IDENTIFICATION, TRANSLATION AND REALISATION OF REQUIREMENTS FOR A KNOWLEDGE MANAGEMENT SYSTEM IN AN ENGINEERING DESIGN CONSULTANCY

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ABSTRACT
This paper provides an overview of the development of a Knowledge Management system for an engineering design consultancy. It sets out a methodology from the initial importance of identifying requirements based on the particular organizational context through to training and roll out. While system development, implementation and testing is ongoing, this paper explores the issues associated with the early stages of knowledge management intervention, exploring the methodology utilized from the study of existing practice through to software development. Techniques employed as part of this methodology include the study of existing practice, user requirements mapping, and business and software specification development. The translation of these requirements and specifications into system features are illustrated by focusing on three key themes identified during the project: a reluctance to contact other regional offices, the time burden of finding existing design knowledge and capturing new design knowledge, and robust validation procedures. It is anticipated the techniques utilized and insights gained will be directly applicable to other organizations, particularly those in the engineering design sector, seeking to implement a knowledge management system.

Keywords: Knowledge management, requirement identification, requirements mapping, system specification.

1 BACKGROUND AND MOTIVATION
Hulley and Kirkwood (H&K) is a leading UK based Mechanical and Electrical Building Services Design Consultancy. Established in Glasgow in 1953, H&K has expanded to over 180 staff in 10 locations distributed across the UK. Glasgow remains the head office hosting just over 30% of the total staff, with regional offices located in Inverness, Aberdeen, Edinburgh, Manchester, Birmingham, Bristol, Cardiff, Plymouth and Epsom. Distribution throughout the UK allows H&K to respond effectively to projects based in any UK location. Leveraging skills and resources through distributed working across regional offices on a project-to-project basis facilitates cost effective agility. The approach H&K adopt involves the project being managed from a “Lead Office” located closest geographically to the actual “Project Site”. The Lead office correspond with the external design team members and relay information back to designers in a “Support Office” who have more time or appropriate skills and knowledge to complete elements of the design work.

The rapid evolution of IT has in recent times enabled a move beyond the limitations of paper records in the management of complex organizational knowledge and information sets [1]. It has been suggested that harnessing this potential can enhance design creativity [2] and that computer supported knowledge and information environments provide performance benefits [3-5]. Accordingly, H&K have invested in an IT infrastructure for efficient multi-site communication and to ensure consistency in the use of templates and design tools. However, to date the company has been concerned predominantly with communication, document and tool management rather than Knowledge Management (KM). This research is derived from a Knowledge Transfer Partnership (KTP) intended to strategically develop knowledge and information management within H&K.

A consistent finding from past studies is that that ‘personalized’ capture and codification is necessary for different organizations [6-8]. This work therefore focuses on the process of identifying requirements as appropriate for an organization and translating these into suitable system features. Prior to commencing the project H&K identified several issues with their existing practice including:

individuals with significant experience, but no current methods of capturing, storing and validating this knowledge for reuse; inadequate ongoing evaluation and reuse; too much “starting from scratch” on new projects when there is existing data; lack of expertise in information and knowledge management approaches. The capture of requirements relating to these issues, and their translation and realisation as system features is the focus of this paper.

2 METHODOLOGY

The project consists of seven main stages as illustrated in Figure 1. Currently, the first four - study of existing practices, mapping of user requirements, development of business and software specifications and software selection - have been completed with the software development stage currently on-going. This paper focuses on these five stages and will describe the capture and identification of requirements from a study of existing practice through to their translation in to system features.

Initially, a study of existing knowledge and information management practices was conducted. This is discussed in detail in section 3. Understanding existing practice facilitated the mapping of user requirements which is described and presented in Section 4. Identifying and mapping user requirements formed the foundation for developing business and software specifications which is described in section 5. A suitable software platform was then selected by benchmarking and evaluation against key criteria from the business and software specifications. Currently software development is on-going and three specific system features are illustrated in section 6. On completion of the first round of software development, software testing will be conducted followed by user evaluation. The findings of the software testing and user evaluation will inform further software development. This cycle will iterate until full software testing and user evaluation have been conducted and company-wide roll out is achieved.

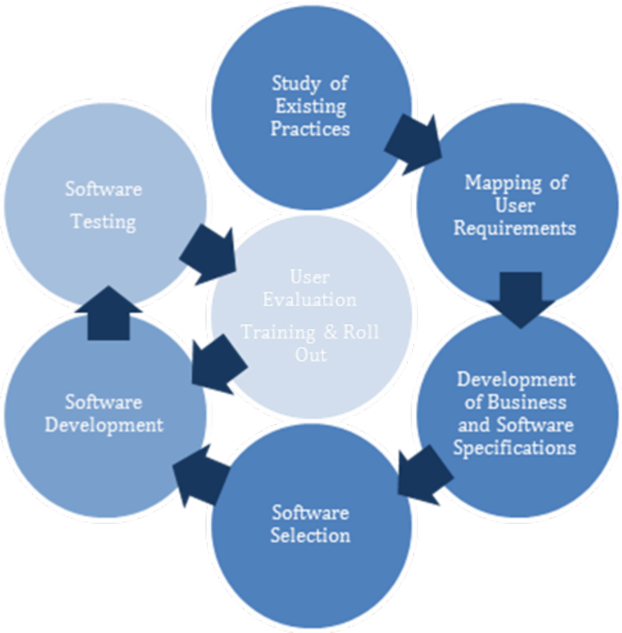


Figure 1. Overall methodology

3 STUDY OF EXISTING PRACTICES

3.1 Approach

Three main approaches were adopted to investigate and identify current knowledge and information management practices:

Semi-structured Interviews: were carried out with a cross section of H&K’s staff across the regional offices, to gain a qualitative insight into the existing practices and procedures for retrieving, using, creating, validating and storing information and knowledge.

Structured Questionnaires: were adopted to gain an insight into the usage of existing resources for information and knowledge management. Questionnaires were conducted with a cross section of staff across regional offices, capturing mainly quantitative data.

Informal Discussion: informal staff discussions were used to elaborate and validate findings of semi-structured interviews and structured questionnaires.

A summary of findings from each are provided in the following section, 3.2.

3.2 Existing practices - summary of findings

Semi-structured interviews

The quotes from the structured interviews below are representative of typical responses regarding standard practice for retrieving, using, creating, validating and storing information and knowledge:

Retrieving information and knowledge: "I don't have a specific process for retrieving information, but I would always start off by speaking to a senior engineer if they have not dealt with the subject themselves then they are usually best placed to point me in the right direction. I would not have any problems about approaching anyone in this office for information. However, I would not feel comfortable contacting anyone in any of the other offices. Think the current systems are quite good once you get to know them. I find asking people first the easiest route because nine times out of ten it is already there within someone's head."

Information and knowledge use: "Primarily the information is used for guiding the design and pushing the design forward. There was a lot of information required for each area, so you had to streamline the information before you actually started the design, and integrate all the elements into one."

Creation of new knowledge: "Realistically I should create a new document but when you are busy it is very easy not to put this information down."

Validation: "I would start by validating new knowledge against a benchmark so I had an idea if there were any problems with it. I would then validate the knowledge through peer review. Some information could also be validated through the client or manufacturer reps."

Storage of knowledge/information: "Usually any information that I gather I would put on files on my desktop. There is only a small percentage that I have felt a need to put on to the system. This is because I'm unsure if the information is already on the system and I don't have time to check. Therefore it is not stored in a place that makes it easily accessible for others; the biggest reason that stops me from publicising this information is the worry that it is not relevant."

The following key points can be summarized:

- normally information and knowledge is sought verbally from other engineers;
- engineers are reluctant to seek information and knowledge from staff in regional offices;
- it is easier to ask someone than become familiarized with existing systems;
- information and knowledge generally requires processing before it is useful;
- engineers are generally too busy to document and detail new information and knowledge they have created;
- new information and knowledge is generally validated by peers;
- new information and knowledge is generally not shared amongst the community but stored on individual desktops;
- time restriction plays a major role in the practices adopted for retrieving, using, creating, validating and storing information and knowledge.

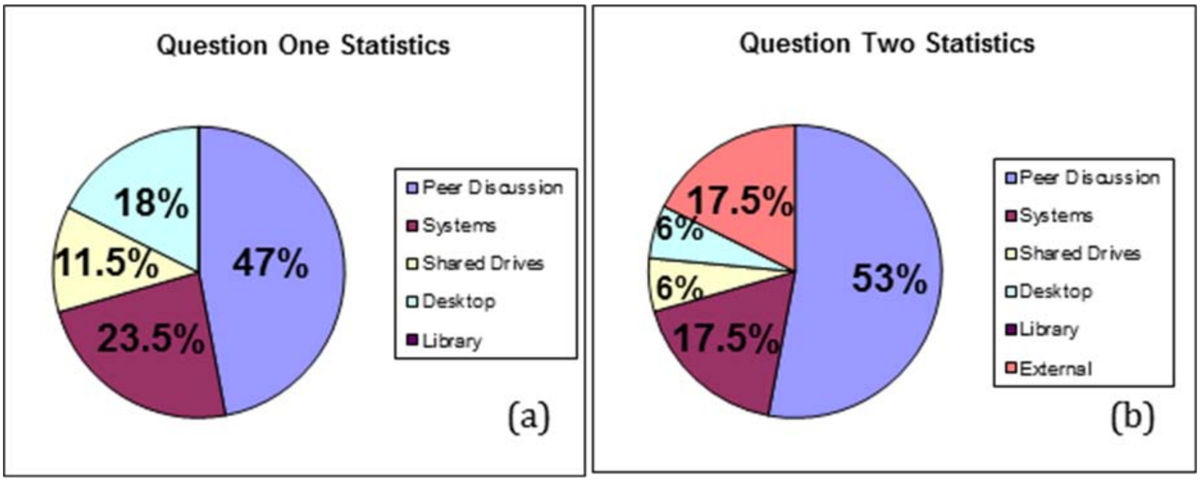
Structured Questionnaire

The findings presented in this section cover two of the questions posed in the structured interview specifically:

Q1. Which internal sources of knowledge you use the most (rank 1-5, 1 being most often)?

Q2. Which internal or external sources of knowledge you use the most (rank 1-5, 1 being most often)?

Figures 2(a) shows the results to Q1 which is concerned with "internal sources" of knowledge whilst Figures 2(b) indicates the findings to Q2 "internal and external sources" of knowledge. The pie charts show the percentages that each source ranked top. It is clear that peer discussion i.e. communicating with others ranks top on both occasions scoring 47% and 53% respectively, confirming the results of the structured interviews. Interestingly, when given the option of using external sources of knowledge and information such as the internet only 17.5% select this as their top choice and in fact, peer discussion increases in popularity by 6% to 53%. Respondents felt that using peer discussion to source knowledge encourages team working and collaboration.



Figures 2(a) & (b). Results from structured questionnaire

Informal Discussion

The main finding from informal discussion was that whilst peer discussion (communicating with others) was the most popular, employees would not usually engage with individuals in other regional offices to seek information unless they were explicitly told to do so. This emphasizes that there is a general reluctance to approach other regional offices for information or knowledge or to give or share information with other regional offices.

4 MAPPING OF USER REQUIRMENTS

The results from the interviews, questionnaires and informal discussions were then used to derive the user requirements for the system. These requirements are identified and mapped out below in Figure 3. In order to focus on the translation of requirements into system features three specific requirements have been selected for illustrative purposes. These have consistently emerged as important issues in the practical application of KM systems [9-11] and align with the three themes addressed in this paper:

1. *Access to knowledge in other offices:* this was key theme that emerged from the structured interviews. Engineers are happy approach others in their own office for knowledge and information but do not feel comfortable contacting those in other offices despite a recognition of a potentially rich knowledge source.
2. *The user would have the ability to place metadata tags on knowledge in the system quickly and efficiently:* this is another central requirement of the system that was evident in the user interviews. In the current system it was found that engineers often do not share knowledge due

to the time constraints associated with doing so. Furthermore, it was found that existing shared knowledge was poorly referenced making it difficult and time consuming to find and reuse.

3. *Robust knowledge validation through company-wide experts:* Validation of information and knowledge is another area that was evident from the interviews as a key requirement. H&K employ peer validation which can be difficult to implement with expertise being distributed throughout each of the regional offices.

5 DEVELOPMENT OF BUSINESS AND SOFTWARE SPECIFICATIONS

The development of specifications was delineated according to business and software specifications. The business specification document addressed the requirements for the system in three ways: user requirements, high-level system functionality and financial implications. Many of the business requirements were derived from the mapping of the user requirements, and included specific requirements that derived from different levels of organizational hierarchy such as directors, associates, graduates, administration and finance users. High-level systems functionality specifies the technology constraints imposed due to variations in technology resources across regional offices such as bandwidth etc. Finally the business specification included key requirements to record specific financial information.

The second document created was the software specification. This defined at a functional level the software requirements specification for the KM system. These were derived from the business specifications previously identified. As well as tackling the technical issues such as user interface and metadata taxonomy, the software requirements also addressed broader usage issues such as performance requirements. The business and software specifications were rigorous documents consisting of approximately 40 and 300 requirements respectively. For illustration purposes, however, three key user requirements have been selected as explained in section 4 to illustrate how these were captured first in the business specification, then in the software specification, and finally manifested in system features. The requirements selected and their presence in each of the documents and end system features are set out in Table 1.

Table 1. Translation from User Requirements to Software Features

User Requirements	**Business Specification**	**Software Specification**	**Software Feature**
Access to knowledge built up in other offices.	Identify where expertise lies across all offices, encourage communication between offices, and understand what projects other offices are working on.	Access to the system across all offices. Easy to add information and knowledge to the system from any location.	System has the ability to present information and knowledge to the user from a different source that has links with what the user is currently viewing.
Ability for the user to place metadata tags in knowledge in the system.	Record information and knowledge with a metadata tags. Will ensure reuse of valuable information and knowledge.	Structured taxonomy and process for tagging information and knowledge to the system.	Ability to place multiple metadata tags on documents and entries using the taxonomy.
Ability for knowledge to be validated by experts from anywhere in the company.	All displayed information must be validated against standards and guidelines or peer review.	Structured validation process. Ability for all documents and entries to pass through a validation process.	Implemented validation process. Interactive process that allows user to send information to be validated and approved for the system.

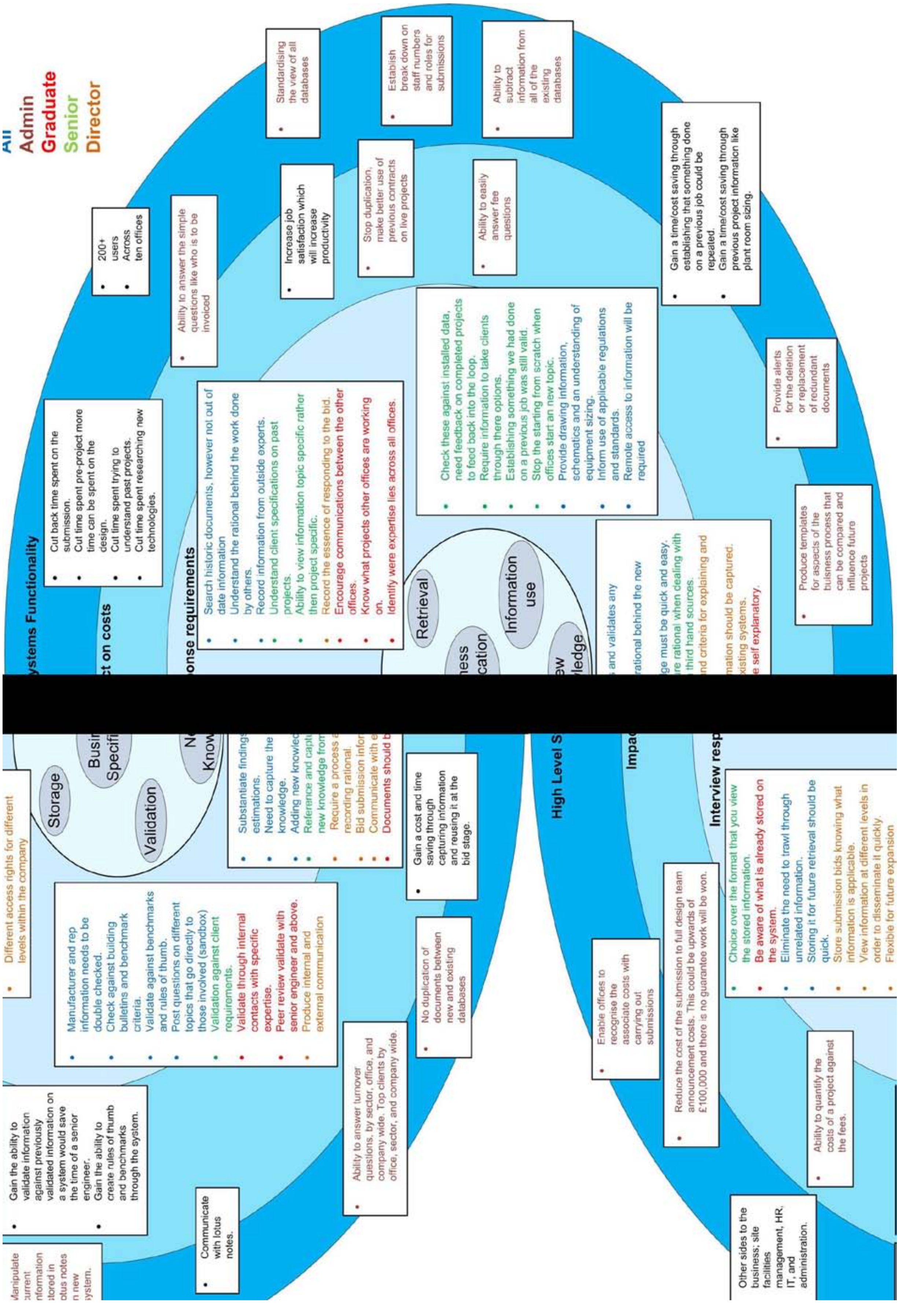


Figure 3. Mapping user requirements

6 DEVELOPMENT OF PROTOTYPE

This section illustrates how the three specific key requirements have been translated in to system features through a series of screen shots from the prototype currently under development.

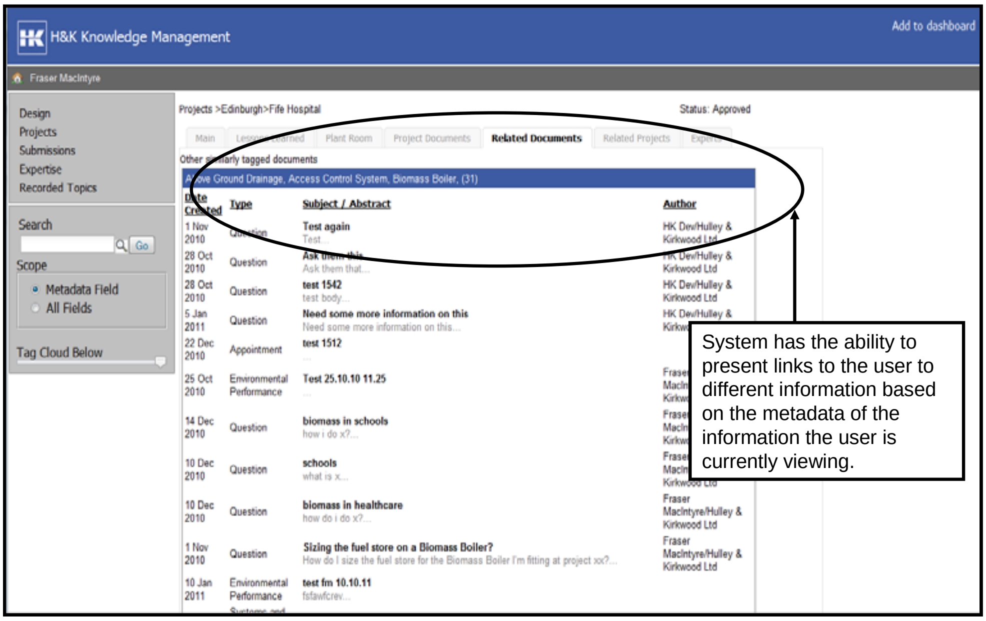


Figure 4. Access to knowledge built up in other offices

Access to knowledge built up in other offices: one of the key user requirements is that the system would allow and encourage access to knowledge that exists in all regional offices. Figure 4 demonstrates through the use of a screenshot how a user can be viewing a project and then select to view related documents, the system will then carry out a search of the system based on the metadata tag in the project the user is viewing. This will allow the user easy access to information and knowledge throughout the company and the opportunity to view related links from all regional offices.

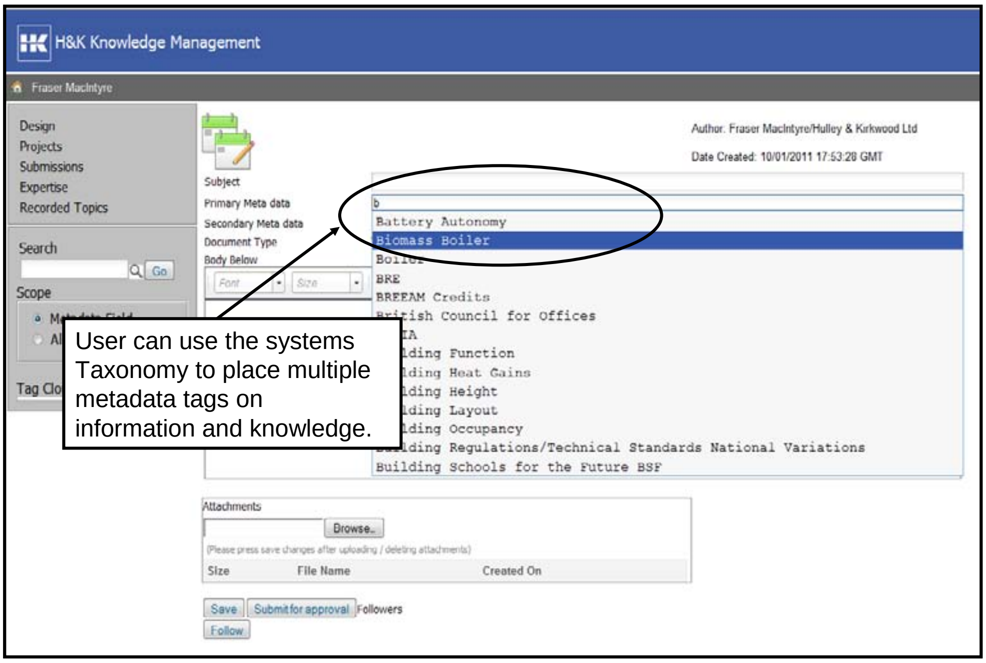


Figure 5. Ability for the user to place metadata tags on knowledge in the system.

Ability to place metadata tags on knowledge in the system quickly and efficiently: Figure 5 demonstrates how a user can quickly tag a piece of information and knowledge in the system. The screenshot above shows how the user can use the specifically created company taxonomy to select multiple metadata tags for that piece of knowledge of information. Using the taxonomy allows the user to do this quickly and efficiently.

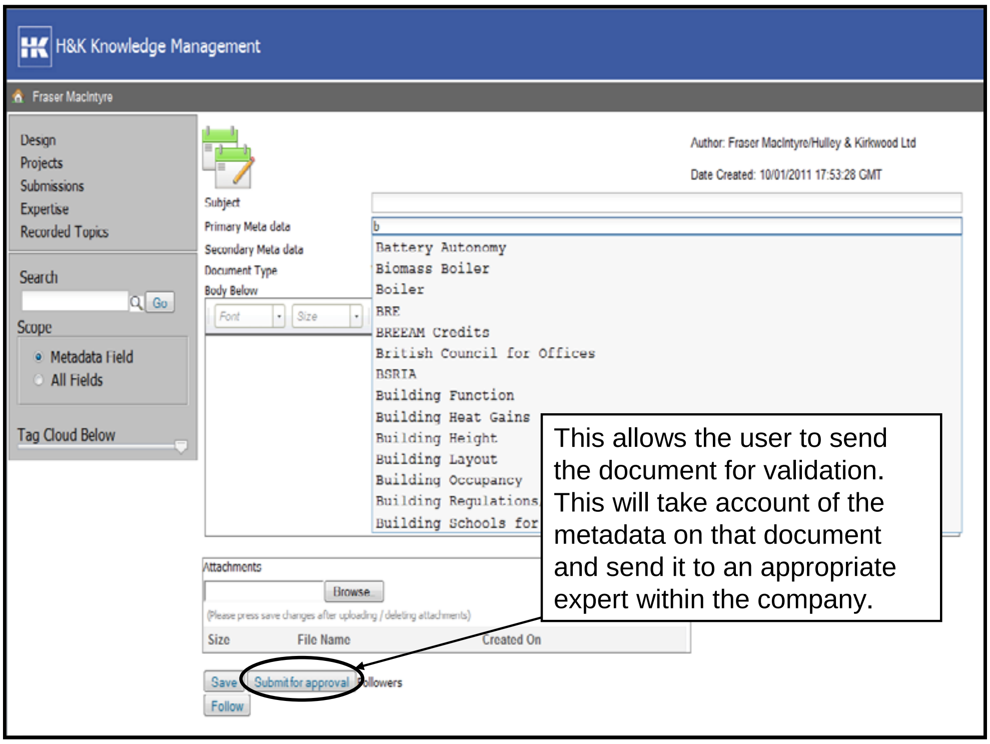


Figure 6. Ability for knowledge to be validated by experts from anywhere in the company

Figure 6 demonstrates how a user can submit a document or article with metadata tags for expert validation. The system will uses the metadata tags placed on the document to identify an expert to validate this information. Experts throughout the company are authorized to validate information and knowledge in the system have metadata tags assigned to them which are topics in which they have substantial expertise.

7 CONCLUSIONS AND FUTURE WORK

This paper has reviewed the ongoing development of a knowledge management system for an engineering design consultancy. It highlights the approach adopted from the study of existing knowledge and information management practices through to developed system features. A number of key steps have been undertaken, including requirements mapping, business specification and software specification. These have provided a robust developmental path that has allowed the translation of initial requirements into system features. The approach has been illustrated through highlighting three key themes identified from the study of existing practice and following their translation through requirement mapping and specification development to realization as system features. The three main themes that emerged are:

Reluctance to contact regional offices: whilst engineers recognize peer discussion as a rich set of knowledge they are often reluctant to move beyond their own physical space and network despite the realization that valuable knowledge may exist.

Time constraints: are preventing engineers from capturing and sharing their knowledge.

Validation: peer validation is common practice but difficult to implement when experts are distributed

System features addressing each of these themes are described in section 6. Future work will focus on iterative testing, user evaluation, training, roll out and further development, until full training and implementation of the Knowledge Management system is achieved throughout the company.

Whilst this paper describes the development of a knowledge management system for a specific engineering design consultancy it is felt that the approach in whole or in part are transferrable to other organizations, particularly those in the engineering design sector, seeking to implement a knowledge management system.

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