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THE DESIGN PROCESS OF A POST-OCCUPANCY DECISION TOOLKIT (PODIT)

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ABSTRACT

Post occupancy evaluation (POE) and associated processes have recently been highlighted as an important stage in a buildings' lifecycle. This stage is now well embedded in the Royal Institute of British Architects' (RIBA) plan of work. For educational institutions, buildings are important assets in providing good quality services and are subject to rigorous statutory requirements by governing authorities. The effective delivery, maintenance and operation of these assets throughout their lifecycle are therefore equally important. The post occupancy processes such as maintenance and improvement are often complicated as a result of the high number of stakeholders involved, the funding and responsibility hierarchy and the complexity of space functionality. Performance requirements as well as legal and liability-related issues and requirements also need to be taken into account.

Preliminary research has shown that these complex and multi-layered processes can be improved by the support of an information and communication technology (ICT) toolkit. This toolkit should be of the same level of complexity or higher to be able to effectively assist in the daily operation of school sites, while providing decision makers with a real-time information support system. The aim is to promote a more direct, informed and feedback-based decision process among stakeholders and other interested parties.

This paper presents partial outcomes of an on-going research project and sets out to describe the design principles for this toolkit. It starts with an overview of the stakeholders, their needs and workflow practices and the performance and legal requirements they have to comply with. It then investigates the relationships among stakeholders and what factors need to be prioritised within the system. The paper concludes by presenting an overview of the proposed toolkit based on these user-prioritised factors and the design principles that allow the toolkit to enhance, yet integrate with the established managerial and decision making practices, with the objective of low risk and seamless deployment.

Keywords: Decision toolkit, ICT in construction, Post-occupancy design, School buildings.

INTRODUCTION

In the UK the central government is responsible for pre-university education. The new coalition government believed that BSF (Building Schools for the Future) had not been able to fulfil its targets; hence an overhaul to England's school building programme was announced in July 2010 (DfE 2011a) but they are still committed to providing a world class education system by giving greater autonomy to schools, improving parental choice, offering more support for the poorest, whole system improvement, and great quality provision for children (DfE 2011b). Nonetheless, contrary to previous strategies, there has been a certain level of responsibilities devolved to local authorities and the school management teams.

On the other hand, buildings in general are subject to rapid obsolescence, dilapidation, deterioration, and deficiencies in performance and sustainability and it is important to introduce post-occupancy interventions to minimise those defects (Douglas 2006). Furthermore, a considerable amount of post-construction resources are spent on performance upkeep of buildings. Lack of engagement of designers, builders and sometimes even procuring clients with building performance may create one-off or chronic problems, which tend to persist, or result in innovation targets being missed and true successes being overlooked - even in some of the best buildings (Bordass and Leaman 2005). The justification of this research project therefore, lies in identifying and minimising design-sourced problems in the post-occupancy stages of school projects.

This research project was conceived to investigate post-occupancy intervention challenges in school buildings, using the South East England schools as case studies. Such as poorly defined design intent (Perelman *et al.* 2001, Green and Simister 1999, Kelly *et al.* 2005), poor design decision making (Kelly *et al.* 2005), inadequate information and knowledge processes (Bouchlaghem *et al.* 2004, Gigerenzer 1996, Galbraith 1977, Koutamanis *et al.* 2008, Quanjel and Zeiler 2007), inefficient collaborative working practices (Bertelsen and Emmitt 2005, Emmitt and Gorse 2003, Kalay 2006) and ineffective performance monitoring (CIB 1993, Preiser *et al.* 1988, Cory 2001).
Working closely with affected stakeholders in this sector, the research investigates post occupancy intervention problems from the stakeholder perspective. It then maps out the flow of information and the exchange of knowledge in post occupancy processes so as to devise an integrated decision support toolkit for different role-players in this sector. This paper enumerates the toolkit development criteria, presents the toolkit and concludes by presenting evaluation feedback from the steering group on benefits offered by the system.

RESEARCH AIMS AND OBJECTIVES

The aim of this study was to improve post-occupancy processes with the integration of an ICT toolkit. Working closely with a steering group consisting of select members of the proposed benefactors of the system, a process of analysis and design was started to tailor a software solution that aids, guides and improves the daily decision and workflow practices of school management teams and local authorities. In addition, the

use of data captured by the ICT system to improve long-term decision-making was investigated.

The objectives of this research are as follows:

1. Analyse the current post-occupancy decision and workflow practices first-hand using a steering group consisting of a cross-section of post-occupancy related stakeholders from the education sector.
2. Define a set of functionality that can successfully integrate an ICT support toolkit into these workflow practices without the need for greatly modifying and disrupting these.
3. Evaluate the integration of the toolkit by using a proof of concept prototype developed in close coordination with the steering group.
4. Indicate the additional benefit of capturing and organizing the incurring data sets by demonstrating how data-mining techniques can be used to aid long-term decision making.

RESEARCH METHODOLOGY

The particular methodology of this project specific to design and development of the toolkit followed a 4-stage user centred design (UCD) approach (Vredenburg 2002). The stages are: requirements gathering, requirements specification, design and evaluation. This research approach required direct engagement with stakeholders to elicit and optimise wants, needs and limitations. Sampling was based on the Department for Education and Skills' definition of stakeholders as defined in the Building Bulletins BB98 (DfES 2004) and BB99 (DfES 2006).

Stage 1: Requirements Gathering
During the requirements gathering stage extensive steering group meetings provided an outline of the general needs and requirements and design criteria for the toolkit.
In addition to the steering group meetings, on-site visits to two schools and the Brighton and Hove council are planned that should give more detailed insight into workflow practices and issues. Samples of post-occupancy related data, such as condition surveys, budget management tables and reports were also gathered.

Stage 2: Requirements Specification
Based on the gathered information, a set of key requirements and a list of functionality that the system should fulfil, the main entities, relationships and use-case scenarios were specified. These provided the framework for the development stage.

Stages 3 & 4: Design and Development
During this stage, which used an agile development cycle (Bent et al. 2001) initial paper-based prototypes were designed and evaluated internally and a high-fidelity Adobe flash-based prototype developed and evaluated by our stakeholder group. The reviews formed the basis for the current functionality set and a refinement of the toolkit design criteria.

In this research project, in addition to what was addressed above, there were other methods and techniques used, but we are not specifically addressing any of those in this paper.

STAGE 1 & 2: REQUIREMENTS GATHERING AND SPECIFICATION

Stage 1 and 2 where used to formulate the requirements to be used in the actual design and development process of the toolkit (stage 3 & 4). While the gathered data from the steering groups is not listed in this paper, an overview of the specified requirements is given below.

High Level Requirements
The approach to requirements elicitation was to hold two stakeholder/ steering group meetings. The steering group meetings showed that there was a desire for change and improvement of the status quo pertaining POE related areas such as communication issues, data management, data incompatibility between software, manual labour required to translate data, changes in legislation, management overhead caused by statutory requirements among others. While it was quickly agreed upon that an ICT support system could help to improve the situation, the members of our steering group offered a major concern during the initial meeting; The integration of the toolkit into the current work-flow of the stakeholders should be as risk-free as possible, while providing additional benefits. This gave the following *high-level requirements* for the toolkit:

- Perform the same tasks that are currently performed just as efficiently or better
- Be able to output the same data as currently used, i.e. paper-based reports
- Provide functionality to make digital back-ups of the entire data-set
- Prevent unwanted access to data

Features and Use Cases
Eliciting the necessary POE related processes that should be supported by the toolkit garnered an extensive wish list of features to be included in the software. The interviews conducted during the steering groups allowed us to prioritise these and define the core set of use-cases that would define the toolkit design:

- School model to capture data relating to building, indoor and outdoor spaces
- Maintenance and condition management.
- Job Package and action management
- Statutory Requirement reminders
- Human resources management
- Budgeting information showing budget and expenses
- Map function that allocates spaces to an up-loadable 2D floor plan of the premises to make finding specific data easier.
- Ability to produce reports that can be either printed in the usual format (i.e. condition survey) or exported as a spreadsheet.
- Ability to data-mine the database to generate knowledge regarding POE related performance measures.

Functional Requirements
In addition to the processes, individual needs gathered during the steering group meetings were also translated into extensive lists of functions and preliminary

workflows. These were also prioritised, resulting in a short-list of *functional requirements* for the toolkit:

- Provide a central storage for scanned documents, photos and other media pertaining to elements and activities on the site.
- Provide data in multiple formats and allow the user to sort by any useful category
- For location-based data, provide an interface that allows for the quick identification of a given element on a map.
- Manage and store a data-model of the site, including outdoor areas, indoor spaces, facilities and human resources.
- Record and manage on-going condition, maintenance and development data. Make it accessible, while providing addition analysis tools such as histories and expense reports.
- Plan recurring, ad-hoc and emergency procedures to deal with statutory requirements, site-development and damages.
- Share the above information with other parties in a controlled manner i.e. with full control over what information is shared and what is not.
- Address several user preferences by offering alternative data views e.g. through spatial hierarchy, maps and other visual tools, properties dialogs
- Make it easy to import, integrate and export standard data types
- Follow common practice workflows and allow for some flexibility in the use of data fields i.e. 'note' fields.

Usability

The usability of the toolkit was rated one of the top priorities during the steering group meetings and has been a central concern from the start of the project. Not all stakeholders are have an affinity to technology and computer literacy is not always a given. Due to this a high emphasis was placed to adhering to usability guidelines and heuristics (Shneiderman 2004, Nielsen and Molich 1990, ISO9241-11 1998).

Nielsen and Molich (1990) define a standard set of usability heuristics that were used during the design of the toolkit:

1. Visibility of system status
2. Match between system and the real world
3. User control and freedom
4. Consistency and standards
5. Error prevention
6. Recognition rather than recall
7. Flexibility and efficiency of use
8. Aesthetic and minimalist design
9. Help users recognize, diagnose, and recover from errors
10. Help and documentation

The requirements elicited during the steering group meeting only formed the outline for the development of the toolkit. During the design and development phase further feedback was sought as to ensure the usefulness and usability of the toolkit.

STAGE 3 & 4: DESIGN AND DEVELOPMENT

After the initial requirement specification process was completed, an agile approach to software development was used during the early prototyping and development phases of the toolkit. The feedback from stakeholder users and in-house reviewers was used to define the functionality of the toolkit as well as to optimise the usability functions. This feedback from the user groups was often interactively incorporated. This was done by using low fidelity paper-prototypes during the design stage and steering group meetings.

Data Model/ Entities

Fuller *et al.* (2010) suggest that the entity-relationship (ER) modelling approach has been one of the early attempts to allow designers to focus on the semantics of their problem domain in terms of the entities of interest and the logical relationships among them. Based on this approach an initial set of entities was designed that provide the foundation for a data-store to capture the properties and relationships of POE related information sets such as condition surveys, statutory checks, general building information and budget management.

Usability Evaluation

The central concern of any UCD led approach to software development is the usability of system functionality. While the steering group was able to provide feedback on many issues, the development phase could not completely involve them at all times. The core functionality of the toolkit prototype was therefore developed with regards to best practice in software application usability. In addition user-interaction principles by Victor (2006) and Crawford (1994) provided additional inspiration for novel approaches to data display management.

Functionality

The toolkit is split into two screens that combine the functionality given by the requirements. The below screenshots were taken directly from the prototype tested by the stakeholder steering group:

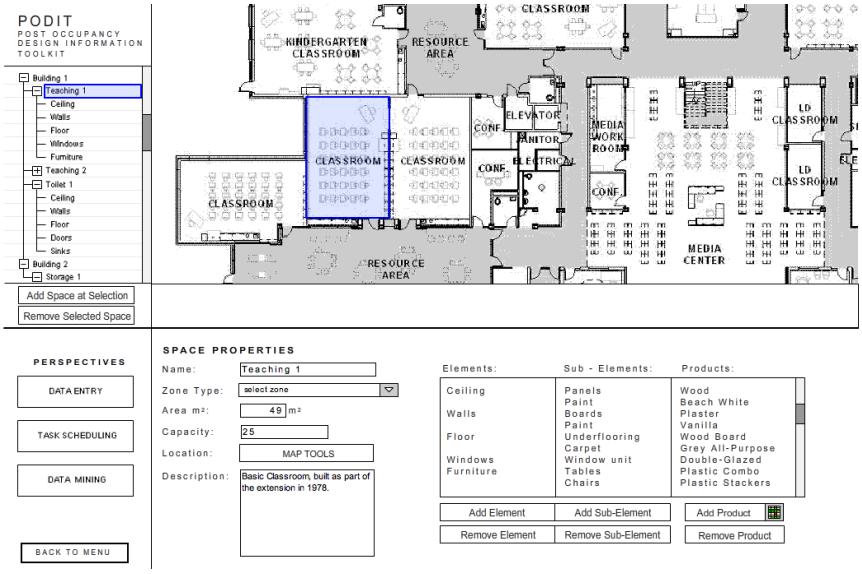

Figure 1 My School: The school model is managed using three separate linked interfaces. A hierarchical school tree provides the main navigation element, while the location of each node on the tree highlights and centres

the view on a location on the map provided in a linked view. The user can select schools, buildings, spaces and elements either using the tree or the map view. Doing so opens the properties of the selection in the properties interface, which shows detailed records and provides functionality for editing the school model.

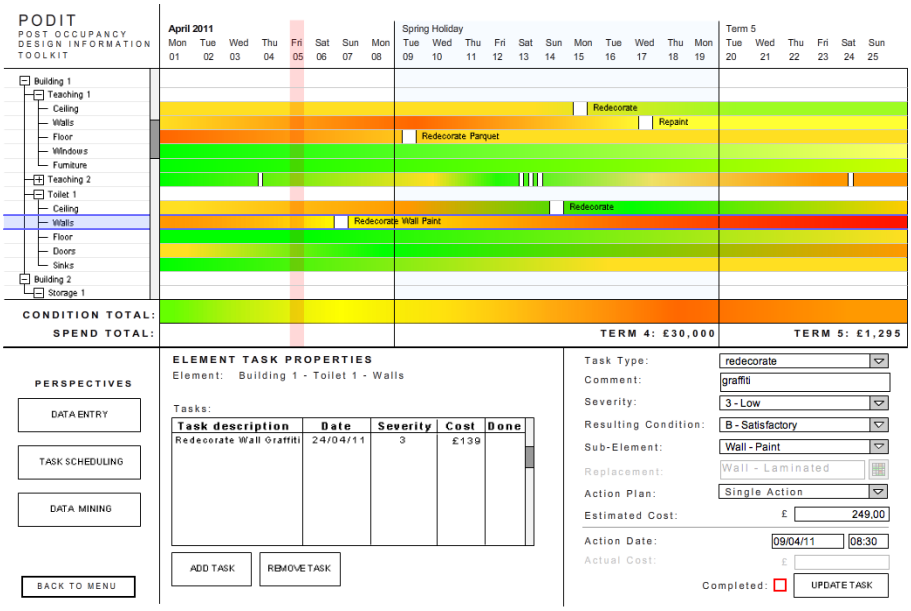

Figure 2 Scheduler: The scheduler screen summarizes and visualizes the information gathered on the Condition, Jobs and Reminders screen on a unified Gantt-style calendar. The Condition section creates an interactive 'living' condition survey in that it visualizes the continuous effects of time on the condition of the managed site. Job Packages are displayed as action handles that be moved to schedule the job. The user can edit the data pertaining to displayed data by clicking on bars and handles on the scheduler or the school hierarchy. The context-sensitive properties view changes accordingly.

Development Environment

For the first high-level prototype Adobe Flash was used since it provided unique mix of strong user-interface capabilities and vector graphics handling. While key functions were implemented, others were simulated for the demo which didn't provide full access to the dataset. The demo was particularly restricted to ensure that the steering group can focus on the core functionality issues.

Design Principles

Apart from adhering to best-practice usability guidelines and principles the development of the proof-of-concept prototype was used as a test-bed for some novel approaches to interface design. A primary focus was the combination of info-graphics with interactivity on the scheduler page. The idea of a 'living condition survey' was inspired by the concepts presented by Victor (2006) and Crawford (1994). In general, their approach sees a move towards context sensitive user interface elements and away from standard navigations and forms. While this couldn't be fully implemented across the entire toolkit, the scheduler and in particular the condition updates visualized on it apply this principle with context sensitive actions and editing capabilities within the scheduler.

The traffic light idea for visualizing condition data on a timeline was inspired by Victor's "Magic Ink" essay (2006) on integrating info-graphics and user-interfaces. The goal was to provide an intuitive visualization of the state of given building

elements, while also visualizing the impact that actions have on their condition and lifetime.

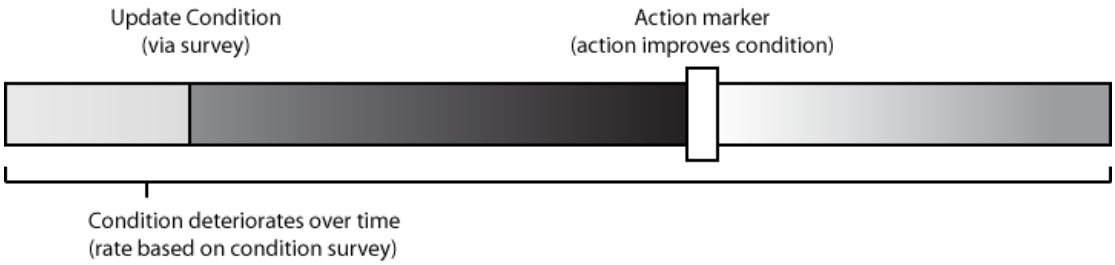

Figure 3 shows the condition bar visualizing the condition of building elements.

Figure 3 shows the visualization of the condition updates in the first toolkit prototype. Using a traffic-light system of coded colours red, amber and green it shows the deteriorating state and priority of a building element (For this paper the colours were converted into a monochrome gradient). The start of each bar represents the condition of an element when it was last checked. The strength of the gradient represents the 'priority' given to any action. A high-priority health and safety-critical element will shift into red faster than a low-priority element.

EVALUATION

The prototype was evaluated with steering group members and the main feedback was as follows (questionnaire data and transcripts are not included in this paper):

- The focus on workflow optimization and the function requirements in the design of the toolkit was a success. The steering group was particularly impressed with the ability to easily navigate the school model via the map and vice-versa via the hierarchical tree.
- The scheduler was deemed very useful as an overview tool and the visualization of the condition of elements coloured bar charts was preferred over the alternative table view of condition data.
- The exact meaning of the colours of the scheduler bars, whether red indicates a bad condition, or a high priority needs clarification. Interestingly, this problem was also found in current condition surveys, which frequently include elements in a 'good' condition yet 'immediate' priority due to health and safety critical concerns.
- Although an initially unexpected feature (since it was based on sub-surface needs), the simple budget management implemented into the prototype was well received and deemed useful.
- Sorting the condition display by priority was requested as a major feature.

Overall, the feedback was positive and the suggestions made during the steering group meeting were highly constructive. These recommendations are now being implemented in the latest revision of the toolkit.

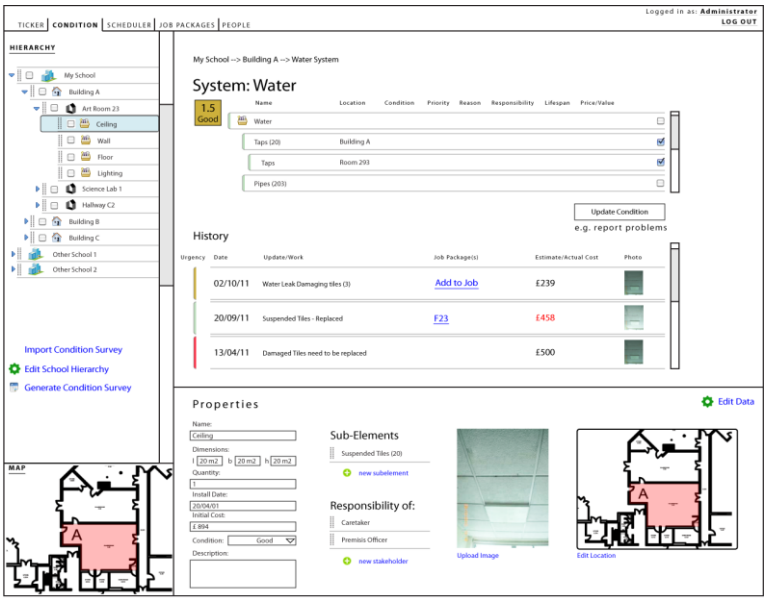

Figure 4 shows a recent update of the prototype user interface, which incorporates feedback from the second steering group meeting. The main navigation was split into 5 distinct workflows: "Ticker" – a front page that shows the most recent information updates pertaining to the particular user, "Condition" – a condition management tool (shown in this screenshot), "Scheduler" – a tool that combines the update information from the condition update and job packages tool, "Job Packages" – a task management system that allows jobs to be assigned to staff and includes progress tracking, "People" – an address book interface that also provides the ability to assign data access and editing levels within the toolkit.

FINDINGS

The feedback on the prototype from the second steering group meeting showed that it is important to focus on use cases and workflow practice optimization when designing a toolkit for POE. While users are quick to add features to their "wish list" of functionalities, it is necessary to prioritise these and focus on the "killer applications" that will draw users to the toolkit. In our case these were Condition monitoring, Job Tracking and Budgeting. The development effort involved in coordinating the data-flow between tools can be substantial, thus focusing on these core features initially and eventually expanding the feature set with more tools is the preferred approach.

CONCLUSION AND FURTHER WORK

For the future we would like to see more refinement of the user-interface and a further move toward context-sensitive and intuitive data editing mechanisms. For example the implementation of a simple drag and drop functionality for re-organizing the school hierarchy was noted during a recent steering group meeting. Several key functions were omitted from the current of the prototype including the ability import/export school data models and importing external datasets from condition surveys, these should also be incorporated in a future version.

Once the toolkit is more refined and the changes suggested by our steering group are taken into account, renewed focus will be on evaluating the possibilities of data-mining the accumulated data. Preferably this would be done using real-world data from an embedded long-term study.

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REFERENCES

Beck, Kent; et al. (2001). "Manifesto for Agile Software Development". Agile Alliance. URL:http://agilemanifesto.org/ [accessed 23.08.11]

Bertelsen, S. and Emmitt, S. (2005), "The client as a complex system", Proceedings IGLC-13, July 2005, Sydney, Australia

Bouchlaghem, D., Kimmance, A.G., Anumba, C.J. (2004), "Integrating product and process information in the construction sector, Industrial Management & Data Systems", 104(3), pp.218-33.

Chris Crawford (1994), "Representation Versus Depiction", URL: http://www.erasmatazz.com/page78/page31/page336/page345/RepresentationDepiction.html [accessed 30.06.11]

CIB (1993), "Building Pathology: A State-of-the-Art Report", CIB Report Publication 155, CIB Working Commission W86, June 993. Holland: International Council for Building.

Cory, C.A., (2001) Utilization of 2D, 3D, or 4D CAD in Construction Communication Documentation, 5th International Conference on Information Visualisation (IV'01), pp. 219-224.

DfES (2004), "Building Bulletin 98: Briefing Framework for Primary School Projects", Department for Education and Skills, Edinburgh: TSO (The Stationery Office)

DfES (2006), "Building Bulletin 99: Briefing Framework for Primary School Projects", 2nd Ed., Department for Education and Skills, Edinburgh: TSO (The Stationery Office)

Emmitt, S. and Gorse, C. (2003), "Construction Communication", Oxford: Blackwell Publishing

Fuller, R. M., Murthy, U., & Schafer, B. A. (2010), "The effects of data model representation method on task performance", Information & Management, 47(4), 208-218.

Galbraith, J. R. (1977). "Organization Design", Reading, MA: Addison-Wesley. In: (Winch, 2002).

Green, S.D. and Simister, S.J. (1999), "Modelling client business processes as an aid to strategic briefing", Construction Management and Economics (1999) 17, 63± 76.

Gigerenzer, G., (1996), "Rationality: why social context matters", In Interactive Minds: Life-span Perspectives on the Social Foundation of Cognition, edited by P Baltes, UM Staudinger, 319.46, (Cambridge: Cambridge Univ. Press).

ISO 9241-11 (1998), "Ergonomic Requirements for Office Work With Visual Display Terminals Part 11: Guidance on Usability", International Organization for Standardization, Geneva, Switzerland. URL: http://www.iso.org/iso/catalogue_detail.htm?csnumber=16883

Kalay, Y. E. (2006), "The impact of information technology on design methods, products and practices", Design Studies, 27(3), 357-380.

Kelly J., Hunter, K., Shen, G. and Yu, A., (2005), "Briefing from a facilities management perspective", Facilities, 23 (7/8), pp.356 - 367

Koutamanis, A, Halin, G. and Kvan, T. (2007), "Information standardization from a design perspective", CAADRIA 2007, CAADRIA, Nanjing.

Nielsen, J., and Molich, R. (1990). "Heuristic evaluation of user interfaces", *Proc. ACM CHI'90 Conf.* (Seattle, WA, 1-5 April), 249-256.

Nielsen, J. (1994). "Heuristic evaluation". In Nielsen, J., and Mack, R.L. (Eds.), Usability Inspection Methods, John Wiley & Sons, New York, NY

Perelman, L.C., Paradis, J. and Barrett, E. (2001), "The Mayfield Handbook of Technical and Scientific Writing", New York: The McGraw-Hill Companies.

Preiser, W.F.E. and Vischer, J.C. (eds) (2004) "Assessing Building Performance", Butterworth-Heinemann, Oxford.

Quanjel, E., Zeiler, W. (2007), "Design Collaboration and Team working, in: Information and knowledge management - helping the practitioner in planning and building", Proceedings of the CIB W102 3rd International Conference, Stuttgart, Germany, pp.51-60.

Shneiderman, B. (2004), "Designing the User Interface (4th Edition)", Boston, MA, Addison-Wesley Publishing

Victor, B. (2006) – "Magic Ink: Information Software and the Graphical Interface", URL: http://worrydream.com/#!2/MagicInk [accessed 30.06.11]

Vrendenburg, K. (2002), "User Centered Design: An Integrated Approach", Prentice Hall PTR