CONTENT ON DEMAND FOR FOURTH YEAR ADVANCED MATERIALS AND MANUFACTURING STUDENTS

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Abstract: There is growing recognition of the key role that social and informal learning play in Higher Education. There is also increasing interest in technologies that enable, capture and channel this type of learning to students at their point of need and personalised to their ability. The objective of this project was to leverage research technologies from the areas of adaptive hypermedia, social and semantic search to create an application to deliver learning resources to students tailored to their specific learning needs. In this project, some 130 digital learning resources, specific to a final year advanced materials and manufacturing module, were made available to the students via a Help Block plugin in the Moodle Virtual Learning Environment. The students were required to use the Help Block as a just-in-time learning resource to help them complete a continuous assessment assignment. The assignment required the students to select an advanced manufacturing process and associated material describing the manufacturing process steps, control and specifications and presenting the technological benefits of the process and material used relative to competing processes and materials. Post-trial, students were asked to complete a questionnaire to describe their experience with the Help Block in terms of whether it assisted them in completing the assignment, for example, and its ease of use. The system, evaluation findings, and some suggestions for future system enhancements are presented in the paper.

Keywords; Informal learning, Moodle, National Digital Learning Resources (NDLR), adaptive hypermedia, semantic search, social search.

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1. INTRODUCTION

Continuous assessment assignments provide students with opportunities for self-directed, autonomous learning which enables them to consolidate prior learning and provides them with opportunities for discovery learning. Lecturers are aware of the pedagogical benefits of problem-based discovery learning but are also aware that students can waste considerable time searching

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the Web or resource repositories because they cannot quickly find resources that meet their specific learning needs or learning context. This results in students becoming frustrated and negatively impacts both the pedagogical potential and motivation associated with problem-based discovery learning. The result for lecturers is that students include non-relevant material in their assignment. In contrast, systems that enable students to quickly find resources personalised to their learning context and knowledge level can have profound pedagogical benefits; for example, enabling students to identify and plug learning gaps, consolidate prior learning, problem solve through focussed discovery learning and become self-directed, independent, motivated learners. Such a system would provide an authentic content discovery learning environment where deep, meaningful learning could occur.

In this paper we introduce the *Help Block* application, which has been designed in the form of a Moodle Virtual Learning Environment plugin. The design of the Help Block plugin was driven by a use case scenario to ensure that it was fit-for-purpose and pedagogically effective. The use case revolved around the National Digital Learning Repository (NDLR), a large repository of disparate teaching and learning resources, a final year engineering students and a lecturer keen to apply problem-based discovery learning strategies to continuous assessment.

The Help Block includes a number of innovative technologies designed to support the learning needs of students. For example, providing learners with a list of disparate search results is not always conducive to learning as it lacks learning structure and learners have to sift through such lists of resources to make sense of them and to find the level of detail they require. Thus, *content composition* technology is deployed as part of the Help Block plugin to construct a coherent learning episode from relevant resources according to a pedagogical sequencing strategy (O'Keeffe et al., 2006; Brabazon et al. 2007). Learners are free to select any or all of the elements of the learning episode depending on the level of detail they require. This facilitates self-directed, autonomous learning and helps develop metacognitive skills.

The content composition technology mentioned above makes use of two key approaches to content search and retrieval: *semantic* and *social* search. Incorporating semantic search into the Help Block plugin enables the retrieval of context-relevant resources; semantic search is based on learner intent, the contextual meaning of the search term and its relationship to other concepts in the learning domain. In addition, social and informal learning has become ubiquitous and plays an ever-increasing role in the daily lives of students who expect to find it as part of any learning technology solution. Thus, we also consider social search technology in the application, which leverages learner feedback to rank future search results by using the past experiences of the learning community to identify and channel high quality learning resources.

In this paper, we evaluate the performance of the Help Block application in the context of a live user trial. The structure of the paper is as follows. A brief overview of related work is presented in Section 2, followed by a description of the application in Section 3. Section 4 presents the findings of our evaluation and conclusions, and directions for future work are given in Section 5.

2. RELATED WORK

The vast quantity of learning resources available on the Web and in learning repositories is driving research into technologies that facilitate the discovery and retrieval of resources that are personalised to the needs and attributes of the querying user. Adaptive hypermedia is one such technology. Traditional one-size-fits all hypermedia present all users with the same hypermedia document irrespective of their information needs. This can increase the cognitive load on a learner as they must not only attempt to learn the subject matter but also successfully navigate the hypermedia to find the most appropriate content. Adaptive hypermedia attempts to address these issues by adapting the hypermedia to the individual user based on various properties of the user; for example, the user's goals, prior knowledge or preferences (Brusilovsky, 2001; Lawless et al., 2005). Several systems have been successful in demonstrating the real benefits that personalization can provide through the adaptive selection and sequencing of multimedia content to meet the needs of the learner (Smits and De Bra, 2011).

In recent times, there has been a shift towards the separation of personalisation and adaptivity information from the physical learning content (Henze and Nejdl, 2001). Content can be selected regardless of source and inserted into an e-Learning experience in a sequence that suits each individual learner. Research is also being carried out into ways of improving search using personalisation (Zhou et al., 2012). The work focusses on a novel query expansion framework based on individual user profiles mined from the annotations and resources the user has marked. The proposed approach appears to significantly benefit personalized web search by leveraging users' social media data. Adaptive hypermedia research typically involves closed systems which lack the ability to pull in open content such as that found on the Web or in repositories. The use of adaptive hypermedia in the Help block plugin is novel in that it leverages both semantic and social search technology to access open corpus content. The incorporation of pedagogical strategy also differentiates the Help Block plugin from other adaptive hypermedia systems such as GALE (Smits and De Bra, 2011), which do not have an associated pedagogical framework.

3. HELP BLOCK APPLICATION

The aim of this work was to support learners by providing them with selected access to the NDLR repository of indexed and annotated learning resources for targeted self-directed learning. To this end, the Help Block was designed as a Moodle plugin, thereby facilitating a seamless learning experience for the student. The system architecture is shown in Figure 1 and Figure 2 illustrates the key features of the user interface design. The learner initiates a search session using the Help Block by specifying the learning need via a free-text search query.

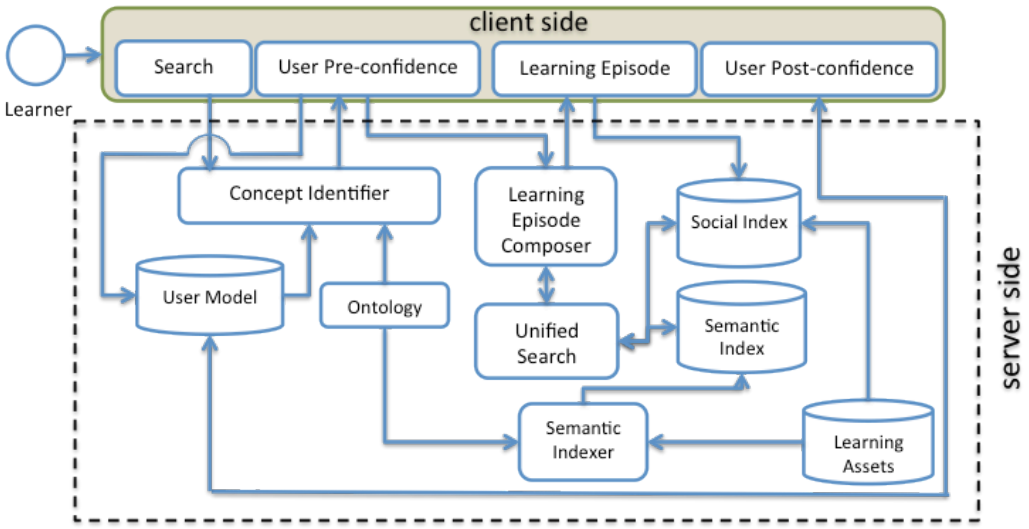

Figure 1. System architecture for Help Block plugin to Moodle.

In what follows, the main user interaction steps and system components are briefly described:

- **Concept Identification**. This component is designed to match the learner's search query to concepts defined by the domain *ontology*. The ontology is itself a key component of the system; it formally represents knowledge as a set of concepts within the domain and defines the relationships between those concepts. A bespoke ontology containing 188 concepts was developed for this application. The purpose of concept identification is two-fold; first, it represents a form of query expansion – helping to address the vague query problem in Web search (Smyth et al., 2004) – and second, it facilitates *personalization* as described below.
- **Pre-confidence Scores**. Following concept identification, learners are requested to specify their degree of confidence with respect to each concept. Confidence scores facilitate the personalised retrieval of resources, tailored to suit the knowledge levels of each learner in relation to each concept. Learners can specify low, medium or high confidence for concepts or choose "skip" to exclude concepts from further consideration. In Figure 2(a), for example, the concepts "Ceramic" and "Ceramic Matrix" have been identified for the search query "ceramics" and low confidence has been specified by the learner for both concepts.
- **Learning Episode Composition**. Rather than presenting traditional unstructured result lists to the learner, this component is designed to dynamically generate a personalised *learning episode* based on the learner's immediate information needs and their prior experience in the subject domain. Resources selected by this component are sequenced according to the domain *pedagogical strategy* which, as shown in Figure 2(b), consists of three steps: "Test Your Knowledge", "Introduction" and "Lesson". In essence, for each step, relevant resources for each concept/confidence score are retrieved using a combination of *semantic* (Tummarello et al., 2007) and *social* (Smyth et al., 2009) search technologies. Briefly, semantic search returns resources that match the concept in the domain ontology while social search leverages *user feedback* to return resources that were found to be relevant for similar queries in the past. Learners are free to navigate and select resources from the learning episode as they so choose.

- **User Feedback**: Once a resource has been selected from the learning episode, feedback is requested from the learner as shown in Figure 2(c). Learners can indicate whether they found the resource to be helpful or not; further, learners can assign freeform tags to a resource to facilitate its future retrieval. This feedback is leveraged by the social search component to identify and promote those resources in future searches that have received positive feedback from the wider learning community.
- **Post-confidence Scores**: Finally, the user can optionally specify their post-confidence scores for concepts (Figure 2(d)). The objective is to encourage the learner to reflect on their learning experience and to adjust their confidence scores as necessary. All pre- and post-confidence scores for concepts are captured by the system's user model component for each learner; thus the system learns over time the degree of confidence and knowledge that learner's possess regarding domain concepts.

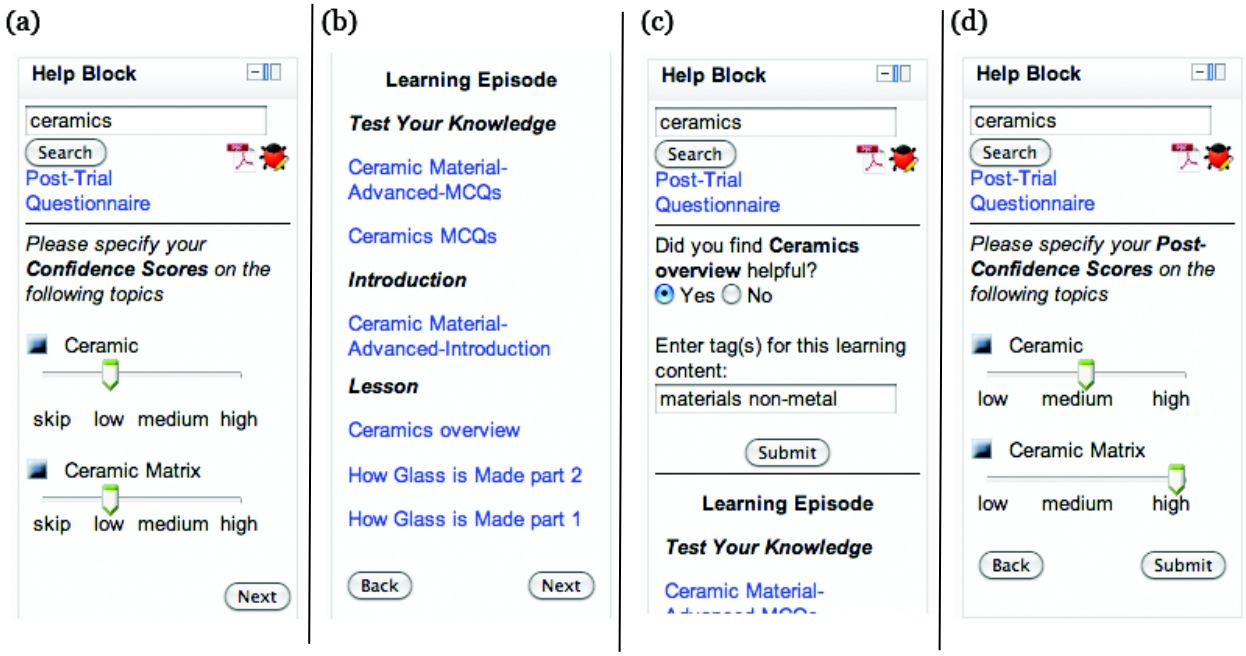

Figure 2. The Help Block user interface design: (a) pre-confidence scores, (b) learning episode, (c) user feedback and (d) post-confidence scores.

4. EVALUATION

To evaluate the Help Block, 4th year Mechanical Engineering students from an Irish university (Dublin City University) were requested to use the system to source reference material for a module assignment. Over approximately three months prior to semester starting, appropriate resources were gathered and associated with appropriate metadata to allow semantic searching described above. The assignment involved selecting an advanced material and a corresponding advanced manufacturing process. Of the 19 registered module students, 18 interacted with the Help Block and 12 students completed the post-trial questionnaire.

4.1 Usage Statistics

In total, 841 searches were performed using the Help Block during the 6-week trial period. Figures 3(a) and 3(b) show the distribution of searches across time and trial participants, respectively. There was a spike in search activity on each side of the assignment due date (December 6th), with the maximum number of daily searches (155) recorded on November 29th. Over the course of the trial period, the median number of searches recorded per day was 12.5. The distribution of searches across participants was long-tailed as can be expected in such a trial setting, with a small number of participants making regular use of the Help Block while most participants used it less frequently. For example, two participants executed more than 100 searches and a further three participants executed more than 60 searches, while the main cohort (13 participants) executed a median number of 28 searches.

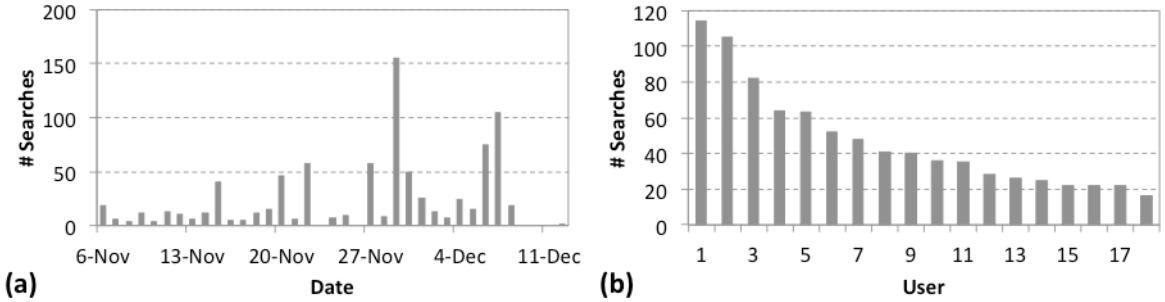

Figure 3. Help Block usage statistics (a) by date and (b) by user.

For this trial, 130 resources were available for retrieval by the Help Block. The majority (114) of these were Lesson resources, which represented the core learning material for the assignment. All available resources were selected at least once during the trial and in total resources were selected on 419 occasions. As expected, Lesson resources were selected most frequently (264 occasions), while Introduction and Test Your Knowledge resources were selected on 119 and 36 occasions, respectively. In the next section, the learners' questionnaire responses in relation to these resource types and the functionality provided by the Help Block are presented.

4*.2 Qualitative Analysis*

Following the completion of the trial, participants were requested to complete a questionnaire to capture their overall experience with the application. To evaluate the effectiveness of the Help Block, trial participants were asked how often the Test Your Knowledge, Introduction and Lesson resources were relevant to their search requirements. Overall, Lesson content was found to be the most relevant, followed by Introduction and Test your Knowledge (Figure 4(a)). However, it can be seen that, overall, more negative than positive responses to this question were received. It is likely that the available quantity of Help Block resources influenced the above findings (129 resources in total were available). For example, the following comment broadly reflects the feedback received from trial participants – "*I would suggest additional content be uploaded to the system. This should improve the overall use of the Help Block ... [and] then all the other features of the Help Block would fall into place*". In contrast, most questionnaire respondents (58%) did feel that the level of difficulty of resources was 'just right' (Figure 4(b)), which highlights the benefits of providing personalised (via confidence scores for concepts) learning resources tailored to suit the particular needs of learners.

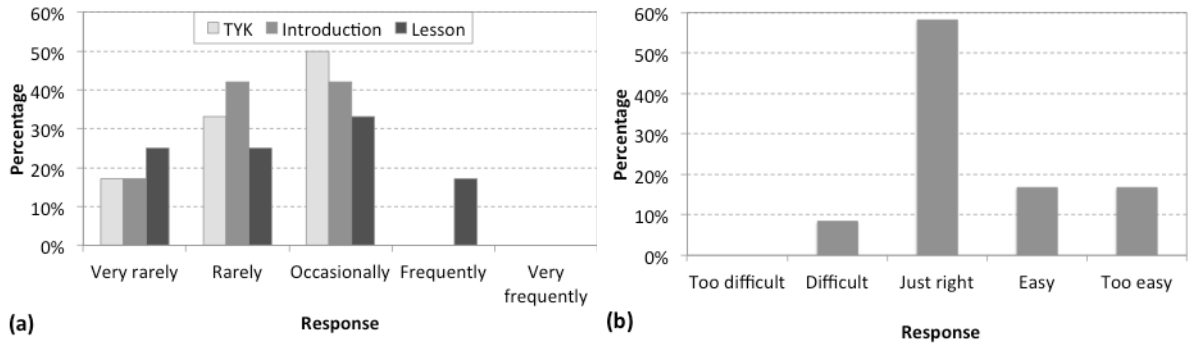

Figure 4. Questionnaire responses: (a) How often were Test Your Knowledge (TYK), Introduction and Lesson resources relevant to your search? (b) How would you describe the level of difficulty of Learning Episode resources?

Finally, in terms of ease of use of the application, Figure 5(a) indicates that the majority (50%) of respondents agreed that the sequencing of resources in the Learning Episode facilitated easy navigation through the content. Further, some 42% of respondents agreed or strongly agreed with the proposition that the system can be learned quickly, with a further 33% of respondents neither agreeing nor disagreeing (Figure 5(b)). These are encouraging findings and provide evidence for the effectiveness of the system design and user interface, particularly as the Help Block brings some unfamiliar functionality (e.g. concept pre-confidence scores) to learners.

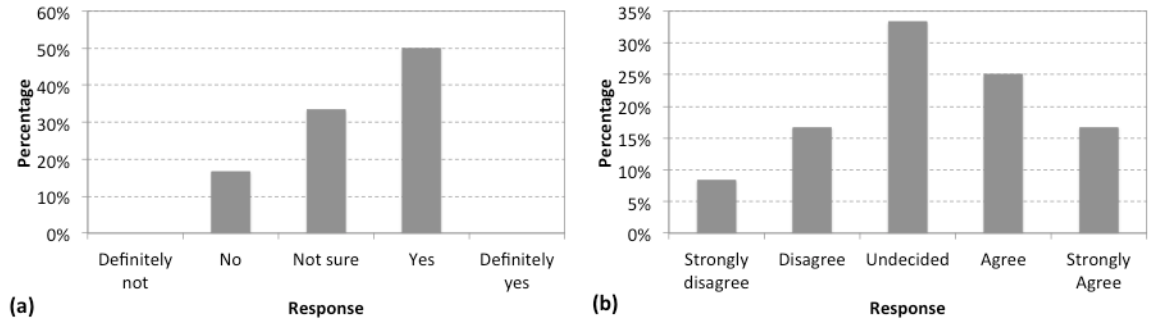

Figure 5. Questionnaire responses: (a) Was the Learning Episode easy to navigate? (b) I would imagine that most people would learn to use this system very quickly.

5. CONCLUSIONS

In this paper, the Help Block application has been described which was designed as a Moodle plugin to integrate seamlessly into the students' learning management system. The application incorporates a number of innovative technologies (for example, composition, semantic and social search components) to address the just-in-time learning needs of students in a personalised manner. For the purpose of the application trial, the Help Block was made available to students to assist them in completing a continuous assessment assignment, for which the number of possible solutions and range of reference material was vast. From the lecturer perspective, the Help Block facilitated the linking of a particular set of relevant resources to course content, thereby providing guidance to students and allowing them more time to focus on learning what was relevant, to analyse the material and to present their work to the required standard.

Regarding the application design and user interaction modes, overall the trial participants found the Help Block easy to use. However, there is scope for improving the system; for example, by enhancing the look and feel of the user interface design and providing additional functionality, such as the ability to save and retrieve one's previous browsing history. Furthermore, while personalisation proved successful in providing resources tailored to learner ability, participants expressed dissatisfaction with the need to explicitly provide confidence scores for concepts. Future implementations will consider user modeling techniques to implicitly capture learners' knowledge levels based on their interaction with the application, and thereby remove the extra task of providing confidence scores associated with the current design.

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