Cover Sheet for Proposals	***JISC Capital Programme***

Name of Capital Programme: e-learning

Name of Lead Institution: University of Hull

Name of Proposed Project:
An interactive virtual radiotherapy and medical imaging centre for the teaching and communication of healthcare technology

Name of Project Partners: University of Hull
Sheffield Hallam University
University of Liverpool
Princess Royal Hospital, Hull & East Yorks Hospitals NHS Trust

Full Contact Details for Primary Contact:
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Position: Research Professor Computer Science,
Director of the Hull Immersive Visualization Environment (HIVE)
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Length of Project: 2 years 3 months

Project Start and End Dates: 1 January 2007, 31 March 2009

Total Funding Requested from JISC: £200,000

Funding Broken Down over Project Years:
Year 1: £107,101
Year 2: £76,428
Year 3: £16,470

Total Institutional Contributions:
Reduction of FEC estates and indirect costs of £283,900
Supply of equipment for project: £29,000
Total Institutional Contribution: £312,900

Outline Project Description

Computer simulation and virtual environments have applications for teaching and training over a wide spectrum of subjects and are able to support work-based learning and widen access to teaching materials. This project aims to build on several existing inter-institutional collaborations to develop an interactive simulation package to support the teaching and communication of healthcare technology, both in terms of the underlying scientific principles involved and in their clinical application. This project will focus on imaging technology (CT and MRI) and radiotherapy technology.

Teaching material will be accessible at 3 levels: Level 1 will be appropriate for patients and the general public; level 2 will be appropriate for Schools and FE Colleges and level 3 for HEIs delivering undergraduate and postgraduate programmes in health sciences.

On completion of the development stage undertaken during year 1, the simulation package will be implemented and evaluated in undergraduate radiotherapy programmes at UK institutions during year 2. The package will be made widely available at the end of the project (via JORUM) and sustainable funding sought to continue its development.

Access to this resource will be provided both through a campus-based, immersive virtual environment and also by an off-campus web-based route. This latter route will facilitate a flexible and personalised learning experience available to campus-based, work-based or home-based learners.

The impact of health-technology computer simulation tools on the achievement of learning outcomes will be evaluated for both the immersive and web-based approaches to determine the degree to which both approaches achieve prescribed levels of understanding.

I have read the Circular and associated Terms and Conditions of Grant at Appendix B (Tick Box)	**YES** √	**NO**

An interactive virtual radiotherapy and medical imaging centre for the teaching and communication of healthcare technology

1. Introduction

Medical imaging and radiotherapy equipment is becoming increasingly sophisticated and presents an increasing challenge for teaching, particularly in conveying a combined understanding of both the fundamental operation of this equipment and also its application in the clinical setting. Diagnostic and Therapeutic Radiographers, Clinical Technologists and Medical Physicists require an advanced level of understanding of both these aspects.

An intermediate level understanding of diagnostic and therapeutic applications of ionising and non-ionising radiation is a requirement for other health professions, including as Nursing and Medicine. A resource for conveying this level of information would also be of great value in widening participation by demonstrating the application of physics to medicine, suitable for use in schools and FE colleges to attract students into medical physics and other healthcare professions. A basic level of understanding of healthcare technology and its application would also be of great benefit for informing patients and the general public.

Computer simulation offers a unique way to provide a compelling visual insight into the operation of healthcare technology and can provide an effective means to communicate both the principles of operation and clinical application. Such simulations can be readily incorporated into web-based Virtual Learning Environments (VLEs), which are being increasingly developed. VLEs encourage students to manage their own learning by providing flexible access to learning resources. Students on professional degree health programmes spend a considerable portion of their course (often over 50%) on practice placements and the opportunity to access self-directed learning resources off-campus is extremely valuable.The potential contributions of VLEs to learning are well established in the literature [1, 2] and clearly underpin the development of the proposed resources in that they:

- Allow learners to personalise their learning experience
- Can provide flexible delivery through online access from home or the workplace
- Readily provide access to the same teaching resources to learners from different institutions
- Readily support stratified levels of information to be targeted at learners at different stages in their careers and to encourage widening participation
- Allow learners to familiarise themselves with technology at a level that is not easily accessible in the real world
- Allow learners to make errors and learn from them that might not be tolerated in the real world
- Integrate graphical, textual and audio information that reduces cognitive load
- Offer learners the opportunity to manipulate parameters and objects (that may not be feasible in the real world) in order to investigate their effects
- Facilitate enhanced understanding of complex, abstract 3D phenomena assuming they are adequately represented

The proposed project will build on previous and ongoing work [3, 4] which has produced a comprehensive simulation model for a radiotherapy department where a) equipment in the treatment room can be operated, b) radiation treatment plans can be simulated and visualised and c) an extensive range of features to support training such as the development of practical skills in patient set up, concept of planning, etc.[17].

The aim of this project is to develop, implement and evaluate a resource, accessible to UK HEIs, FE colleges, secondary schools, and the general public, allowing users to visualise and interact with state-of-the-art imaging and radiotherapy technology. Subject to funding being available, this process will begin in January 2007 and be completed by March 2009. The main development and implementation of the simulation models will occur during the first 15 months and a study to evaluation its impact will be conducted over the last 12 months of the project.

The scope of this proposal concentrates on delivering and evaluating an appropriate level of detail for undergraduate students studying radiotherapy at numerous UK institutions. Further work outside of this project will extend the simulation model for the specific requirements of other health professions, such as Diagnostic Radiography, Clinical Technology and Medical Physics and to the specific requirements of schools, FE colleges (particularly those supporting foundation degrees), patients and the public. The simulation model will be implemented using an open design and modular structure to enable this later expansion and to readily allow the inclusion of future developments in healthcare equipment.

2. Project description

The proposed project will deliver a virtual radiotherapy and medical imaging department, accessible both over the internet via a web-browser on a standard desktop PC (integrated with existing VLEs) and through a static (campus-based) immersive virtual environment (IVE).

The users (FE and HEI students, schools, the public and patients) will be able to interact with this virtual department, using simulated models of healthcare technology to perform various medical imaging studies, to deliver radiotherapy to virtual patients and to investigate the scientific principles behind the technology. Learning will be achieved both through the completion of in-built tasks and through free interaction. Assessment of competency in achieving prescribed tasks will be included and will be available both to the learner and to academic and clinical teaching staff.

Three levels of detail will be built into the simulation model to deliver information appropriate to learners at different stages of their careers, from a basic introductory nature through to advanced details of equipment operation and application suitable for undergraduate and postgraduate students in health science. Specific and novel features of this project include:

- Real-time simulation of respiratory motion of virtual patients, including the effect on tumour position
- The real-time visualization of ionising radiation interactions with matter, conveyed through Monte Carlo simulations of individual particle (photon and electron) interactions, based on an accurate representation of the underlying physics
- The ability to perform and evaluate patient-oriented tasks such as tumour localisation and delivery and verification of radiotherapy
- The ability to perform and evaluate a range of technology-related tasks, illustrating characteristics of radiation beams.

2.1. Learning outcomes and objectives

The following learning outcomes and objectives illustrate the goals of the proposed project in terms of the level of understanding to be conveyed at the specified levels. Due to time and budget constraints, evaluation will concentrate on the specific requirements of students on radiotherapy programmes at Liverpool and Sheffield Hallam Universities. Addressing the specific needs of other user groups and evaluation of their learning experiences with the simulation models will be the subject of further work.

Training information in the simulation model will be partitioned to support learning outcomes at the following three levels.

1. **Basic level:**

   Patients and the general public (academic levels 0 and 1)

   The simulation model will convey the following:

   - Illustrate the processes involved for a patient in medical imaging and radiotherapy procedures:
     - Undergoing an x-ray CT scan
     - Undergoing an MRI scan
     - Radiotherapy planning, delivery and verification for kilo voltage (kV) and mega voltage (MV) radiation treatments
   - Illustrate the basic operation of such equipment

2. **Intermediate level:**

   Secondary schools and FE colleges offering courses in healthcare related professions (academic levels 1 and 2)

   The simulation model will convey the following:

   - Demonstrate the application of ionising radiation in diagnostic imaging and radiotherapy
   - Illustrate the operation of such equipment at an intermediate level
   - Illustrate the processes involved for the patient in medical imaging and radiotherapy

3. **Advanced level**:

   Undergraduate and postgraduate degree programmes (academic levels 2 and 3)

   The scope of the proposed project aims to address specific learning outcomes for students enrolled on Radiotherapy degree programmes. Addressing specific learning outcomes for closely related programmes such as Diagnostic Radiography, Clinical Technology and Medical Physics will be the subject of future development.

   The simulation model will support students in their ability to perform the following:

   - Describe in detail the principles of operation of Radiotherapy equipment: The linear accelerator, kV therapy unit, radiotherapy simulator, virtual simulation and portal imaging systems.
   - Describe the principles of operation of medical imaging equipment: X-ray CT and MRI.

- Describe the safety interlocks and shielding requirements of medical imaging and radiotherapy equipment
- Discuss the characteristics of clinical photon and electron beams in their interaction with matter.
- Demonstrate an understanding of patient preparation and set-up for radiotherapy, an understanding of anatomical movement and treatment margins.
- Demonstrate an understanding of the process of radiotherapy from tumour localisation through planning, delivery to verification.

An important aspect of this project is ensuring that the resources are designed effectively to support teaching and learning. In addition to accounting for the specific learning outcomes outlined above the design of the resources will take into consideration:

- The importance of an intuitive interface that avoids the need for high levels of instruction
- The importance of a high degree of interaction that ensure active participation
- Ensuring that any response to student input is accurate and logical
- Integration of formative assessment activities and tasks consistent with an 'assessment *for* learning' approach
- Provision of textual and audio feedback on student interaction

More detail on the specific technological features to be incorporated into the simulation model are given in Appendix C.

2.2. Evaluation

The evaluation stage of the project will be organised as follows:

1. Piloting the virtual reality models and tasks prior to implementation.
2. Evaluation of the implementation at advanced level (students on BSc and pre-registration PGD radiotherapy programmes) that assesses the following:
    a. Impact on knowledge and understanding in relation to the learning outcomes described in Part 3 under Section 2.1.
    b. The student learning experience
    c. Comparison of immersive and web-based virtual reality environments (VRE's).

Time permitting an evaluation of the intermediate level material that assesses the impact on recruitment on to BSc radiotherapy programmes from secondary schools will be undertaken.

Evaluation at advanced level

Aims:

1. To investigate the take-up of the web-based resource by students on campus, on clinical placement and from home.
2. To identify students' perceptions of the benefits and limitations of the simulation package on their learning experience and of VLEs and VREs in general.
3. To establish the extent to which the simulation package enhances pre-registration radiotherapy students' skills, knowledge and understanding in relation to the project learning outcomes.
4. To evaluate any differences in knowledge enhancement using web-based and immersive VRE's.
5. To evaluate differences in student learning experiences between the web-based and immersive VRE's.
6. To identify applications of similar technology to other HEI programmes

Method:

A quasi-experimental, pre-test post-test design will be employed to evaluate the effect on knowledge enhancement and to compare web-based and immersive VRE's.

Approximately 100 pre-registration radiotherapy students from both Liverpool and Sheffield Hallam Universities (at relevant stages of their course) will undertake the simulation packages using a campus-based immersive VRE. This VRE will employ a passive stereoscopic display based on the use of a forward projection system with polarising filters, polarising glasses and a non-depolarising screen. Students will undertake this at either their own institution or at the Hull Immersive Visualisation Environment (HIVE) at the University of Hull.

A matched group of pre-registration radiotherapy students from several other UK institutions will undertake the same simulation packages via the web-based VRE.

All students will complete a short questionnaire prior to undertaking the package to collect demographic data and determine perceptions regarding use of computer technology in relation to learning.

A 'pre-intervention' MCQ exam will assess students baseline knowledge and understanding of the aspects addressed within the simulation package and enable confirmation that both groups of students are matched. A similar post-intervention MCQ will be undertaken by all students. This will enable:

1. Assessment of the extent of knowledge enhancement
2. Comparison of web-based and immersive VR approaches.

A post-intervention questionnaire will elicit initial views regarding ease and frequency of use, enjoyment, perceived benefits and limitations of the packages as well as perceived differences in knowledge and understanding. A random sample of all students to encompass both approaches (web-based and immersive VR) and different institutions will be invited to participate in follow up interviews that more fully explore and establish the student learning experience. These interviews will be tape recorded and transcribed.

A pilot study using recently graduated students from Liverpool and Sheffield Hallam Universities will enable:

- Debugging and refinement prior to implementation
- Determination of adequate sample size for the main evaluation using a power calculation
- Assessment of questionnaires for reliability.

Analysis:

An independent t-test will be used to compare pre-intervention MCQ exam scores for both groups of students (immersive VRE and web-based VRE) to test for equality.

Independent t-tests will be used to compare differences in pre and post intervention MCQ exam scores for both groups of students in order to assess the extent to which the simulation packages enhance knowledge and understanding and to evaluate any differences between the two approaches. Data for students who do not complete the package or who withdraw for any reason will be ignored in this analysis. SPSS version 13 will be used for the quantitative analysis.

Follow-up interviews will be conducted at the students host institution and as soon as possible following undertaking of the simulation packages and completion of the post-MCQ exam. Interviews will be semi-structured to allow students to comment on ease of use, enjoyment, perceived benefits and limitations and how students used the packages. Themes arising from the interviews will be collated and analysed. NVIVO software will be used to assist with the synthesis of data.

Ethical considerations in relation to the evaluation:

Student participation in the evaluation of this project will be voluntary and all will be given information sheets (designed in accordance with the guidelines provided by the Central Office for Research Ethics Committees) before consenting to take part. All data will be anonymised and held securely for a period of time after completion of the evaluation to allow for audit.

This project will not influence aspects of the students' curriculum or detrimentally affect their learning in any way

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3. Timetable

	Milestone Description	Key Staff	Start	Finish
1	Photography/laser scanning of installed equipment at local hospitals, both as seen by patients and with covers removed to reveal underlying components (subject to manufacturer consent). Photography of typical room and bunker designs and gathering of building plans	CS/JW/AB	Jan 07	Mar 07
2	Development of Monte Carlo model for visualisation of radiation interactions	P/CB/AB	Jan 07	Aug 07
3	Development of visualisations of atomic scale particle interactions	CB/FH /DD	May 07	Nov 07
4	Development of visualisations of radiation generation and component operation	AB/JS	Dec 07	Jun 08
5	Development of a generic patient, or patients, including detailed anatomy and respiratory motion	AB/RA/PB/ KB	Jan 07	Jun 08
6	Development of Monte Carlo model for visualisation of radiation interactions	P/CB/AB	Feb 07	Apr 07
7	Development of practical tasks and competency assessments: Patient preparation, positioning, initiation of imaging or treatment, verification of radiotherapy, visualisations of processes taking place	RA/PB/KB	Apr 08	Sep 08
8	Development of practical tasks and competency assessments:	JS/CS/JW	Apr 08	Sep 08

	Machine QC and beam characteristics			
9	Implementation of radiation generation and component operation	CS/JW/CB/AB	Apr 07	Jun 07
10	Implementation of atomic scale interactions	CS/JW/CB/AB	Jun 07	Aug 07
11	Implementation of Monte Carlo model	CS/JW/CB/AB	Aug 07	Oct 07
	Implementation of patient and technology related tasks and competency assessments	CS/JW/JS/RA/ PB	Oct 07	Jan 08
12	Evaluation of student learning experience, competency gained in specified tasks, web-based vs immersive environments		Mar 08	Jan 09
13	Dissemination: Conference presentation and submission to peer-reviewed journals a) Simulation models b) Monte Carlo visualisation c) Evaluation	CS/RP/JW/AB P/CB/AB RA/PB	Jan 08 Jan 08 Jan 09	Mar 09 Mar 09 Mar 09
14	Dissemination to UK HEIs, FE colleges, schools and the public, JORUM		Mar 09	Mar 09

Key to staff: CS: computer scientist; P: physicist; Other initials identified in section 5

4. Budget

Two Research Assistants (RAs) are requested. A Computer Science RA at Hull will for the duration of the project (27 months) to develop the software and 3D models for the simulation of the virtual imaging and radiotherapy Department and maintain the software during the evaluation stage of the project. A Physics RA at Liverpool will focus on developing the Monte Carlo based physics model to simulate the physics interaction of particles with matter.

Two PCs (£3,000), two passive projection systems (£20,000), access to High Performance Computing clusters (£6,000) will be provided by the institutions at no cost to the project this represents a saving of £29,000 to project costs.

For each of the three academic institutions a request of £1,000 for conference travel, £1,500 for travel between sites and £2,000 for consumables is requested.FEC include the time allocated to the project by investigators. The time allocated is shown in Key Personnel.

The project has been costed using FEC. The total project FEC cost is £483,900 and we are requesting £200,000, i.e. 41.3% of FEC cost. This represents a contribution by the partners of £283,900. Together with equipment provided, this represent a total partner contribution of £312,900. Full FEC details are available on request.

The table below shows the breakdown of request for resources.

	Year 1	**Year 2**	**Year 3**	**Totals**
RA staff	58,131	39,192	8,388	105,711
Investigators	16,496	16,496	4,067	37,059
Conf, Travel, Consumables	6,009	6,009	1,482	13,500
Estates & Indirect Costs	178,495	123,221	25,924	327,630
FEC Total	259,131	184,918	39,862	483,900
JISC request	**107,101**	**76,428**	**16,471**	**200,000**

At the start of the project a detailed project plan will be developed. There will be 3 monthly management meetings for the project. RP will be the overall project manager. There will be fortnightly Skype teleconferences between all institutions for tracking progress and to promote information flow. A Sharepoint repository will be provided for sharing information.

The proposed project expands an existing collaborative team and brings together academics from the two largest programmes in Radiotherapy in the UK. The application of e-learning to provide flexible delivery of teaching, to widen participation and to promote lifelong learning are key areas of development for all institutions involved as evidenced by supporting letters in appendix B. This project will make a significant contribution to these areas. In addition the virtual simulation would provide a valuable learning aid for undergraduates on our Physics and Hull York Medical school and for work-based learning within the NHS Trust.

5. Key Personnel

a) Staff contributing directly to the project:

Newly funded posts:

Computer scientist RA Spine point 7
Full-time for 27 months. To be advertised as soon as notification of award is received.
Physicist / Engineer: RA Spine point 6
Full-time for 15 months. To be advertised as soon as notification of award is received.

Investigators *(brief CVs are provided in Appendix A):*
Prof R Phillips, Department of Computer Science, University of Hull (RP) – 1 hr / week
Dr J Ward, Department of Computer Science, University of Hull (JW) – 3 hrs / week
Prof A Beavis, Radiation Physics Dept., Princess Royal Hospital, Hull (AB) – 1 hr / week
Mr R Appleyard, Faculty of Health & Wellbeing, Sheffield Hallam Univ. (RA) – 3 hrs / week
Mr P Bridge, Faculty of Health & Wellbeing, Sheffield Hallam University (PB) – 1 hr / week
Dr C Baker, Div. of Medical Imaging & Radiotherapy, Univ. of Liverpool (CB) – 3 hrs / week
Dr F Hatfield, Div. of Medical Imaging & Radiotherapy, Univ of Liverpool (FH) – 2 hrs / week
Mrs K Burgess, Div. of Medical Imaging & Radiotherapy, Univ. of Liverpool (KB) – 0.5 hrs / week
Dr J Shaw, Division of Medical Imaging & Radiotherapy, Univ. of Liverpool (JS) – 1 hr / week

b) Staff identified for consultation on learning, teaching and evaluation aspects:
Ms J Strivens, Centre for Lifelong Learning, University of Liverpool (JSt) – 1 hr / month
Mr N Bunyan, Centre for Lifelong Learning, University of Liverpool (NB) – 1 hr / month
Dr D Dickson, Department of Physics, University of Liverpool (DD) – 1 hr / month

6. References

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Appendix A: Brief CVs of contributing staff

Prof R Phillips, Department of Computer Science, University of Hull (RP)
Brief career summary: Research Professor in Computer Science, 2002 -; Professor in Computer Science, University of Hull, 1990-2002; Head of Computer Science Department, 1993-2000; Lecturer, UMIST, 1985-1990; Lecturer, Manchester University, 1975-1985; Experimental Officer, Manchester University, 1973-1975; Software Engineer, ICL, 1970-1972.
Qualifications: PhD in Computer Science, University of Manchester, 1985; MSc (Research) in Computer Science, University of Manchester, 1978; BSc Hons (First Class) in Computer Science, University of Manchester, 1970.
Contribution: Project management. Supervising software development. Advising on simulation, modelling, visualization and algorithms.
Relevant experience: 30+ years of research into computer science. 15 years experience in simulation, modelling and visualization in medical applications, 25+ years lecturing, 5 years experience of radiotherapy planning and visualization, managed several large projects, Head of Department (7 years).
Relevant grants held: 1) 2005-2006 £140k, CMS, *Immersive Visualization for Radiotherapy Treatment & Planning*, Beavis, **Phillips**, **Ward**. 2) 2002-2005, £17k, East Yorkshire Hospitals NHS Trust, *Medical Physics PhDs*, Langton, **Phillips**. 3) 2002-2005, £33k, East Yorkshire Hospitals NHS Trust - Peter Bourne Scholarship, *New Imaging Diagnostic Techniques with 3D Echocardiography*, Langton, **Phillips**. 4) 2005-2006, £6k, Princess Royal Hospital, *Virtual Tour of Oncology Department*, **Ward**, **Phillips**, Beavis. 5) 2005-2006, £6k, Sheffield Hallum Univ, *Evaluation of virtual environment for learning,* Ward, **Phillips**, Beavis. 6) 2002-4 £991k. HEFCE SRIF1&2. Hull Immersive Visualization Environment (HIVE) provision of state of the art immersive visualization & high performance computing facilities for the University, **Phillips, Ward**.

Mr J W Ward, Department of Computer Science, University of Hull (JW)
Brief career summary: Research Fellow in Computer Science, University of Hull, to present.
Qualifications: BEng Software Engineering (University of Sheffield).
Contribution: Software design and development, scientific visualization and 3D computer graphics experience, advice on immersive VR technologies.
Relevant experience: Over 11 years of experience in computer graphics, software engineering and virtual environments. Extensive software and hardware development experience. Previous experience developing medical training, simulation and planning applications, including; Radiotherapy Training and Visualization, Knee Arthroscopy Training Simulator, Computer Assisted Knee Osteotomy Planning, Virtual Fluoroscopy. Recent experience in development of interactive museum displays using touch-screen and web technologies.
Relevant grants held: See above list of grants for Phillips

Prof A W Beavis, Radiation Physics Department, Princess Royal Hospital, Hull (AB)
Brief career summary: Clinical Scientist (Consultant grade), Radiation Physics (Radiotherapy) Department, Princess Royal Hospital, Hull. July 1992 to present. Honorary Senior Research Fellow in the Academic Department of Medical Physics, School of Medicine, University of Hull. Visiting Professor in the Faculty of Health and Well Being, Sheffield-Hallam University, UK.
Qualifications: BSc Physics (Newcastle), PhD Physics (Newcastle)
Contribution: Modelling and visualisation of linear accelerator components. Development of real-time Monte Carlo models
Relevant experience: Over 10 years clinical radiotherapy physics experience [5, 6, 7, 8]. Existing collaborator on virtual reality in radiotherapy [3, 4]. Lecturer on BSc/ MPhys Physics with Medical technology, University of Hull. Lecturer on University of Sheffield MSc Radiography. Listed as an approved educator for the International Atomic Energy Agency
Relevant grants held: 1) 2005-2006 £140k, CMS, *Immersive Visualization for Radiotherapy Treatment & Planning*, **Beavis**, Phillips, Ward. 2) 2005-2006, £6k, Sheffield Hallum Univ, *Evaluation of virtual environment for learning,* Ward, Phillips, **Beavis**. 3) 3) 2003-5, £88k, Yorckshire Cancer Research, Impact of MTI on delivery and verification of IMRT for cancer treatment. .

Mr R M Appleyard, Faculty of Health & Wellbeing, Sheffield Hallam University (RA)
Brief career summary: Senior Lecturer in Radiotherapy and Oncology, Sheffield Hallam University, 1998 to present. Lecturer in Radiotherapy, Suffolk College, 1993-1998 Therapy Radiographer, Ipswich Hospital, 1989 - 1993
Qualifications: MSc (by research) Medical Physics, BSc Radiography, PGCE, Diploma of College of Radiographers
Contribution: Development of patient model. Development of tasks illustrating practical use and processes To lead on evaluation of the project.

Relevant experience: 13 years experience as lecturer in radiotherapy and oncology. Extensive experience in implementation and evaluation of e-learning initiatives. Current collaborator with University of Hull on use of virtual reality in radiotherapy education [e.g. 1, 2] Currently enrolled as PhD student focussing on evaluating educational potential of virtual reality environments in radiotherapy education and training.
Relevant grants held: £4000 Sheffield Hallam University Learning, Teaching and Assessment Fellowship award for *Developing spatial cognition of anatomy using an immersive visualisation environment*. Project currently ongoing as part of PhD studies.

Mr P Bridge, Faculty of Health & Wellbeing, Sheffield Hallam University (PB)
Brief career summary: Senior lecturer in Radiotherapy and Oncology, Sheffield Hallam University, 2001 to present.
Therapy radiographer in Manchester, Auckland, Dundee and Derby.
Qualifications: BSc Physics and Applied Mathematics, BSc Therapeutic Radiography, MSc Radiotherapy and Oncology
Contribution: Evaluation of student learning
Relevant experience: Development of a range of multimedia applications to support undergraduate radiotherapy physics education, including animations and virtual experiments. Prior collaboration with the University of Hull on an immersive visualisation environment application for radiotherapy training [3, 434]. Extensive experience in student evaluation of a range of e-learning initiatives, including online assignment management and automated marking systems.

Dr C Baker, Division of Medical Imaging & Radiotherapy, University of Liverpool (CB)
Brief career summary: Lecturer in Radiotherapy Physics, University of Liverpool. 2001-present. Honorary Clinical Physicist, Clatterbridge Centre for Oncology, Wirral, UK. Honorary Clinical Physicist, North Western Medical Physics, Christie Hospital, Manchester, UK. Clinical Physicist (NHS) 1987-2001.
Qualifications: PhD Physics (Surrey), MSc Radiation Physics (London), BSc Mathematical Physics (Liverpool)
Contribution: To lead development of Monte Carlo modelling for active visualisation of radiation interactions.. To contribute to visualisation of fundamental radiation interactions.
Relevant experience: Active in research areas of Monte Carlo applications to radiotherapy [9, 1010] and Radiotherapy Technology [11, 122]. Lecturer in radiotherapy physics since 2001, teaching principles and operation of imaging and radiotherapy equipment, ionising radiation interactions with matter, radiotherapy planning and radiation protection.
Relevant grants held: 1) Hatfield F, Baker C, Dickson D and Cole P. University of Liverpool Learning and Teaching Fund (2005). £4500 for the *Development of Virtual Reality Simulations of Physics Interactions*.

Dr F N Hatfield, Division of Medical Imaging & Radiotherapy, University of Liverpool (FH)
Brief career summary: Lecturer in Medical Imaging, University of Liverpool 2001 to present.
Research Fellow in Medical Image Analysis, St James' University Hospital, Leeds. 1999-2001.
Research Fellow, Medical Imaging and Virtual Reality, University of Nottingham, 1997-1999.
Research Associate / Clinical Scientist, Royal Hallamshire Hospital, Sheffield, 1995-1997
Qualifications: BSc Physics (Sheffield), MSc Medical Physics & Clinical Engineering (Sheffield), PhD Physics (Sheffield).
Contribution: Lead in visualisations of imaging principles.
Relevant experience: Creation of VR models using various software packages such as 3-D Studio Max, Plasma, dVise, Inventor, VRML and Performer.
These models include the following: Virtual X-ray room, Virtual Reality Ventricular System, Virtual Reality Model of the Lungs, VR MRI Demonstrator, Virtual Reality Particle Accelerator/Collider. Virtual demonstration of Dynamic Atoms and Lattices for the Web.
Relevant grants held: 1) Hatfield F, Baker C, Dickson D and Cole P. University of Liverpool Learning and Teaching Fund (2005). £4500 for the *Development of Virtual Reality Simulations of Physics Interactions*. 2) Hatfield F, University of Liverpool Learning and Teaching Fund (2002), £4800 for *Development of a Virtual X-ray Room*.

Mrs K Burgess, Division of Medical Imaging & Radiotherapy, University of Liverpool (KB)
Brief career summary: Head of the Division of Medical Imaging & Radiotherapy, University of Liverpool, 2005-present. Head of the Division of Radiotherapy, University of Liverpool, 1992-2005
Principal of the School of Therapy Radiography, Christie and Clatterbridge Hospitals, South Manchester Health Authority/Christie Hospital NHS Trust, 1984-1992.
Principal of the Merseyside School of Radiotherapy, Wirral District Health Authority, 1981-1984
Therapy Radiographer (NHS) 1974-1981

Qualifications: Diploma of the College of Radiographers (Therapy) [DCRT]; Higher Diploma of the College of Radiographers (Therapy) [HDCRT]; Teaching Diploma of the College of Radiographers, (TDCR). Diploma in Health Service Management, (DHSM), Leeds Polytechnic; Master in Medical Science (Clinical Oncology), University of Birmingham
Contribution: Design of patient-related tasks, assessments and competencies.
Relevant experience: Over 25 years teaching experience, including programme development and assessment of academic and clinical skills. Membership of School and Faculty Learning and Teaching committees. Member of the Joint Validating Committee (JVC) of the Health Professions Council (HPC) and the College of Radiographers.

Dr J Shaw, Division of Medical Imaging & Radiotherapy, University of Liverpool (JS)
Brief career summary: Part-time University Teacher, Division of Medical Imaging and Radiotherapy, University of Liverpool, 2005-present; Director of Research and Development, Clatterbridge Centre for Oncology, Wirral, Merseyside, 1998-2004; Director of Technical Services, Clatterbridge Centre for Oncology, 1992-1997; Head of Medical Physics Department, Clatterbridge Centre for Oncology, 1980-1992
Qualifications: BSc Physics (Sheffield), PhD Physics (Sheffield)
Contribution: Development/design of component-level simulations for imaging and radiotherapy equipment. Development/design of technology-related student tasks.
Relevant experience: Over 30 years experience in clinical medical physics and teaching of radiotherapy physics and equipment [13-16].

Dr D Dickson, Department of Physics, University of Liverpool (DD)
Contribution: Consultant for visualisation of fundamental radiation interactions with matter.
Relevant experience: Research involving the evaluation of activities aimed at improving the perception and appreciation of science.Current activities in the field of science communication are:
1. Science Journeys: a PPARC funded project aimed at secondary school children in which they gain an appreciation of particle physics and astronomy. 2. Sound Proof Projects: a NESTA funded programme of projects involving a crossover between science and music. 3. Big Bang: a musical comedy, aimed at a 15-25 audience. 4. The Magic of Materials and Machines: an EPSRC funded project, which married science and theatre to stimulate the imagination of pupils at several secondary schools.

Ms J Strivens, Centre for Lifelong Learning, University of Liverpool
Contribution: Consultant on integrating with personal development planning (PDP), lifelong learning, assessment and evaluation of learning experiences and competencies, identification of applications to other disciplines.
Relevant experience: Janet Strivens has taught in various universities in the UK for over thirty years and is a Registered Practitioner of the Higher Education Academy. She is an Educational Developer at the University of Liverpool and is also the Senior Associate Director of the Centre for Recording Achievement, the UK's national network for the promotion of personal development planning processes across all sectors of education. She was a member of the team which developed the Liverpool University Student Interactive Database (LUSID), one of the first electronic tools to support personal development planning. Since then she has been involved in a number of JISC projects, most recently two of the DEL projects in the North West. Her particular expertise is in e-portfolio use and electronic support for personal development planning.

Mr N Bunyan, Educational development Division, Centre for Lifelong Learning, Univ. of Liverpool
Brief career summary: Learning Technologist, The University of Liverpool 2002 to present.
Research Fellow, Centre for Construction Innovation, The University of Salford 2000 to 2002.
Researcher, Construct IT, The University of Salford 1999 to 2000.
Chartered Landscape Architect within the UK construction industry 1987 to 1998.
Qualifications: M.Phil Landscape Design (Newcastle), PG.Dip IT in Construction (Salford), B.Sc. (Hons) Geology (Southampton).
Contribution: To help support the project team to develop and disseminate an e-learning project that will have application in development of lifelong learning in other subject disciplines.
Relevant experience: Learning Technologist within the University of Liverpool responsible for the learning and teaching development of the University's virtual learning environment.
Actively involved in the development and implementation of e-portfolios and PDP software within the University of Liverpool. Extensive experience in the development of a range of e-learning projects at adult education undergraduate and post graduate level.

Appendix B: Supporting letters

The supporting letters are provided in the following documents.
Signed original copies of all these letters are available on request.

1. **Bruce HU – Prof W Bruce, Deputy Vice Chancellor, University of Hull**
2. **Withers NHS – David Withers, Head of Education and Development, Hull and East Yorkshire Hospitals NHS Trust**
3. **Jeffrey NHS – K Jeffrey, Clinical Manager, Radiotherapy, Princess Royal Hospital, Hull and East Yorkshire Hospitals NHS Trust**
4. **Whitton NHS – V J Whitton, Head of Radiation Physics, Princess Royal Hospital, Hull and East Yorkshire Hospitals NHS Trust**
5. **Merry LI – Dr Anne M Merry, Director of Lifelong Learning, University of Liverpool**
6. **Thornton LI – E Thornton, Head of School, Faculty of Medicine, University of Liverpool**

7. – Duxbury SH – Prof A Duxbury, Subject Leader Radiotherapy and Oncology, Faculty of Health and Wellbeing, Sheffield Hallam University

Appendix C: Specific features of the simulation model

1. Tumour localisation / radiotherapy planning
    a. Radiotherapy simulator – already modelled through previous collaboration [3, 4].
    b. Virtual simulation – as an extension to the x-ray CT room (below).
    c. Tumour localisation, margins for microscopic spread and uncertainties in position.
    d. X-ray CT
        i. Basic (external) appearance and operation
            Gantry and patient couch, Control area, Vertical and longitudinal couch movement, Optical indication of patient and slice position, Indication of radiation path through patient with gantry rotation, Interactive display of CT slices, updating with couch longitudinal movement
        ii. Intermediate operation and internal components
            X-ray source (tube), Detector array, Generation of multiple projections of radiation intensity with gantry rotation
    e. Magnetic resonance imaging
        i. Basic (external) appearance and operation
            Gantry and patient couch, Control area, Vertical and longitudinal couch movement, Receiver coils, Display of MR images in selected planes,
        ii. Intermediate operation and internal components
            Static magnet, RF pulse and gradient coils, Simple description of image acquisition (movie file)
2. Treatment: The linear accelerator
    f. Basic appearance and operation: This has been accomplished through previous collaboration [3, 4].
    g. Intermediate operation and internal components: The following components will be identified under external covers, a brief description of their function should be indicated:
        Modulator, Electron gun, Magnetron/klystron, Accelerating waveguide, Focus and steering coils, Beam bending section, Treatment head, to include: a) Photon target (moveable for dual modality machine), b) Flattening filter (moveable for dual modality machine), c)Electron scattering foils (3-4 sets for different available energies), d)Primary collimator, e) Secondary (adjustable) collimators, f) Ionisation chamber, g)Light source, h) Dynamic wedge
    h. Advanced operation: For the internal components identified above, visualisation of the operation of each component will be represented either through user interaction or fixed movie sequences.

    Additional equipment function to be illustrated:
        i. Beam monitoring – flatness and symmetry monitoring via the ion chamber
        ii. Equipment interlocks – illustration of selected mechanical and radiation interlocks: Photon target in/out, Scattering foils/flattening filter in/out,Gantry/couch/collimator settings correct and achieved, Door, Beam flatness/symmetry, Dose-rate, Set monitor units achieved, Channel 1/2 discrepancy
        iii. Room design: Primary and secondary radiation barriers, maze or door
3. Treatment delivery:
    i. Patient set-up via linear accelerator room lasers, distance indicator and field light
    j. Uncertainties in patient position, effects of respiratory motion on tumour position.
    k. Verification (pre- and post-treatment): MV and kV planar imaging, Cone-beam CT, Image registration.
4. Quality control / dosimetry
    A set of virtual experiments to demonstrate machine quality control (QC), beam characteristics and dosimetry measurement. For each experiment the equipment necessary will be simulated, together with dynamic simulation of the irradiation and measurement acquisition. Measurement of depth doses; Measurement of profiles; Measurement of TMR/TPR; Light to Radiation match; SSD checks; Dose measurement; Radiation leakage measurement; Dosemeter intercomparison.
5. Interactions of ionising radiation with matter
    l. Development of a simplified Monte Carlo model to allow visualization of radiation interactions on the macroscopic scale. This will provide a powerful tool for conveying the behaviour of ionising radiation in its interaction will matter in a real-time manner, based on the underlying physics involved, without requiring any mathematical insight.

i. Develop an algorithm to determine coordinates of photon and electron interaction sites, energy loss and emission angles of interaction products.
ii. Interface with room simulation models to determine appropriate properties of geometry elements encountered; determine atomic number (high or low) and density (high or low).
iii. Determine optimum number of histories for visualization, continuous track replacement, etc.
iv. Develop optimum visual representations of the tracks of individual particles and energy deposition through matter.
v. Visualization of fundamental interactions via movie files. This builds on previous work and will cover: Electron-electron collisions; excitation and ionisation, X-ray production (bremsstrahlung), Photoelectric effect, Compton effect, Pair production, Photo-nuclear interactions, neutron transport for photon beams at or above 15MV.

THE UNIVERSITY OF HULL

21 June 2006

To JISC Capital Programme Committee

Re: JISC proposal: An interactive virtual radiotherapy and medical imaging centre for the teaching and communication of healthcare technology.

The University has recently made a capital investment of £1M through SRIF in the Hull Immersive Visualization Environment (HIVE). This aim of this facility is to provide state of the art visualization resources to encourage and enable research throughout the University and nurture innovative applications of these technologies in industry and for teaching and learning.

A major success for the research team led by Prof. Phillips, in collaboration with the Radiation Physics Department at a local hospital, has been the development of a virtual simulation of a radiotherapy treatment room. Use of this virtual simulation is being prototyped as a treatment planning aid at a Florida Hospital and is being developed commercially.

The proposed project will extend this innovative technology and make it available for teaching in the HE and FE sectors and in the workplace. The project will provide teaching tools based on this virtual simulation that can be delivered in a classroom using normal or 3D projection technology or via a web-based learning platform for flexible access and work-based learning.

The evaluation of this technology and its delivery platform will provide important feedback to inform the adoption of visualization techniques and expertise for e-learning.

This proposal is strongly aligned with the University's strategic plan. Following the launch of our joint Medical School with the University of York we are expanding our activities in the area of Medicine and Health Sciences. We have significantly increased our provision in Sport, Health and Exercise Science, with major developments in sports rehabilitation. We are rehousing our nursing and midwifery section with upgraded facilities, and are planning a new school of pharmacy. Our medical school has major local strengths in anatomy, and biomedical sciences is one of our three inter-disciplinary research centres (IRCs) with a special interest in medical engineering. HIVE plays a major role in this IRC and the project adds to new initiatives in distance learning being pursued in our Faculty of Health and Social Care.

Professor J W Bruce
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In summary, the University views this as a very important project which has significant potential in providing a learning tool for those undertaking study in the healthcare area. The University gives this proposal its strongest support.

Yours sincerely

Professor J W Bruce
Deputy Vice-Chancellor

Sheffield Hallam University

June 2006

To Whom It May Concern:

Statement of support for Robert Appleyard, Senior Lecturer, Sheffield Hallam University (SHU) to work on the following research collaborative project.

Re: JISC proposal 'An interactive virtual radiotherapy and medical imaging centre for the teaching and communication of healthcare technology'

This project meets both the Radiotherapy and Oncology team and the Faculty's and strategic objectives particularly in relation to participation in high quality research and development of e-learning initiatives. Collaboration with the University of Liverpool and the University of Hull (UoH) will build on and strengthen an existing successful collaboration between SHU and UoH in relation to the development of virtual environments for radiotherapy education. The outputs of the project will be made available to the UK HE and FE community (as is the case with all JISC funded projects) and thus the project is of national significance. Intellectual property rights will remain with the key personnel named in the application. The project will lead to a number of publications in relation to the development of the VR models, the application of Monte Carlo visualisation and evaluation of the implementation in UK educational institutions. The evaluation aspect of this project will be lead by Rob Appleyard.

I fully support Rob Appleyard and his work with this project. This project has the potential to provide ground breaking evidence and underpin developments which will be of benefit to educators and professionals, not only in Radiotherapy, but in wider education and health care fields.

Yours faithfully

A.M.Duxbury

Professor Angela Duxbury MSc FCR TDCR
Subject Leader
Radiotherapy and Oncology
Faculty of Health and Wellbeing

Radiation Physics Department

Our Ref: VJW/AMR

Tel: 01482 676691
Fax: 01482 702147

21 June 2006

Joint informations System committee

An interactive virtual radiotherapy and medical imaging centre for the teaching and communication of healthcare technology.

I have been involved with the training of Radiographers (Therapy and Diagnostic) throughout my career. The Physics content of training courses often causes problems for the students without a strong scientific background – even when their motivation is high. Nevertheless, it is clearly important that our colleagues in all disciplines have a good understanding of relevant concepts and the physics issues surrounding new technology in order to facilitate the safe introduction of new clinical techniques.

We have achieved effective collaboration between my group and the Computer Science Department at the University with a number of projects in both scientific and training aspects of Radiotherapy, so are well placed to produce effective learning tools for Radiography and other related professions. The collaboration with Sheffield-Hallam University (our regional radiographer training school) has also proven successful in the past. Prof. Beavis provides regular lectures and supervision on the degree programs there - I understand that his lectures are well received and popular.

In summary, I will support this project and will encourage ongoing NHS involvement.

Yours sincerely

V J WHITTON
Head of Radiation Physics

Education and Development Department

DW/JB

21 June 2006

Tel: 01482 674286
Fax: 01482 674183
email: David.Withers@hey.nhs.uk

RE: An interactive virtual radiotherapy and medical imaging centre for the teaching and communication of Healthcare Technology

As Head of Education and Development for the Hull and East Yorkshire Hospitals NHS Trust it gives me great pleasure to support such an educational innovation.

The potential of this project is extremely significant as we consider the historical and continued difficulties professional groups have in finding the time to attend formally delivered programmes of development. Add to this the justified requirement for Continual Professional Development as and integral component of Professional Registration and a number of present or emerging development initiatives such as the Knowledge and Skills Framework (KSF) within Agenda for Change, all this then set in the context of Recruitment and Retention difficulties.

The development materials proposed as part of a 'blended' learning approach can only then have a positive impact on these ongoing issues. The media for which the materials are intended will inevitably widen education participation and also access, allowing individual access anywhere at a suitable time and venue and at a pace which suits them. This would also contribute to achieving balance between the ever present struggle to meet education needs and the immediate priority of service provision.

The materials will have a multiprofessional interest which may also make a contribution to addressing issues surrounding professional barriers. The materials would be linked to other educational resources and may potentially set the benchmark for such future developments and perhaps serve as inspiration for other professions to follow.

I welcome and wholeheartedly support the proposals and look forward to their arrival.

Yours sincerely

Dave Withers
Head of Education
Education and Development

Radiotherapy Department

Our Ref: KJ/SL

Tel: 01482 676852

21 June 2006

To Whom It May Concern:

Re: JISC proposal 'An interactive virtual radiotherapy and medical imaging centre for the teaching and communication of healthcare technology'

In the modern NHS environment, especially Radiation Oncology technology continues to advance at a rapid pace requiring staff to constantly update skills and knowledge necessary to fully utilise these new technologies and techniques.

As a Professional Manager it is my responsibility to ensure staff and students are fully equipped with these skills and underpinning knowledge. The demands of the service coupled with chronic radiographer shortages frequently prohibit attendance at study days and courses. Therefore, it is imperative that alternative methods of teaching and learning are available. Electronic/virtual training and educational materials would be highly advantageous in supporting continuous professional development, student training and 'return to practice' radiographers. This facility would enable staff to access teaching materials away from the pressures of the clinical service at a time most appropriate to the individual.

Additionally, it has always been challenging to teach students the more technical aspects of radiotherapy as it requires spatial awareness and an ability to view 2D information in a 3D format in order to fully understand the fundamentals of radiation physics and radiotherapy technique. Thus, if these particular areas were presented with informative graphics and demonstrations they may prove to be less daunting and problematical.

I fully support this application as I envisage many advantages for the radiotherapy profession if this initiative is successful.

Yours faithfully

Kay Jeffery
Clinical Manager, Radiotherapy

THE UNIVERSITY
of LIVERPOOL

Dr Anne M Merry
Director of Lifelong Learning

Student Services Centre
150 Mount Pleasant
Liverpool L69 3GD

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21 June 2006

JISC e-learning programme
Cross-institutional use of e-learning to support lifelong learners

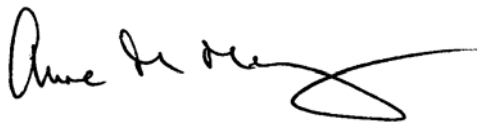
To whom it may concern

Development of an interactive virtual radiotherapy and medical imaging centre for the teaching and communication of healthcare technology

The Centre for Lifelong Learning at the University of Liverpool is very happy to support the above bid from the Universities of Hull, Sheffield Hallam and Liverpool.

Members of the Learning Technology and Educational Development Teams of the Centre for Lifelong Learning will provide advice and support for the Liverpool project team. This works builds upon previous activity in the University and is complementary to the work of the Centre for Lifelong Learning in supporting staff and students to use e-learning in an effective way.

Yours faithfully



Dr Anne Merry

THE UNIVERSITY
of LIVERPOOL

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21st June 2006

To whom it may concern

Re: 'Development of an interactive virtual radiotherapy and medical imaging centre for the teaching and communication of healthcare technology'

The above project is a welcome extension to previous internally funded projects performed within the School of Health Sciences, undertaken within the remit of the Education Research sub-group of the Faculty of Medicine.

This area of work is directly aligned with School, Faculty and University strategies in Learning and Teaching, in pursuing innovation through e-learning and in supporting the development of lifelong learning by providing an environment in which students have flexible access to resources, encouraging them to manage their own learning.

The proposed project therefore has the full support of the School of Health Sciences.

Yours sincerely

E Thornton
Head of School