A Recommender Framework for the Evaluation of End User Experience in Adaptive Technology Enhanced Learning Systems.

Catherine Mulwa, Seamus Lawless, Ian O'Keeffe, Mary Sharp, Vincent Wade
Knowledge and Data Engineering Group
School of Computer Science and Statistics
Trinity College, Dublin

mulwac@scss.tcd.ie, seamus.lawless@scss.tcd.ie, ian.okeeffee@cs.tcd.ie, mary.Sharp@scss.tcd.ie, vincent.wade@scss.tcd.ie

ABSTRACT

The Centre for Next Generation Localisation (CNGL) is involved in building interactive adaptive systems which combine adaptive web techniques and technologies, information retrieval (IR) and Adaptive Hypermedia (AH). AH research is concerned with the dynamic composition and personalisation of hypermedia documents in order to provide more context sensitive retrieval and reuse of digital content. The evaluation of adaptive educational hypermedia systems (AEHS) is a difficult task due to the complexity of such systems. It is of crucial importance that the adaptive features of the system can be easily distinguished from the general usability of the designed tool. Several researchers have identified challenges, problems and pitfalls encountered by developers and evaluators of these systems. The main challenge is how to evaluate adaptivity. These complex systems encounter inherent usability problems. In an attempt to address this issues and challenges, several evaluation approaches have been used: empirical, layered, utility, heuristic and user-centered evaluation (UCE) approach. The UCE approach has proved cable to addressing these problems.

This paper proposes a UCE approach of adaptive systems and presents an evaluation framework for end-user experience (EFEx) of adaptive educational hypermedia systems and also tackles the question of "What are the techniques used (and benefits of) user-centered evaluation (UCE) in evaluating the end-user experience in AEHS: How can these techniques be best combined and applied for evaluating end user experience in adaptive educational systems?" Our definition of user-centered evaluation (UCE) stems from the user-centred design principles by Gould and Lewis (1985) and the definition of user-centred approach found in ISO 13407 (1999): "User-centred evaluation deals with the empirical evaluation of a system by gathering subjective user feedback on satisfaction and productivity, quality of work, support and training costs and user health and well being" In this research the evaluation does not emphasize on subjective feedback, we also examine user interaction with the framework to identify its efficiency, accuracy, task and completion. Furthermore "An adaptive system refers to a system which tailors its output, using implicit inferences based on interaction with the user" (Van Velsen et al., 2008); and an adaptive hypermedia system as: "An adaptive hypermedia system (AHS) refers to any hypertext and hypermedia system which reflects some features of the user in a user model and applies this model to adapt various visible aspects of the system to the user" (Brusilovsky, 1996). In other words, the simplest form of an AHS system should be able to satisfy three criteria: it should be a hypertext or hypermedia system; it should have a user model; and it should be able to adapt the hypermedia using this model.

A review of UCE approaches, methodologies and techniques adopted by existing systems and frameworks has been conducted and the results analysed. From these results, an architectural design for the EFEx framework was specified and designed as a typical 3-tier architecture which has an interactive and collaborative user interface and consists of: **i) the presentation layer** which is the topmost level of the application which displays information related to services such as browsing. It communicates with other tiers by outputting results to the browser/client tier and all other tiers in the network. **ii) The business logic layer** which is pulled out from the presentation tier and, has its own layer, it controls an application's functionality by performing detailed processing and **iii) the data persistence layer** this tier keeps data neutral and independent from application servers or business logic. Giving data its own tier improves scalability and performance. The collaborative nature of EFEx framework will initially facilitate the sharing of information among people in three scientific communities: e-learning, adaptive hypermedia and information retrieval. The development of the EFEx framework is divided into five subsections: i) recommendation of evaluation methodologies, ii) illustrations and explanation of how the recommended methodologies can be conducted, iii) a knowledge repository containing the results of user-centered evaluations (UCE) of other adaptive systems, iv) a set of components which enable the implementation of UCE, v) specification of adaptive systems design and structure. The scope of the

recommender section consists of: i) Recommendations to users on how to evaluate nine models for adaptive systems (i.e. user model, task model, system model, content model, domain model, strategy model, presentation model, navigation model and device model), ii) Recommendations on how to evaluate adaptive systems. Each recommendation is based on a set of identified criteria (i.e., system name, function, application area, evaluation method, evaluation criteria used, data types, system purpose and content used), iii) provision of user-centered evaluation studies of these systems and models. Implementation of the recommender section has been completed. Currently users are able to get recommendations on evaluation of the adaptive system models and also (select, search, view, add, and submit queries). The database consists of (i.e. evaluated systems, the models for adaptive systems and the UCE studies). Each study(s) has a title, author, citation and reference. Each evaluated system mentioned in this study(s) is described in terms of: system name, the functions it fulfils, the purpose, application area, evaluation methods and criteria used and data type analysis, content used. Each model is described in terms of: name, purpose, description, model type, evaluation methods, data type, evaluation metrics and model relation.

Following is a **user case scenario** of an end user (i.e., People developing adaptive hypermedia technologies / systems who wish to test out the effect on end users of the adaptive technologies/systems, People who are developing the adaptive experiences using the adaptive hypermedia systems / technologies and people who are authoring adaptive technologies) requiring recommendations on how to evaluate their adaptive system or model: Suppose a user comes along and wants to use EFEx framework to get recommendation on to evaluate his or her adaptive system. First, the user is required to register (i.e., user name, institution or organization, email address, password). Then they are provided with a form and requested to fill it (i.e. their system name, function, application area, evaluation method, evaluation criteria used, data types, system purpose and content used) and then press the submit button. The EFEx framework reasons about the system and decides on suitable evaluation objectives. Based on the end user choice of evaluation objectives the framework suggests evaluation techniques appropriate for that user and provides explanations as to how to apply those techniques.

Experiment and User Evaluation: The experiments will be designed based on a task-based problem scenario which will involve a developing a use case. Use of questionnaire and interview (i.e. users of the framework) and video; will provide qualitative feedback on user experience after using the framework. The task based experiment will be significant in evaluating the overall performance and usefulness of the developed framework. In this case, test users will be presented with a list of tasks that are specific to the particular domain chosen for the experiment. The techniques adopted will be based on internal quality consisting of six characteristics: i) functionality, concerned with what the framework does to fulfil user needs, ii) reliability, evaluating the frameworks capability to maintain a specified level of performance, iii) usability, assessing how understandable and usable the framework is, iv) efficiency, evaluating the capability of the framework to exhibit the required performance with regards to the amount of resources needed, v) maintainability, concerned with the framework's capability to be modified and finally portability, which will involve measuring the frameworks capability to be used in a distributed environment.

The educational benefit of the EFEx framework is: i) Provision of interactive user interface in a technology-enhanced learning environment (TELE) to learners and teachers. Technology enhanced learning (TEL) practices cater to students and teachers who use many different learning tools and environments and have experience of interaction derived with open, ubiquitous, and socially-oriented services. The process of learning in formal education no longer takes place solely in traditional, educator-centric settings. Interactive, learner-centric experiences are being used to support learner collaboration, knowledge acquisition and reflection. Learner enquiry, activity and engagement are key requirements in such experiences and TEL applications are being designed and utilized to meet these requirements. TEL is expected to make a radical difference to education, specifically, the quality and effectiveness of the learning experience with one of its key contributions being 'personalised learning'. TEL methods have been known to change the deployment of the most important resource in the education system: teachers' and the learners' time (Mulwa et al., 2010) and also in cost savings to performance and strategic benefits (Rainsford and Murphy, 2005). In most cases learners using these technologies are able to receive instant and personalised feedback, active engagement, reusable learning materials and a safe environment where one can learn from one's mistakes and be able to access huge amounts of beneficial material on-demand. These technologies make learning more flexible in terms of time, space and place, ii) the educational data collected from users who require recommendations on how to evaluate the system models and adaptive systems will provide very significant data set for UCE of adaptive systems. Currently the reporting of UCE studies is poorly conducted and no data exists on how different models for adaptive systems have been evaluated. Provision of the collected data in a structured way will encourage research in this application area, iii) By provision of recommender approach based on this educational data such as evaluation

methodologies and metrics for these systems will reduce time spent and cost. Users will also improve usability evaluation problems encountered by evaluators of these systems and iv) The final version of the framework will enable the researchers tackle the question introduced in this paper.

References

BRUSILOVSKY, P. 1996. Methods and techniques of adaptive hypermedia. *User Modeling and User-Adapted Interaction,* **6,**87-129.

MULWA, C., LAWLESS, S., SHARP, M., WADE, V. & SANCHEZ, I. 2010. Adaptive Educational Hypermedia Systems i in Technology Enhanced Learning: A Literature Review. *In:* SHERIDAN (ed.) *Association for Computing Machinery's Special Interest Group for Information Technology Education*. H Hotel 111 W Main St. Midland, MI48640.

RAINSFORD, C. & MURPHY, E. 2005. Technology-enhanced learning. *Journal of European Industrial Training,* 29.

VAN VELSEN, L., VAN DER GEEST, T., KLAANSSEN, R. & STEEHOUDER, M. 2008. User-centered evaluation of ad adaptive and adaptable systems: a literature review. *The knowledge engineering review,* 23**,** 261-281.