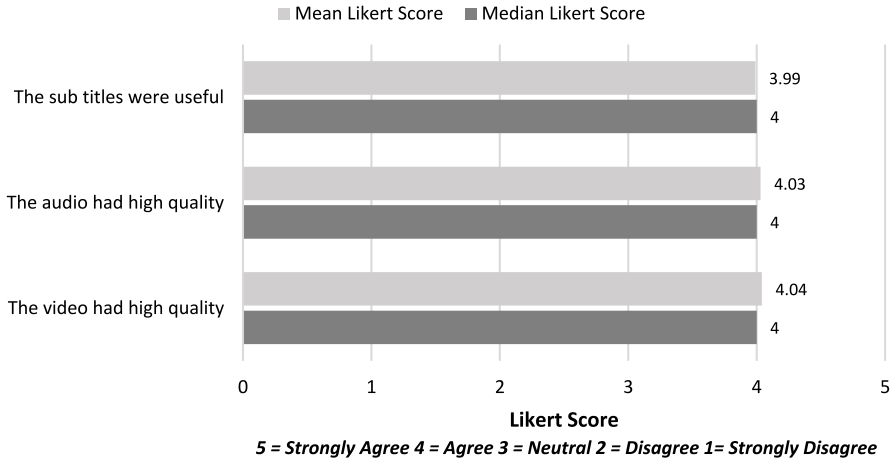

Figure 10. Opinions on Audio, Video and Subtitle quality.

Open comments from participants

A majority (73 %) of open text comments conveyed unqualified overall positivity towards the SBL resources and the FORCE VLE.

Four themes were evident from the data: that cases are interactive and applicable; that cases assist consolidation of knowledge; that cases promote patient care and communication; and that some modifications would be beneficial. Each theme is discussed below.

Cases are interactive and applicable

The Standards Committee of the International Nursing Association for Clinical Simulation and Learning Realism advise that realism, and hence applicability, in SBL are important for quality learning and are influenced by physical, conceptual, and psychological fidelity in simulation.[16] These aspects of fidelity were carefully considered in designing SBL cases for the FORCE VLE. Videos captured real clinical environments, and more importantly patients and staff had active voices and realistic conversations such that the learner could follow the context of an examination from referral through to completion.

Overall feedback on the applicability and interactive nature of the SBL was good. Participants found that the simulations were realistic, stating: *". . a fun and easy way of applying clinical knowledge to specific cases"* (Participant 2, Academic Lecturer), and *"they are very applicable to real life clinical scenarios"* (Participant 117, year 2 radiography student). Interactive materials are engaging for the learner and check understanding throughout the case studies. The interactive format employed was perceived as a real benefit by both staff: *"interactive questions … maintained engagement"* (Participant 9, academic lecturer), and students: *"it is way easier to keep things in mind, when I learn them in an interactive setting"* (Participant 68, year two radiography student).

A key feature of the SBL format was the provision of feedback. Findings from other studies about simulation suggest the level and speed of feedback play a prominent role in achieving the outcomes,[10,17,18] with one paper[19] suggesting that direct formative feedback is essential if students are to be empowered to work autonomously through their clinical placement period. The use of self-testing throughout the SBL cases was deemed valuable by staff: *"(interactivity) brings theory to life enabling students the opportunity to reflect and be challenged throughout"* (Participant 90, academic

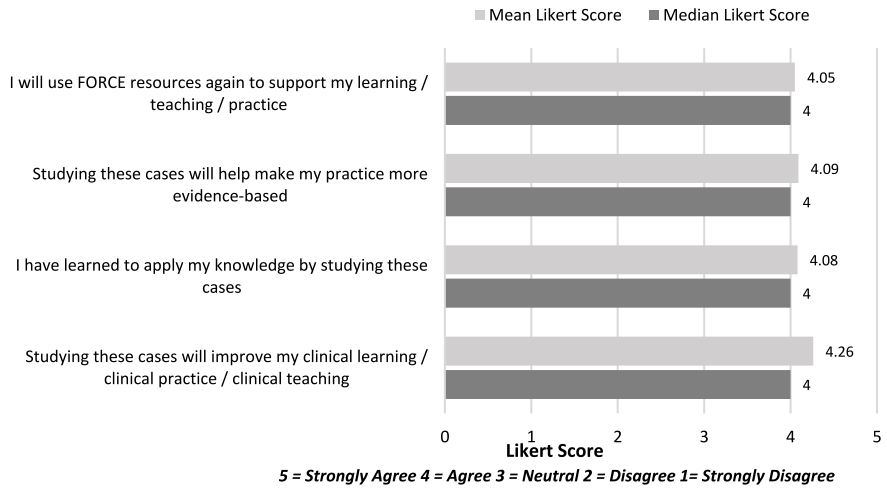

Figure 11. Overall opinions of the FORCE VLE.

Table 1
Themes derived from open comments.

THEMES	Number of comments	
THEME 1: Cases are interactive and applicable		
Applicable to clinical preparation, clinical practice, and revision	18	**55**
Applicable for teachers and learners and may use again	8	
Inbuilt interactivity helps learning	16	
Inbuilt interactivity is fun or interesting	5	
Cases worked well or sections helped when the case was long	5	
Cases were easy to follow and understand	3	
THEME 2: Cases assist consolidation of knowledge		
Cases were comprehensive	6	**28**
Specific content sections were particularly useful	6	
Seeing application or evidence helps knowledge consolidation	5	
Helpful to learn English vocabulary	8	
Repetition, interpretation and variety help learning	3	
THEME 3: Cases promote patient care and communication		
Patient communication content is good and or helpful	13	**18**
Variation in practice is discussed	4	
Care content is particularly good for early students	1	
THEME 4: Modifications suggested		
Minor aspects of navigation could be improved	18	**38**
Aspects of content or instruction text could be improved	11	
Aspects of video, audio or image quality could be improved	6	
Miscellaneous	3	

Table 2
Suggestions for future content in FORCE.

SUGGESTED TOPICS	FREQUENCY
Magnetic resonance cases	12
More radiography cases	9
Computed tomography cases	8
Ultrasound cases	4
General technology	4
More radiotherapy cases	3
More modalities generally	3
More nuclear medicine cases	2
Fluoroscopy cases	2
More image interpretation	2
PET CT cases	2
RNI therapy cases	2
DEXA cases	1
Mammography cases	1
Theatre radiography cases	1
Linked diagnostic to therapeutic cases	1
Interventional cases	1

lecturer) and by students: *"I liked the quizzes … as they ensured that you paid attention and helped apply what you just saw"* (Participant 7, year two radiography student).

Cases assist consolidation of knowledge

It has been suggested that linking supplementary reading and learning materials within online learning allows students to extend their reading around a subject while remaining guided to the most relevant information.[20] Furthermore, linked materials can be regularly updated, providing a useful way for educators to regularly but easily revise subject materials.[20] Linked materials are an extensive feature of the FORCE SBL cases, allowing a learner to choose whether to explore a topic in more detail. Participant 94, a year 4 radiography student, commented *"I found when more detailed information of the cases was provided it made them more interesting."* These further resources provide opportunities to build on areas of practice, focus on different stages in the examination, clarify areas of uncertainty, or simply develop areas of interest, thus allowing students to consolidate their knowledge as they progress through a simulated case from start to finish.

Cases promote patient care and communication

Within the SBL cases, the FORCE team wanted to demonstrate good practice in communicating with service users from different backgrounds and with a range of ages, abilities, and disabilities. Several participants identified elements of patient care or communication as a specific strength of the SBL cases, stating *". patient perspective questions were insightful into real practice"* (participant 76, year four radiography student), and *"patient care and communication examples are TOP!"* (participant 67, radiography lecturer).

The project team were aware of variation in radiographic practice across Europe, and also between centres in the same country. The project team endeavoured to ensure that practice portrayed in

the SBL cases was presented as a discussion point concerning practice variation and evidence on good practice. This was seen as an overall strength by several participants, one stating: *"The international nature of the course* (was a strength). *It was great to see and learn from the practices of other departments"* (Participant 65, clinical radiographer).

Modifications suggested

While many modifications were suggested, these tended to identify individual preferences regarding navigation or very specific content. Navigation through the SBL cases was and is dictated by the software package used, and the FORCE team have kept this as simple as possible to suit a majority of users. Online systems must be easy to use so that navigating through a learning environment does not detract from the end learning outcome.[18] Some technical 'glitches' with aspects of navigation or broken links were identified and these were all addressed at the close of the survey period.

Suggestions for future content in FORCE

All participants, both students and radiographers, indicated they would use the SBL cases again. Several lecturers reported they would be integrating FORCE SBL cases with their existing teaching materials. Participants were specifically asked to identify useful future content, and responses covered a gamut of suggestions for cases across all modalities (Table 2). An important deduction from this range of responses is that participants seem to believe that SBL can be applied across a broad spectrum of imaging and therapy cases. Indeed, Participant 2, an academic lecturer suggested: *"It would be great to have more cases. … You could develop a training programme for universities to learn how to create cases and integrate them into FORCE"*. As the project period is now complete, the FORCE VLE is moving to the stewardship of the European Federation of Radiographer Societies (EFRS), and it is indeed the ambition that instructions on development of further cases will be issued. Under this EFRS stewardship, a committee chaired by a member of the EFRS Education Wing will monitor the VLE and ensure update of existing cases on a periodic basis, thus maintaining relevance and currency. The committee will also invite submissions of further case simulations across a more comprehensive patient data set and range of modalities, and undertake editorial review of any submissions to ensure appropriate standard before inclusion in the FORCE VLE. As well as making more online SBL cases freely available to contribute to teaching and learning in Radiography, the sharing of these resources could have positive effects on inclusivity in radiographer education. In the words of Participant 111, a radiographer: *"This is a great way to enhance learning and to activate the students. Eventually unified teaching methods and quality might make it easier to standardise education across Europe."*

Conclusion

Survey opinions of radiographers and student radiographers indicate the FORCE VLE and SBL cases are a useful and well received resource to support clinical and professional learning. Future development to expand the case portfolio is desirable and should follow similar approaches to those employed during the FORCE project.

Acknowledgements

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.radi.2025.01.005.

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