Developing and Researching Personalised Learning with Haptics when Teaching with Online Media (PHANTOM): methodological strategies and solutions for technological, curriculum and teaching challenges


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Summary of the symposium: The overall aim of the PHANTOM project is to develop and evaluate purpose built computer control devices which respond to a person’s touch and manipulation (haptics) linked to graphical computer simulated displays which provide feedback for the learner. These are being trialled by a range of dental clinicians, students and other professionals over a period of three years to innovate their learning opportunities. The work of this research project which began in July 2007, involves three overlapping strands with a strong interdisciplinary focus:

- Strand 1 - the technical strand which involves the development, evaluation and refinement of haptic devices and online simulations in a three-dimensional virtual learning environment (3D VLE) setting;
- Strand 2 - the curriculum and context strand which involves developing and refining the dental curriculum and associated teaching strategies through a blended learning approach;
- Strand 3 - the educational evaluation strand to measure the impact of the Technology Enhanced Learning (TEL) devices on teaching and learning.

The symposium will report on the progress and results of the three project strands and use the evidence and theoretical relevant frameworks to date together with contributions from the discussants and the audience to produce a consensus document on:
1. strategies for the development, pedagogical design and incorporation of innovative techniques in higher education;
2. effective methods for evaluating the impact of these multimedia devices on the curriculum and on learning;
3. a theoretical framework for the development of haptic related Virtual Learning Environments;
4. strategies and methods to promote interdisciplinary research and development in E-learning.

Keywords: Curriculum, Evaluation, Higher Education, Innovation, Knowledge Representation, Learning Models, multimedia, research, user interface, virtual reality

Themes: Innovators and Creators in Higher Education

Perspective: Research

Chairs for the session: Margaret Cox, Patricia Reynolds and Jonathan San Diego

Contributors (from which a subset plan to attend the conference):
Ally Barrow       Tim Newton
Margaret Cox      Barry Quinn
Stephen Dunne     Patricia Reynolds
Bruce Elson       Brett Robinson
William Harwin    Jonathan San Diego
Joe Harper        Brian Tse
Jon Hindmarsh     Nairn Wilson
Brian Millar      Mark Woolford

Discussants: (To be arranged from WG3.3 membership)

1. Background

There is now substantial evidence spanning 30 years of the positive effects which different types of Technology Enhanced Learning (TEL) can have on students’ learning [1][2][3][4]. There is also evidence of the growth of the use of TEL to enhance teaching different dental concepts and skills [5][6][7][8] and in the uses of TEL in General Practice [6]. However, there is very limited evidence of the effects of new multimedia technologies on teachers' pedagogies, the integration within the curriculum and the transformation of learning in post-compulsory
Developing and Researching Personalised Learning ..., IFIP WCCE 2009

education for the professions. Most of the research at higher education level has focused on either evaluating the students’ abilities to use new technologies in their courses [9] or evaluating the attitudes of students towards the new learning environment [10] or new methods of teaching and assessment such as online assessment. There is also little evidence to date of the impact of specific technologies such as haptics on students' learning, on university teaching programmes and on the institutions adoption of such technologies.

Before the uptake of haptics in educational settings the growth and range of IT resources had led to an expanding range of representational systems and different modes of human computer interfaces which has extended the specification of knowledge and knowledge domains that learners now meet in education [11][12][13][14]. From the early days of IT simulations it has been recognised that IT software can provide new representation systems which require different understandings of the way knowledge is codified and constructed [15][16][17]. The different types of human computer interactions required of the learner also require an understanding of the new literacies which these representations present. The use of haptics for teaching and learning introduces contexts in which the learner is immersed in a virtual reality which will affect the learner's ability to move between different states of reality. [16][18] Furthermore, research by Ijsselstein, Freeman and de Ridder [19] in 2002 showed that the extent to which the learner moves between these different states of reality will change continuously. The development of haptics in the gaming industry (e.g. see http://www.ceasiamag.com/article.asp?id=1532), with the range of input and output devices adds to the complexity of the levels of immersion and the transfer between the virtual and real worlds. In the case of dental students, who are learning skills in teeth treatment, and other students in medicine and veterinary practice, then the learning experience is not just in the manipulation of the haptic devices as is the case in using them in games, but is to acquire skills which can eventually be used in the real world with patients. This learning experience will affect the students according to the different stimuli which each individual student might feel, and the level of presence [20], the stages in the learning process [21] and the correspondence between and real and the virtual world [16]. As a consequence, the impact on the students' learning is extremely complex and research into this impact needs to take account of such variables as level of presence, stages in the learning process, levels of immersion and the transfer between the virtual and real worlds.

An important approach to address these gaps in the research is to involve researchers and end users across a range of disciplines bringing together key researchers, clinicians and users with expertise in instrumentation, psychology, sociology, clinical practice, human computer interfaces (HCI) and educational research.

Using the work of the PHANTOM project’s interdisciplinary team, this symposium draws on the results and experience from the last 2 years to identify: (a) the strengths and limitations of innovative haptic techniques which can be used
within a university undergraduate curriculum; and (b) the range of research methods which can effectively measure the impact on the teaching and learning within a very organized curriculum.

2. Organization of the symposium:

The symposium will be organized into four presentations;
- an overview presentation of the project’s aims and the successes and problems encountered during the first 2 years (Cox, Reynolds, and San Diego);
- a presentation on the development and evaluation work of the haptics workstations (San Diego);
- a presentation on the curriculum and teaching issues to enable the technology to be incorporated into the university curriculum (Cox and Quinn);
- a presentation on the assessment of students’ 3D perceptions; manipulative skills; and dental knowledge (Cox).

3. Symposium Programme

Aims of the symposium: 10 minutes
Contributions: 4* 25 minutes (including 5 minute discussion)
Discussants: 2* 10 minutes
Planning the position paper with the audience: 50 minutes

4. Contributions to the symposium

4.1 Interdisciplinary TEL research in higher education: the PHANTOM experience

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A key requirement for the effective development and evaluation of technology enhanced learning resources is to have a range of skills and expertise within the research team which enables it to understand the complex concepts associated with the changing and diverse nature of TEL and its scope and potential for learning and teaching. As many delegates will know, as the technology has changed and expanded over the last 30 years so have the opportunities for new ways of interacting and working with it. On the one hand a detailed understanding
of how haptics devices might affect the level of immersion of the learner within the environment shows that research needs to delve deeply into the learning activities taking place, with both qualitative and quantitative methods. On the other hand many previous research studies have not been successful in leading to subsequent integration of the technology because of insufficient consideration being given to the established curriculum into which the innovation is aimed to be incorporated. [22]

A further dilemma for a complex TEL project is the need to ‘standardise’ on the resource at some point so that the researchers can measure the impact of the TEL within a curriculum setting. In the field of haptics, there are always new developments on the horizon as with any other TEL resource, so the research involves balancing the need to be as up to date as possible but at the same time having a robust resource and in the case of the PHANTOM project sufficient numbers, to be able to conduct reliable studies of the impact on teaching and learning in a very important undergraduate curriculum. Throughout the two first years of the project we have been monitoring how these goals have affected our priorities and what are the emerging issues regarding a large team working with parallel goals yet a single overall vision. The paper will present the emerging issues and priorities and the lessons learnt to date on how to achieve reliable innovate TEL research in higher education.

4.2 The Synergy between haptics development, simulating the reality and meeting the needs of the users.

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Vision, sound and touch are three sensory modalities whereby people can learn about objects they manipulate. Dentistry is a field of interest to examine learning effects with multimodal interfaces as there have been several attempts to model near-realistic touch, sound and vision in order to enhance learning experiences. [23][24][25] Whilst it may be possible to develop an expensive training system that incorporates haptic, visual, and auditory features, it is technically challenging to develop an affordable system that can be deployed into a classroom for learners to use. To ensure that a technology-enhanced training system can support learning of some key skills set in the curricular context, certain design trade-offs need to be carefully considered. Some learning theories argue that each sensory modality transmits different information to users and is processed cognitively by different faculties. [26][27] In designing a virtual learning simulation, the extent to which a particular modality can best help augment the learning of skills for drilling a cavity, for example, has required the research team to make informed decisions on the tradeoffs in considering combinations of haptic, visual, and auditory features as defined by users (both clinicians and students); the consequent affordances of
new technologies; and learning benefits from these combinations. In this paper, we will demonstrate how force feedback, head-movement tracking, stereoscopic visuals, digital sound effects, may enhance the opportunities for learning in the context of dentistry. A dental training workstation prototype has been developed intended for training dental students. Whilst the empirical evidence provided is preliminary, we shall describe the potential of multimodal interaction via these technologies for enhancing dental-clinical skills. We will discuss how the investigation of haptics, vision and sound in the context of dentistry can contribute to learning theories, cognitive load and multimedia, in the design of multimodal interfaces for other tactile learning goals.

4.3 Strategies to incorporate new technologies within a university professional undergraduate curriculum: contextual, pedagogical and institutional issues

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Research into the impact of TEL in the curriculum in other contexts has shown that there are three very significant factors which will affect the uptake and use by teachers and the learning outcomes of the students. Firstly, the teachers' attitudes and pedagogies (beliefs) about how students' learn and what kinds of teaching and learning experiences will be most effective can make it difficult for teachers to adopt new technologies in the curriculum. [28][29] Secondly, the ways in which haptic technologies can be incorporated into a very structured undergraduate curriculum and in this case forming an integral part of the clinical teaching laboratory work requires substantial changes in the organization of the laboratory programme of work and changes in the teaching practices of the tutors involved. Thirdly, in the wider context of the institution as a whole, the ways in which the new technologies can be integrated into the whole undergraduate programme will affect the uptake of new technologies by the institution itself. The latter is affected by a range of institutional factors which in turn affect how such technologies are adopted in the curriculum. [30][9]

This curriculum strand of the PHANTOM research is using two taxonomies of pedagogies used in ICT education [27] to classify the approaches to teaching which are used before, during and following the introduction of the haptic environments, on the basis of observations and discussions with teaching staff. The evaluation of the project prototype tools and technologies with a range of clinicians and university teachers includes: pilot studies with individuals and groups of users (clinicians/undergraduate and postgraduate tutors) who use the resources and provide oral and written feedback; video-recordings of users
working with the resources which are then analysed to explore the ways in which
the technologies support or inhibit training discussions and co-participation
between teachers and learners. In human computer interface (HCI) research,
video-based studies of interaction with and around advanced technologies in trial
situations [31][32] have significant success in informing the further development
of those tools and technologies. The findings from these studies will be used to
inform further technology development work and to consider the factors that
might lead to more successful combinations of media and learning contexts.

The paper will report on the different curriculum factors discussed above which
have had to be considered and evaluated to enable the integration of haptic related
technologies in the undergraduate clinical skills programme.

4.4 Researching the impact of TEL in higher education: matching
the methods to the technology and the theory

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The main purpose of the PHANTOM project is to investigate the impact of
these haptic technologies on students’ learning and understanding. As has been
shown above in the background to the project, we need to measure a range of
skills and knowledge, which from previous research evidence have been shown to be
important in TEL studies:

- Attitudes towards the use of TEL resources within the undergraduate
  programme and the relationship between these and the students’ experience of
  computer enhanced learning.
- The effects of using TEL resources on the students’ understanding of such
  concepts as the hardness, textures, non-homogeneity, size, shape of teeth.
- The effects of using 3D imaging and tasks on the students’ 3D perceptions
  and skills.
- Measurement of the relationship between levels of immersion, presence and
  transfer between the virtual and real worlds and the skills acquired by the
  students.

The overall methodological framework for this strand involves two
complementary methods. Firstly we shall be running a Randomised Controlled
Trial across multiple baselines comparing the standard approach to teaching with a
teaching approach accompanied by haptic devices. Secondly we are conducting a
range of qualitative measurements based on specific tasks using observations and
records of clinicians and then student activities.

The randomized trials involve splitting students into two groups, then
introducing haptic devices to one group at random, whilst assessing changes in
skill and learning, then later introducing haptic devices to the other group(s). For
the Dental Undergraduates, we plan to provide the resource to 20 students in turn
forming the experimental group out of a total cohort of 150 students. Over the next academic year all 150 students will have used the haptic work stations. If the results show that change occurs in response to the introduction of haptic work stations which is greater than that for introduction of the structured teaching alone, or greater than maturation then we can be confident that it is related to the haptic devices. Embedded within this overarching design will be sub-studies exploring various aspects of the students’ learning listed above. Over 70 students have completed tests of their 3D spatial reasoning, manipulative skills and their attitudes to using TEL. The paper presentation will present the results from the first phase on the study and discuss the strengths and limitations of the research methods used so far.

5. Discussants’ feedback

5.1 General discussion: Planning the position paper on

- strategies for the development and incorporation of innovative techniques in higher education;
- effective methods for evaluating the impact of these multimedia devices on the curriculum and on learning;
- strategies and methods to promote interdisciplinary research and development in E-learning.

References


