Tool Kits for a Dynamic Review Journal

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Abstract

The Virtual Orthopaedic European University provides an infrastructure for clinicians to manage the administrative, research and educational workload of a university within the digital domain. An aim of the project is to maximise the relationship between different pedagogical approaches, tools and resources in a novel learning environment, while providing support for decision-making using a toolkit approach. This paper focuses on a specific framework, the Dynamic Review Journal, which supports the development and dissemination of documents by assisting authors in collating and analysing experimental results, organising internal project discussions, and in producing papers. The system has been deployed in a local hospital and is presently being deployed to support a regional training service.

1 Introduction

This paper reports on a project which developed as part of a Virtual University European Orthopaedics (VOEU) and particularly on a system that enables Higher Surgical Trainees (HSTs) to develop material for peer review. In the UK's medical education system, HSTs are qualified surgeons training to become consultants. The VOEU provides an infrastructure for clinicians to use computer-assisted surgical tools and to clinical data collection from ongoing trials in orthopaedics; with dedicated interactive media linking the educational environment of the Web Based Training (WBT) scheme to the resources. Continuing Professional Development (CPD) is an essential part of the healthcare professions. The use of Information and Communication Technology (ICT) provides an opportunity to improve the efficiency of both the teaching and the learning in the context of lifelong learners.

Furthermore, surgeons are mobile well-educated individuals whose work demands excellent availability of educational material that is up-to-date and focused on their particular learning situation. With the advent of virtual infrastructures, there is the possibility managing most of the administrative, research and educational workload of the university within the digital domain. This has potentially huge benefits for surgeons, providing greater access to information without the friction associated with traditional infrastructures.

This paper reports on the pedagogical strategy adopted within the VOEU project and its relationship with the developed architecture. The system design needed to take account that the content for this area is constantly changing, giving rise to the need for dynamic and interactive systems, which allows new and updated materials to be included. This paper first introduces the system and how it is used in education, then presents the toolkits used in the preparation of material by trainees. The paper concludes by discussing the potential impact of such systems.

2 The Virtual Orthopaedic University approach

VOEU provides a working environment to help with familiarisation of new surgical procedures and the management of clinical case audit. The implementation enables users to communicate using material tailored for their specific needs, which allows the presentation of media to be adaptive to the user experience and knowledge base. This combines declarative (factual) content with feedback from a clinical (procedural) case-based training and evaluation environment. There are three underlying characteristics of the training needs of orthopaedic surgeons which need to be satisfied.

1. There is a need for constant updating of the knowledge base for both procedural and declarative learning.
2. The learners typically have limited time and computing expertise.
3. The specialist knowledge base varies according to experience and application.

Specialist knowledge includes both essential and important knowledge. The essential knowledge includes that part of the core curriculum relating to safety issues and every trainee must be evaluated against this and demonstrate passable skills on every occasion. Important knowledge is also part of the core curriculum; although time is not formally available to test this, it will be included within the questions of the core modules. Important knowledge is that required to achieve a high quality of service, such as knowing a wide range of detail regarding conditions. The system developed to meet these requirements included the following components; the last two being the focus of this paper.

- *Multimedia Educational Modules*, which provide the declarative (factual) base of material for the education of the users [4].
- A *Virtual Classroom* environment for exchange of views, and monitoring of progress [18].
- *Novel Modalities of Simulation* [7,8] for the emulation of surgical procedures for training and experimentation, focusing upon micro-surgery.
- A *Virtual Observatory* for the collection of data from simulation systems and the actual intra-operative data collection.
- A *Dynamic Review Journal* (DRJ) will allow HSTs and tutors to analyse data from existing journals, investigate hypotheses, comment on reviewed articles, and even prepare and submit articles for review. The DRJ is a web-based archive of medical and technical material, which is peer-reviewed. In addition, tutors will be able capitalise on these reviews by including the corresponding declarative and procedural knowledge in the educational modules.

Combining the above disciplines within one working environment, the virtual university infrastructure [9] aims to meet the needs of clinicians by combining clinical, educational and research duties. VOEU is an integrated digital educational and working environment for the training of orthopaedic surgeons. This includes the concept of a digital personal profile of the trainees. This is formalised as a surgical educational ontology, which is part of the learning agreement. There is a core of documents and components linked into the VOEU surgical educational learning agreement, which will continue to be refined as part of the VOEU pedagogy.

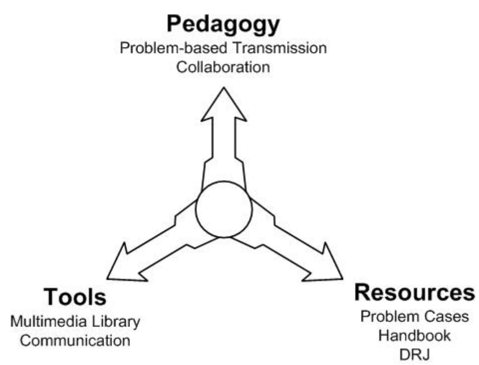

Figure 1 Relationship between pedagogy, tools, and resources

The aim of the project was to create a novel learning environment which tries to maximise the relationship between different pedagogical approaches used to support learning, and the associated tools and resources available to support them (see Figure 1). The project builds on current thinking in educational research on pedagogy in terms of learning being situated and authentic, with learners adopting an active and constructive approach. In particular it builds on the problem-based learning literature [12], constructivism [14, 15], communities of practice [17], situated learning [1, 16, 11] and activity theory [6]. The pedagogical strategy aims to create an environment which allows the different benefits of each of these pedagogical approaches to be made explicit. Guidance and exemplars will be included as part of the learning environment. The guidance and exemplars will be developed and stored in a pedagogical 'toolkit'. This builds on our previous research on using toolkits to provide guidance and support, which are developed through a process of co-participation with relevant stakeholders. 'Toolkits' provide a pragmatic-based approach to applying theory to practice and can be used to support decision-making [2,13]. We have developed a framework for integrating learning technologies into courses which builds on Laurillard's 'conversational' framework [3]. The framework is designed to take the user through the thought processes of re-engineering a course.

It begins with an evaluation of the existing course and an analysis of strengths and weaknesses. Different media types are then assessed, and the different educational interactions they support are considered. A selection process then takes into account limiting factors, including resource issues and local constraints. We define toolkits as decision-making systems based on expert models, positioned between wizards and conceptual frameworks. They are more structured than frameworks. A toolkit is a model of a design or decision-making process, with tools provided at key points along the way. Each of these individual tools is designed to help the user access a knowledge base in order to make informed decisions.

The VOEU learning environment consists of a supportive underpinning technical architecture and a range of supplementary guidance and tools. The tools and resources are designed to be flexible to enable their use at a number of levels, from major pedagogical re-engineering of courses through to enrichment of aspects of the learning process with engaging and illustrative resources.

3 Dynamic Review Journal

The Dynamic Review Journal has two main functions: to support the educational process and to aid surgeons in preparing findings for publication. Orthopaedic surgical trials typically run for extended periods (up to 2 years), with postoperative assessment results being collected regularly. The collated results are then analysed and discussed by a team of surgeons before being disseminated to the wider orthopaedic community.

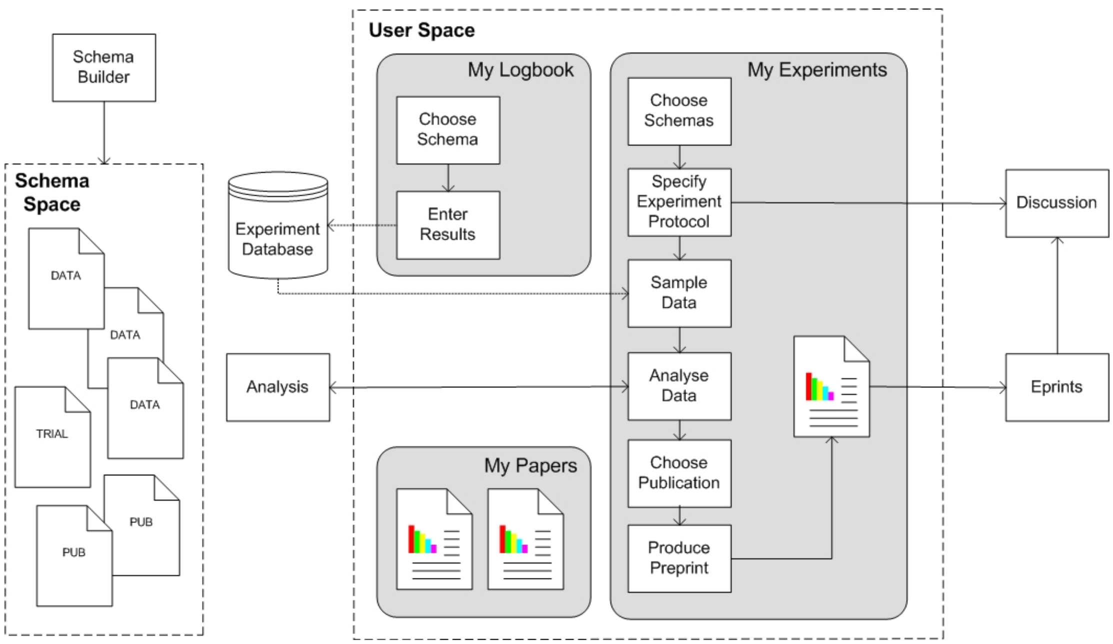

Figure 2 Workflow in the DRJ Framework.

The VOEU-managed learning environment for training surgeons consists of hypermedia educational material (including problem cases and assessment), interactive simulators, and communication tools (moderated and asynchronous message boards) together with the Dynamic Review Journal. An objective of the project was to provide integrated computer support across the research and educational cycles because these activities are intrinsically coupled as a part of the requirements of the surgeon's CPD. They must undertake research and papers published to achieve goals under the learning contracts with their Professional Colleges.

3.1 Schema Space

The schema space is the mechanism by which the Dynamic Review Journal is configured to a particular e-learning community, through the formal specification of e-experimentation procedures relevant to that community. This configuration is currently achieved using three different types of schema:

- **Data schemas** describe the exact nature of the experimental data (for example, specification of variable names, types, and possible values). In VOEU there are a number of data schemas for collecting orthopaedic clinical trial data.

- **Experiment schemas** describe experimental procedures or *protocols*. For example, a protocol could specify that any e-scientist conducting an experiment of type *X* needs to record an *experiment description*, *statement of purpose* and an *outcome hypothesis*. Human-readable guidelines are also included, to help HSTs meet the requirements of the protocol and to help reviewers to ensure that the requirements have been met. As a simple example, the HST guidelines for the *experiment description* may state "summarise the content of the experiment", whereas the reviewer guidelines ask "does the experiment description adequately summarise the content of the experiment?"
- **Publication schemas** describe the required format for submitting experimental results to relevant journals/conferences (for example: *Abstract*, *Introduction*, *Background*, *Experimental Methods*, *Results*, and *Conclusions*). As with experiment schemas, human-readable guidelines are also included in publication schemas. In VOEU there are currently two publication schemas presenting the submission formats for the Journal of Bone & Joint Surgery (JBJS) and the British Medical Journal (BMJ). Where possible, the publication schema also describes any mappings between the experiment protocol (for example, specifying that the experiment *hypothesis* should appear in the *Experimental Methods* section of the article). This allows outline preprint 'previews' to be generated automatically without requiring the HST to copy and paste information between protocol and preprint).

3.2 User Space

The user space is where HST uses the schema space to orchestrate practical data entry and collation, e-experimentation, and dissemination. The user space is further subdivided into three personalised areas *My Logbook*, *My Experiments*, and *My Papers*.

My Logbook or *e-portfolio* is an experiment logbook, in which experimental results can be entered (in accordance with a selected data schema). Logbook entries are subsequently added to the Dynamic Review Journal community database, making data available (anonymously) to other community members.

My Experiments is a workspace for e-experiments, which the e-scientist works on. An e-scientist may be involved in an experiment in the capacity of *lead investigator* (initiates experiment and acts as co-ordinator and contact for duration of experiment), *associate investigator* (assistant), or *reviewer* (monitors the progress of the experiment and reviews its outcomes according to guidelines). Reviewers have read-only access to the experiment protocol and set-up. When a new experiment is initiated, a discussion facility is automatically set up to facilitate and record communication between the e-scientists involved (this is also the means by which reviewers can give feedback the practitioners).

3.3 Example of Use

To illustrate how a HST may use the DRJ, this section outlines the process of managing e-experiments from the perspective of a fictional trainee surgeon, Sam. In Sam's view of the DRJ user space, Sam is shown to be currently working on three trials, undertaking a different role in each. Sam is the co-investigator in the "charcot joints" trial, is writing a systematic review of experiments in the "rotator cuff" trial, and is also a peer reviewer of the "tear size" trial. Sam has also entered several experimental records in the personal logbook (patient details, operative procedures, and assessment results), part of Sam's e-portfolio.

Formalising Trial Protocol - To initiate a new trial, Sam first selects the experiment protocol from the available experiment schemas. The DRJ then uses this schema to generate a number of data entry forms into which Sam enters specifics of the experiment. Guidelines for completing these forms are presented as "stretch text links" [12], which can be viewed/hidden as required. A tutor specifies the associate investigators and peer reviewers who will assist Sam on the trial. When created, the new trial will appear in Sam's DRJ user space, and also in the user spaces of the associate investigators and peer reviewers.

Selecting a Dataset - To create a dataset for the new trial, Sam searches the data repository for appropriate data used in previous trials for suitable cases or uploads new cases from Sam's logbook. Since Sam has already specified the experiment schemas, only those cases matching this schema will be searched. Sam and associates subsequently add 42 different experimental results to the trial, which can be viewed in tabulated form for visual comparison.

Analysing the Dataset - To perform analyses on the dataset, Sam and associates choose from statistical methods offered by a distributed Analysis Engine. Using the experiment schemas and metadata from the Analysis Engine, the DRJ tool is able to generate an entry form for each statistical method, which Sam can use to fine tune the analysis (specify test variables, groupings etc.). The Analysis Engine queues the requested analysis and notifies Sam when results are available. These results appear in Sam's DRJ user space, and can be viewed.

Discussing the Results - Having obtained some significant results from the statistical analyses, Sam then decides to create a pre-print, for discussion by the co-investigators on a discussion board created for the e-print. Sam, co-investigators, or a tutor can specify who is able to see the pre-print and comment on it. For the trial, the pre-print can be take on to publication. In this case Sam selects the JBJS publication schema, and the DRJ toolkit generates a pre-print template using the information Sam entered in the trial protocol. Sam fleshes out this template, following the JBJS guidelines provided, and specifies which analysis results should be included in the preprint. After previewing the pre-print, Sam submits it; behind the scenes the DRJ tool submits the pre-print and its associated metadata to the community E-prints server (where it subsequently becomes available to the members of community), and makes the paper available in the user space of Sam and associates.

4 Defining Data Schemas

The Dynamic Review Journal stores patient case data from hundreds of thousands of operations, each case being described by one of several different schemas; it therefore made sense for us to focus our initial efforts on facilitating user generation of data schemas, before considering the experiment and publication schemas. The schemas in the Schema Space provide an interface between the data stored by the system and the users' view of that data. In the case of the data schema, the type and format of sets of data variables are specified and subsequently used to dynamically generate interfaces for entering, viewing, and performing statistical analyses of the stored data (since the data definition is abstracted in the schema, new views of existing data can also be added with little effort). Therefore, in order to introduce different datasets to the DRJ environment, the user must first formally describe the data structure and add it to the Schema Space.

Until recently, this mechanism was only available to expert users with the appropriate technical knowledge to formalise their data requirements using the XML Schema grammar. Our aim was therefore to develop a schema-building tool which would enable the wider (non-expert) DRJ user community to configure their working environment to their changing needs. The first barrier to achieving this goal was the use of the term 'schema' itself. For surgeons this is an alien term within their day-to-day work experience, so the more familiar term 'template' was chosen in its place. This change of name from schema to template also emphasised the evolutionary nature of most schemas. Rather than start with a blank schema and add new items, the majority of new schemas would be modifications of existing ones. Therefore an existing schema would form a template around which new ones could be created. The DRJ's schema-building component thus became known as the Template Generation Toolkit.

4.1 The Template Generation Toolkit

The Template Generation Toolkit (TGT) enables non-expert users to quickly and easily add new schema specification, or 'templates' to the DRJ Schema Space, in accordance with their specific requirements. The TGT has been developed in the form of a *pedagogical toolkit* — such toolkits guide users through the process of articulating their information needs to produce an information plan for a particular task. Pedagogical toolkits lie between restrictive wizards which force a user through a particular route (for example, a printer installation wizard) and more open frameworks which provide unrestricted access to a different parts of a creation process. The TGT therefore, is designed to provide a structured way of creating a new data schema and specifying the variables associated with it.

To aid this task, variables can be grouped together into sets based on the type of data they record. For example, a patient data set could include age, weight, height, and ethnic origin, while a data set for recording the range of movement in the elbow could include range and degree of motion in various directions, pain experienced, and muscle response. New schemas can then be built using sets defined by existing schemas, and 'fine-tuned' by adding, deleting, or modifying individual variables. To add a variable to a new schema, the user can either select an existing variable from a list of previously defined variables, or create a new variable. When creating a new variable, details such as description, data type, default value and variable type must be specified. The variable type defines the statistical affordance of the variable; the user selects from a list of variable types such as dependent interval, independent ordinal, ratio etc.

4.2 Using Data Schemas

Once a data schema has been created using the Template Generation Toolkit, it is immediately available to members of the VOEU community for use to input new case data via the entry forms generated by the new schema. When a suitable number of cases based on the new schema have been entered into the VOEU database, a group of surgeons may choose to carry out a trial to identify trends in the data. The new schema is selected as the data source in the trial protocol, allowing the entered cases to be added to the trial dataset. Relevant cases can be extracted from the database by using a search form generated from the schema. The surgeons can then choose between a number of statistical analysis methods and invoke them on the dataset. Since the statistical affordance of each variable was specified at the time of schema creation, the DRJ can generate an interface which hides the variables which are inappropriate to the selected statistical analysis.

4.3 Issues Raised

The development work on the Template Generation Toolkit has raised some issues within the context of the VOEU community, which have wider implications that must be borne in mind as we move towards our goal of more widespread adoption of a Dynamic Review Journal-based infrastructure supporting the experimental work of other on-line scientific communities.

One issue that was faced concerned the lack of presentation information defined within the data schema. Without this information, the interfaces generated from the data schema (including data entry forms, data viewing tables, search forms, and data analysis forms) are simplistic and simply list each variable in the order that they are defined in the schema. While this was sufficient in most cases, in specific cases we were asked by surgeons to adjust the appearance of the forms so that they mirrored the paper-based counterparts which the surgeons were used to. This issue potentially hints at a much larger one - that in large-scale trials involving participants from multiple institutes throughout the EU there is a much greater need for customised presentation of information then would be required in the case of a smaller trial whose participants are all part of the same institute. Issues such as cultural, linguistic and political differences all need to be properly addressed. This requires a larger development effort; in the current DRJ implementation few of these issues have been addressed. However, VOEU does currently hold a ‘user profile’ information for each registered user of the system, which provides a useful starting point for future development in providing customised interfaces in different languages or presentation styles. For example, user-specified style sheets could be used to render schema-based views in such a way as to mimic each institution’s paper-based forms - this may include structural definitions such as defining the order in which a list of variables should appear, or purely presentational devices such as logos and fonts in order that the user’s interface adheres to their institute’s corporate identity.

Another issue facing multi-national trials is the potential difference in local policies between participating institutions; a VOEU-specific example is that of different policies used in different regions for assessing a patient’s pre-and post-operative motor facilities - surgeons in the US use the AIPES system, whereas in the EU the CONS system is used. A mechanism to enable the DRJ to map between the different types of assessment could be defined in this instance, allowing scores from both types of system to be compared and analysed side by side; however, there may be some cases in which a measurement in one system has no equivalent in the system to which it is being compared.

5 VOEU EVALUATION

The VOEU project has recently carried out a broad usability evaluation of the range of services offered by the UK Web site. This evaluation focused on capturing users’ general responses to the overall VOEU ‘experience’.

Scale	**User Experience**
‘Aidability’	The degree to which the VOEU site assists the user to resolve a situation
Command	The extent to which the user feels that they are in control
Comprehension	The degree to which the user understood the interaction with the VOEU site
Effectiveness	The degree to which the user feels that they can complete the task within the VOEU site
Impression	The user’s feelings or emotions when using the VOEU site
Learnability	The degree to which the user feels that the VOEU site is easy to become familiar with
Navigation	The degree to which the user can move around the VOEU site

Table 1 Questionnaire scales in relation to the user’s ‘experience’ of using the VOEU site.

The evaluation was carried out by 18 orthopaedic surgeons with a mean age of 30.2 (SD 4.6), and a mean of 5.1 years surgical experience (SD 4.3). The majority of the participants responded to background questions in a way that indicated that they were technically well informed — they understood the benefits of electronic access to information, used the Web regularly at home and work, and preferred the electronic medium over traditional media.

Even those who were less technically aware praised the benefits of electronic access. Only one participant, a self-confessed ‘techno-phobe’, maintained that paper-based materials were the easiest and preferred working medium.

Each participant followed a tour through the VOEU Web site, with each area — Digital Library, Education (part of each surgeon’s Continuing Professional Development commitment), and DRJ — being demonstrated, before allowing the participant to familiarise himself/herself with its function through ‘hands-on’ experimentation. Participants were also invited to carry out simple tasks, such as finding information in the VOEU digital library, and taking part in an interactive surgical simulation. In the case of the DRJ, each participant was given the opportunity to run through the entire process of setting up a clinical trial, carrying out data collection and analysis, and producing a targeted pre-print. Each participant then completed a questionnaire designed to capture their responses to a number of different aspects of their VOEU ‘experience’, enabling us to measure the experience in terms of *impression*, *command*, *effectiveness*, *learnability*, and ‘*aidability’*, based on the Software Usability Measurement Inventory (SUMI) [10], as well the *navigation* and *comprehension* extensions to SUMI proposed by Crowder *et al*. [5] for evaluating hypermedia systems. Table 1 shows how each scale corresponds to a different aspect of the VOEU ‘experience’.

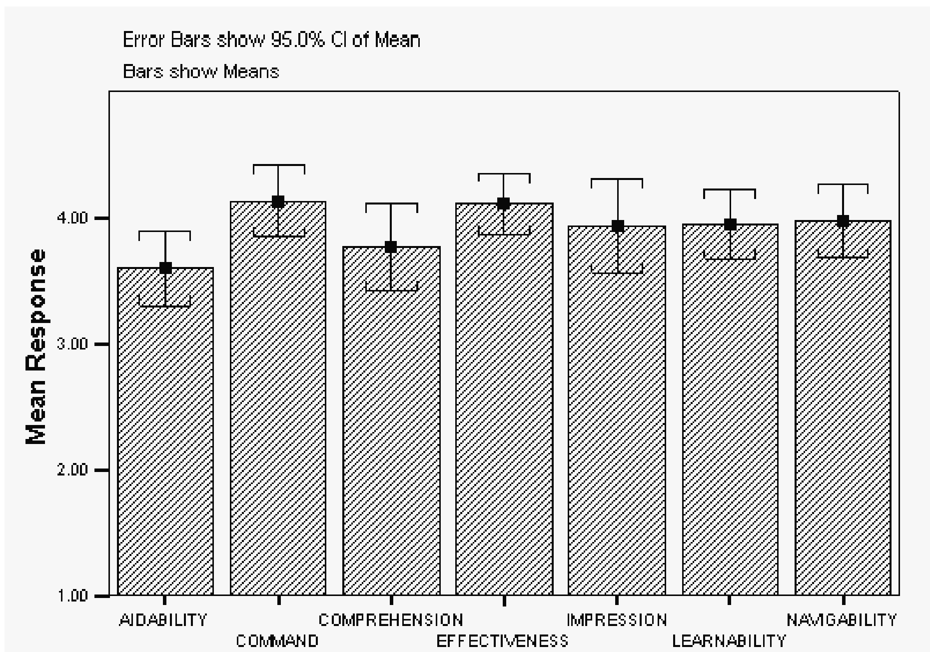

Figure 3 Results of the VOEU usability trial, showing average participant responses for different areas of their VOEU experience

The results of the evaluation are shown in Figure 3, where a mean response value of 5.0 indicates an entirely positive result, and a mean response of 1.0 indicates an entirely negative result. Initial indications from this trial therefore show a positive response to all aspects of the VOEU usability experience. The greatest positive responses were to the statements “I was able to move around the information in VOEU easily” (navigation), “learning to use the system was easy” (learnability), “I felt at ease trying different ways to get to the information I needed” (learnability), “the system help files provided enough information to use the system” (‘aidability’), “VOEU could be of use to me in my job” (effectiveness), and “using VOEU allows me to accomplish tasks more quickly” (effectiveness). Areas which proved more controversial included “I often become lost/disoriented when using VOEU”, “it was difficult to learn more than the basic functions of the VOEU system”, and “the system was awkward to use if I wanted to do anything out of the ordinary”.

6 Conclusions and Future work

The development of a Virtual Orthopaedic European University described in this paper is underpinned by a pedagogical approach built on current education research. Using a toolkit approach allows us to maximise the relationship between different pedagogical approaches, tools and resources in a novel learning environment, while providing support for the decision making. The tools and resources are designed to be flexible to enable their use at a number of levels, from major pedagogical re-engineering of courses through to enrichment of aspects of the learning process with engaging and illustrative resources. This paper has focuses on a specific framework, the Dynamic Review Journal, which supports the development and dissemination of documents by assisting authors in collating and analysing experimental results, organising internal project discussions, and producing papers.

The VOEU has been developed in a consortium consisting of orthopaedic surgeons, educationalists and computer scientists, and has undergone expert review at several stages in its development. The system provides a distributed architecture for institutions to manage multiple centres, advancing surgical standards through education and research. The tools are generic, applicable across surgical and medical training. The system has been deployed in a local hospital and basic and HSTs validated the trials. The project has now received further funding for the development of the DRJ software using a web-services infrastructure and is to be realised nationally.

7 Acknowledgements

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