Supporting Problem-based Learning in Moodle using Personalised, Context-specific Learning Episode Generation

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Abstract

Providing learners with a list of disparate search results is not always conducive to learning. In particular, this approach lacks learning structure, and learners have to sift through lists of resources in order to make sense of them and to find the level of detail they require. In this paper we outline the Moodle Help Block, a Moodle block plug-in that provides learners with Just-In-Time context relevant learning material using a defined pedagogical strategy. The Moodle Help Block uses a combination of Semantic Web, Social Web and learning composition technology to generate learning episodes as needed by learners. The Moodle help block conducts a dialogue with the learner to extrapolate where a given learner's knowledge gaps lie and generate learning episodes with learning material to help the learner overcome their knowledge deficit. It is thought that the Moodle Help Block can assist learners with targeted help when a teacher is not available.

Keywords

Moodle block, search, semantic web, social search, personalization

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. (Savery & Duffy, 1996) Teachers are aware of the pedagogical benefits of problem-based discovery learning but are also aware that students can waste considerable time searching the Web or Learning Object Repositories (LOR) 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. 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 Moodle Help Block. The design and implementation of the Help Block was driven by a real-world use case scenario to ensure that it was fit-for-purpose and pedagogically effective. The Moodle Help Block includes a number of innovative technologies to deliver the most pedagogically effective learning resources to the learner and to present this material in a pedagogically sound manner in the form of a "learning episode" that is personalised to the needs of that learner and their learning context. The use case revolved around a large repository of disparate teaching and learning resources, a cohort of final year engineering students and a lecturer keen to apply problem-based discovery learning strategies to continuous assessment.

In this paper, we outline the design of the Moodle Help Block application and also outline the results from our evaluation of the tool using a live user trial. A detailed description of this trial can be found in (Brabazon et al., 2012).

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 design of the application in Section 3. Section 4 presents the User Interface. Section 5 looks at each of the components that makes the Moodle Help Block possible. In Section 6 the findings of our evaluation and conclusions, and directions for future work are given in Section 7.

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.

Moodle Help Block Design

The aim of this work is to support learners by providing them with selected access to trusted Learning Object Repositories for the purpose of targeted self-directed learning. The research problem addressed is driven by an industry-defined use-case, whereby the Moodle LMS must be able to support the learner with targeted help in scenarios where a teacher is not available. The premise is that it should be possible to map conceptual gaps in a learner's knowledge to an ontology and that this ontology can then be used to locate semantically annotated learning resources to help the learner overcome their knowledge deficit.

As part of the design a detailed process flow was defined outlining the interaction between the Help Block and the learner. The interaction model is illustrated using an UML activity diagram in Figure 1. As outlined, the interaction model is based on establishing the concepts that the learner was having difficulty through dialogue with the learner and then locating resources associated with those concepts in a trusted LOR(s).

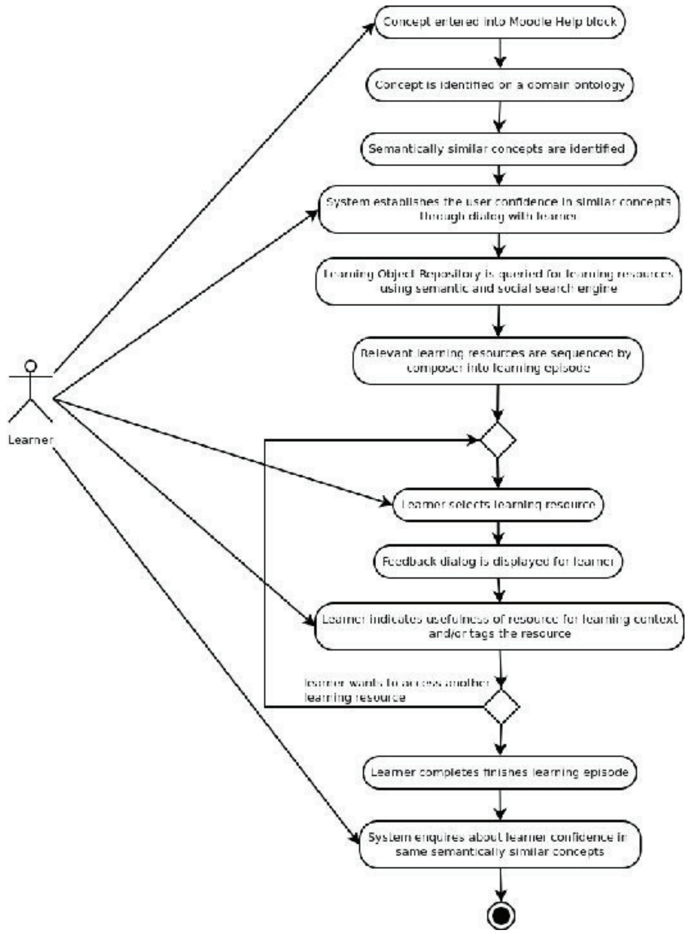

Figure 1 UML Activity diagram outlining process flow of the Help Block

As mentioned, the Help Block was designed as a Moodle plug-in known as a “block”. Blocks are small widgets at the side of the screen in Moodle that generally provide some auxiliary function to learning or learning management (such as a calendar or progress bar). Moodle blocks were chosen as they were seen to facilitate a seamless learning experience for the student whereby the block does not interfere with learner’s learning until its functionality is called upon by the learner.

User Interface Design

Figure 2 illustrates the key features of the user interface design. In this section each of the main user interaction steps are briefly described.

Concept Identification & Pre-confidence Scores

This interaction is designed to match the learner’s free-text 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 well-known vague query problem frequently encountered in Web search (Smyth et al., 2004) – and second, it facilitates personalisation as described below.

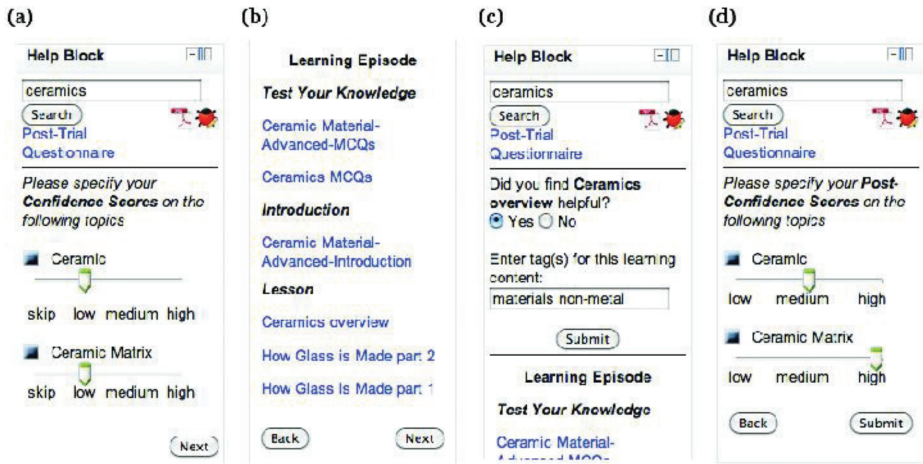

Figure 2 The Help Block user interface design: (a) pre confidence scores, (b) learning episode, (c) user feedback and (d) post-confidence scores.

Following concept identification, learners are requested to specify their degree of confidence with respect to each concept found. 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 confidence indicators for concepts 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 free-form 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.

Learning Episode Generator Components

The diagram in Figure 3 outlines the various components on in the Moodle Help Block (client side) and the server side. In this section we will look at the server side components needed to allow for the generation of context-specific learning episodes through the Moodle Help Block.

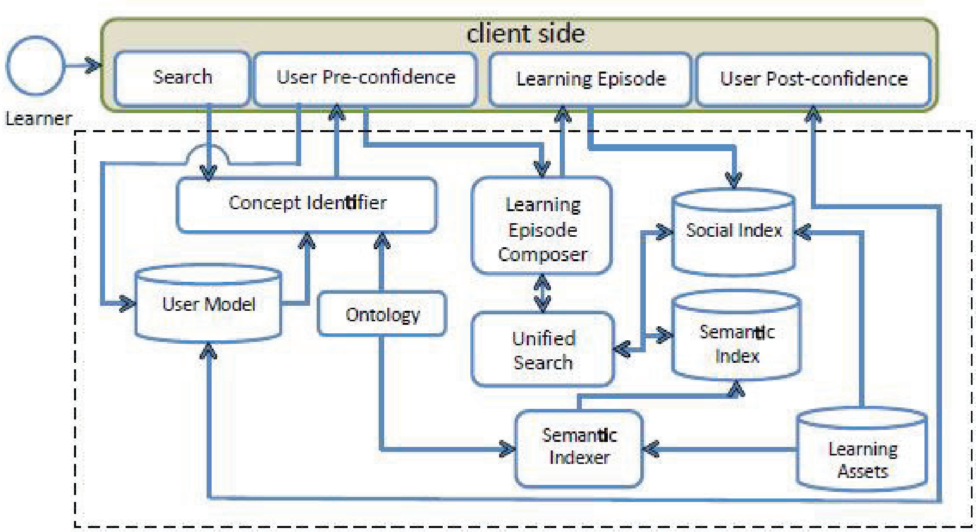

Figure 3 Moodle help block and learning episode generator archtecture diagram

Concept Identifier

The Concept Identification component is designed to identify appropriate concepts, defined in a domain specific ontology, based on a free text search query. Based on the input provided to the service it searches across the predefined domain model, implemented as an ontology, in order to identify domain concepts that correspond to the information needs of the learner as specified by the search query terms. Once appropriate concepts are identified, the service then interacts with the LOR (labelled "Learning Assets") in order to retrieve the current user's confidence scores for those concepts, where available.

This component simplifies the user's experience by automatically mapping the user's free-text search query to domain concepts. In this way, the component facilitates the use of the semantic technologies that underpin other system components.

Learning Experience Composer

The Learning Experience Composer is a web service designed to dynamically generate a personalised learning experience based on the learner's immediate information needs, as expressed by their search query, and their prior experience in the subject domain. Resources selected by this component are sequenced according to a pedagogically informed composition strategy.

The Learning Experience Composer is based on a state of the art Adaptation Engine, which has been integrated with the Semantic Search and Social Search services in order to facilitate the generation of learning experiences that incorporate content from a trusted LOR.

Based on the concepts that the learner has identified as being of interest to them, the Learning Experience Composer adaptively sequences the concepts according to the pedagogical strategy. Within the constraints of this strategy the sequencing of these concepts is adapted based to better suit the needs of the learner. This is achieved by considering the learner's confidence in their knowledge of the respective concepts as specified by them through a set of confidence score indicators. Appropriate content from the LOR is then dynamically selected by the Learning Experience Composer in order to build a personalised learning episode. In selecting appropriate content the Learning Experience Composer again takes into account the needs of the learner based on their confidence scores. Appropriate content is identified by dynamically generating tailored search queries that describe the content that the Learning Experience Composer needs for a given concept, for example "Introduction Beginner Superalloy". The learning episode generated by the Learning Experience Composer is in the form of a model that can then be interpreted by a client application and made available to the Learner.

Semantic Search

Unlike a standard free-text search, semantic search is a concept search (Hogan et al., 2011). It searches for resources that match a concept in an ontology. An ontology represents knowledge as a set of concepts within a domain, and defines the relationships between those concepts. For example, 'metals' and 'ferrous' may be defined as concepts in an ontology, and they may be defined as having a parent-child relationship conceptually.

To provide for contextulised help, there are two parts to a query: a domain concept and pedagogical concepts.
Domain Ontology: A domain ontology designed for the Higher Education use case defines a subset of concepts in the domain of Advanced Manufacturing Processes and Materials, and the relationships between them. The NDLR resources in the Percolate project have been tagged with these concepts where appropriate.
Pedagogical Concepts: A simple ontology of pedagogical concepts used to annotate learning resources.

Social Search

The Social Search component leverages community feedback to return search results that were found to be relevant for similar search queries in the past (McNally et al. 2010). Social search operates as follows.

Social search maintains a set of staks, where each stak stores resources that are related to a particular type or topic. Each stak is associated with an index, in which each resource is represented by a set of index terms and relevance indicators. Examples of relevance indicators include the number of times the resource has been selected, the number of votes (both positive and negative) it has received and the number of times it has been tagged, while the index terms for a resource include terms extracted from the resource title and text and the set of terms that have been used to tag the resource by the community.

At search time, the user's query is first matched against the stak indices, and any resources with index terms that match that user's search query are considered as recommendation candidates. Then, a set of evidence filters is applied to each of the recommendation candidates to determine which of these should actually be returned to the user and in what order. For example, resources that have been selected many times in the past or resources that have received many positive votes are ranked higher than those with few selections or votes. Further, evidence thresholds can be applied to ensure that resources with less than a certain number of selections, for example, can be discounted. In this way, the Social Search service leverages community feedback to identify those resources that are most likely to be relevant for a given search query.

User Trial

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 for semantic searching as 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 a post-trial questionnaire.

Usage Statistics

In total, 841 searches were performed using the Help Block during the 6-week trial period. Figure 4(a) and Figure 4(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). 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.

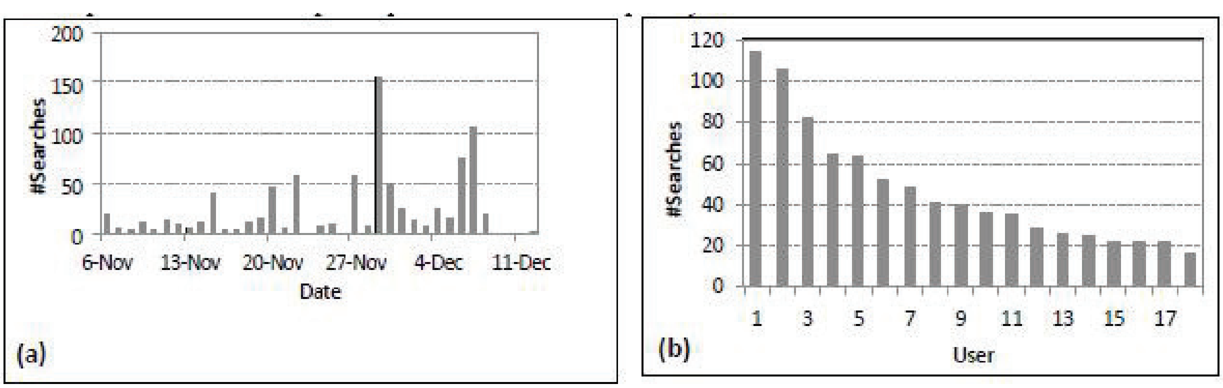

Figure 4 Help Block usage statistics (a) by date and (b) by user

For this trial, 129 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 Knowledgeresources 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.

Qualitative Analysis

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 5(a)). However, it can be seen that, overall, more negative than positive responses to this question were received. A possible explanation for this is that the available quantity of Help Block resources influenced the above findings (129 resources in total were available) but this requires further analysis. In contrast, most questionnaire respondents (58%) did feel that the level of difficulty of resources was 'just right' (Figure 5(b)), which highlights the benefits of providing personalised (via confidence scores for concepts) learning resources tailored to suit the particular needs of learners.

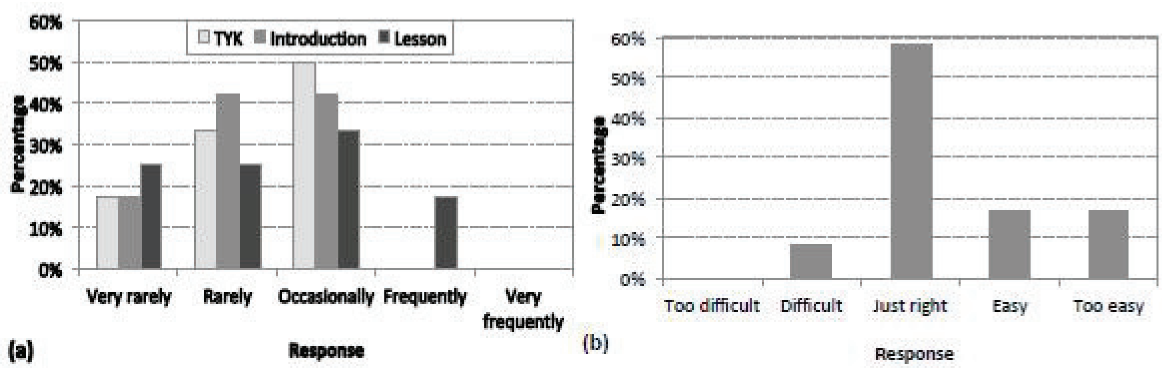

Figure 5 Questionnaire responses: (a) How often were Test Your Knowledge, Introduction and Lesson resources relevant to your search? (b) How would you describe the level of difficulty of Learning Episode resources?

Finally, in terms of ease of use of the application, Figure 6(a) indicates that the majority (50%) of respondents agreed that the sequencing of resources in the Learning Episode facilitated easy navigation. Further, some 42% of respondents agreed or strongly agreed that the system can be learned quickly, with a further 33% of respondents neither agreeing nor disagreeing (Figure 6(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.

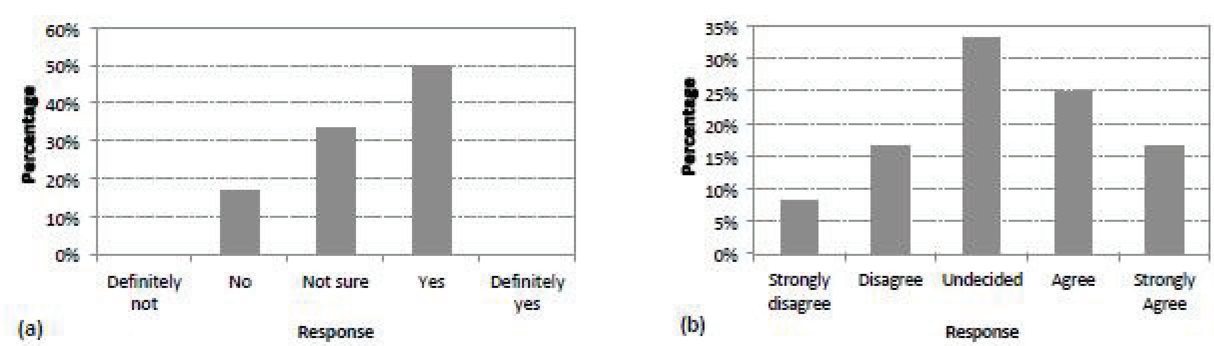

Figure 6 Questionnaire responses: (a) Was the Learning Episode easy to navigate? (b) I would imagine that most people would learn to use this system very quickly.

Conclusions

In this paper, the Moodle Help Block application has been described which was designed as a Moodle plugin to integrate seamlessly into the Moodle LMS. The application incorporates a number of innovative technologies 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. 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. Also we would like to look at improving the flexibility of the system allowing by allowing it to easily integrate with other domain ontologies and LORs.

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