A TOOL FOR DEVELOPING KNOWLEDGE MANAGEMENT STRATEGIES

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SUMMARY: *While organisations recognise that Knowledge Management (KM) is essential for improving performance, many have difficulties in developing strategies for implementation. The nature of knowledge is of particular complexity in organisations such as those within the construction industry characterised by temporary 'virtual' organisations formed for the completion of projects. A significant proportion of construction organisations realise the benefits of KM but most remain at the infancy stages of developing and implementing KM strategies. This paper identifies the need for a methodology to help organisations establishing these strategies. It then describes a framework developed within the CLEVER (Cross-sectoral Learning in the Virtual Enterprise) project at Loughborough University. The framework introduces a methodology that supports KM at both the tactical and strategic levels in order to aid organisations, especially in the construction and manufacturing industries, in developing KM strategies. The methodology was encapsulated into a prototype software system to achieve a simpler format and is easier to use. Industrial collaborators evaluated both the paper format and the prototype software and it is evident that the developed methodology has the potential to provide a very useful way for developing KM strategies and that very little exists elsewhere to assist companies in developing KM strategies in this way. The software prototype was seen as an important enhancement to the paper version. The inviting format, simplified guidance, reduced input duplication, and automated report generation were found the most significant enhancements. The focus of this paper is on the development and operation of the prototype. Its key benefits and lessons learned in implementing it are highlighted in the paper.*

KEY WORDS: *Construction organisations, knowledge management, KM strategies, software prototype.*

1. INTRODUCTION

Knowledge Management (KM) is any process or practice of creating, acquiring, capturing, sharing and using knowledge, wherever it resides, to enhance learning and performance in organisations (Scarborough *et al*, 1999). This process of capturing, consolidating, disseminating and reusing knowledge within an organisation (Kazi *et al*, 1999) is the way it gains competitive advantage and builds an innovative and successful organisation (Kanter, 1999). It enables "the creation, communication, and application of knowledge of all kinds to achieve business goals"

(Tiwana, 2000). KM, therefore, provides strategies that help in retaining organisational knowledge and organisations that are successful in achieving this will increase profits, lead markets, avoid rework, and have better chances for innovation (Davenport, 1997; Tiwana, 2000; Al-Ghassani *et al*, 2001a). The true promise of benefits from implementing KM is evident in many cases and this has encouraged even more organisations to adopt KM with many now allocating several resources to retain and manage the knowledge they possess.

Most research on KM has been undertaken in industries such as manufacturing, pharmaceuticals, chemical, financial and the information technology sectors while very little was carried out in construction (Ribeiro, 2000). The multifaceted nature of knowledge breeds complexity especially in construction environments. This project-based industry depends on constantly changing members of project teams and supply chains (Carrillo *et al*, 2000; Patel *et al*, 2000) where most knowledge comes from the successful completion of projects (Conheeney *et al*, 2000). Although a significant proportion of construction organisations are aware of the benefits of KM, most of them are at the infancy stages of implementing their KM strategies and these strategies are not likely to be successful unless major barriers are identified and addressed (Robinson *et al*, 2001). Unsuccessful cases are mainly attributed to unclear goals (CIRIA, 2000; Davenport, 1997; Storey and Barnet, 2000; Tiwana, 2000; Al-Ghassani *et al*, 2001a) and therefore unclear and incomplete strategies.

This paper describes the methodology, development and operation of a software prototype developed to help organisations plan their KM strategy. First it discusses the importance of a clear KM strategy.

2. KM STRATEGY

The implementation of successful KM initiatives requires clearly defined objectives and a well-planned strategy. But for strategies to be established, organisations need a framework at the strategic level (Patel *et al*, 2000) to support the process of developing a clear and appropriate strategy. A 'clear strategy' can be described as a detailed plan at the high level of an organisation including a set of clear goals, and describing in detail how these are to be achieved within a specified timeframe with an identification of the short-term and long-term actions. It also specifies the major plans that need to be undertaken, allocates resources to them, and sets detailed plans for overcoming barriers (Carrillo *et al*, 2000).

A clear KM strategy is important because it provides significant benefits and prevents critical losses. A clear KM strategy helps to:

- *Ensure that KM plans are in line with organisational goals.* Any organisation, whether profit-making or non-profit-making, has goals that it aims to achieve and a KM strategy should support achieving these goals. Profit-making organisations, for example, aim to increase profits through improving business performance while non-profit-making organisations aim to deliver certain services within minimum cost and acceptable quality. As unclear goals from implementing KM can lead to the failure of a KM system (Davenport, 1997; Storey and Barnet, 2000; Al-Ghassani *et al*, 2001a), clear goals and a strategy will allow viewing how KM will help in achieving the organisational goals.
- *Gain continuous commitment from top management.* Top management commitment is one of the key issues that are required for implementing KM initiatives (Storey and Barnet, 2000) and because new initiatives often face resistance during implementation, top management support is crucial at the different stages of implementation. A clear KM strategy provides top management with a detailed description of the proposed KM plan, its implementation barriers, and how to overcome them. This strengthens their commitment to the system and also prepares them to make corrective actions to support the system whenever it comes to a bottleneck.
- *Allocate enough resources for the system.* KM systems are expensive (Davenport *et al*, 1997; CIRIA, 2000) and sophisticated requiring various resources. These resources include monetary figures, staff, tools and technologies with skills for using them, and time for contributing to the system and for using it. In construction organisations, the resources that are considered crucial for a KM strategy are the availability of budget, time, staff, and IT infrastructure (Robinson *et al*, 2001) and unless all these

resources are clearly stated in the KM strategy and approved by the top management it will be almost impossible to get them during implementation.

- *Allow for compatibility between existing and required structures of culture and technology.* Culture and technology are two important elements of KM systems. A clear strategy identifies characteristics of existing culture and technology in an organisation and builds on them. Culture is identified as the most significant barrier in the implementation of KM strategies in construction organisations (Robinson *et al*, 2001). A construction organisation took more than four years to convince its staff to share their knowledge while some staff in another construction organisation did not accept the idea and left the company (CIRIA, 2000). Understanding technology requirements is also critical because it is expensive to acquire and to modify. A KM system failed because its new technology did not go with the existing one (Storey and Barnet, 2000).
- *Reduce modifications and modification costs.* A system that is not properly designed is subject to several changes and modifications where modifying a KM system after it is developed is very difficult –if possible, time consuming and expensive (CIRIA, 2000). Requirements for modification may not be clearly visible during the design stage unless detailed designs are included. A clear KM strategy should include a detailed description of the system architecture, how its parts relate to each other, and how the development should take place. This will make needs for modification obvious at the planning stage.

3. METHODOLOGY FOR DEVELOPING A KM STRATEGY

The management of project knowledge especially within the construction industry where projects are implemented by temporary 'virtual' organisations requires considerable improvement, both within construction organisations, and between firms in the supply chain (Carrillo et al). Literature review (Carrillo *et al*, 2000; Patel *et al*, 2000) and semi-structured interviews with construction companies show that one of the required improvements is a framework to support the way organisations develop their KM strategies.

3.1 Background

A methodology for developing KM strategies was developed within the CLEVER (Cross-sectoral Learning in the Virtual Enterprise) research project (Anumba *et al*, 2001; Kamara *et al*, 2001). The aim of CLEVER was to develop a coherent framework for supporting the implementation of KM with special emphasis on construction and manufacturing organisations. This framework targets people who are developing KM initiatives at both tactical and strategic levels such as Knowledge Managers and Chief Knowledge Officers (CKOs). In order to achieve its aim, several objectives were established to provide appropriate strategies to address specific KM problems by:

- Identifying the KM problem and linking it to business drivers/goals;
- Creating the desired characteristics of KM solutions;
- Identifying the critical migration paths to achieve the desired characteristics; and
- Selecting appropriate KM processes to use on those paths.

The subsequent sections discuss, in some detail, the methodology, development, and operation of a prototype system developed to address the last three objectives of the CLEVER framework. Details about a prototype developed to address the first objective, "Identifying the KM Problem", can be found in Al-Ghassani *et al* (2001a) and Al-Ghassani *et al* (2002), the description of which is beyond the scope of this paper.

3.2 Structure of the CLEVER framework

The Framework addresses its objectives through four main stages illustrated in Fig. 1. The first stage, "identify KM problem", aims to clarify the overall KM problem within a business context to deliver a refined KM problem and a

distilled set of KM issues from the overall problem. The second stage, "identify current and required KM characteristics", aims to identify the current and required status of a range of knowledge dimensions to highlight the problem areas, which need more focus so as to deliver a set of concerns or specific KM components of the problem. The third stage, "identify critical knowledge migration paths", aims to identify a set of the most critical paths for each specific KM problem and an overall set of paths for the whole problem. The last stage, "select generic KM processes", aims to help in selecting the appropriate KM processes which, when tailored to a particular organisations need, will help in implementing KM. Each stage consists of a main template, guidelines, and a glossary.

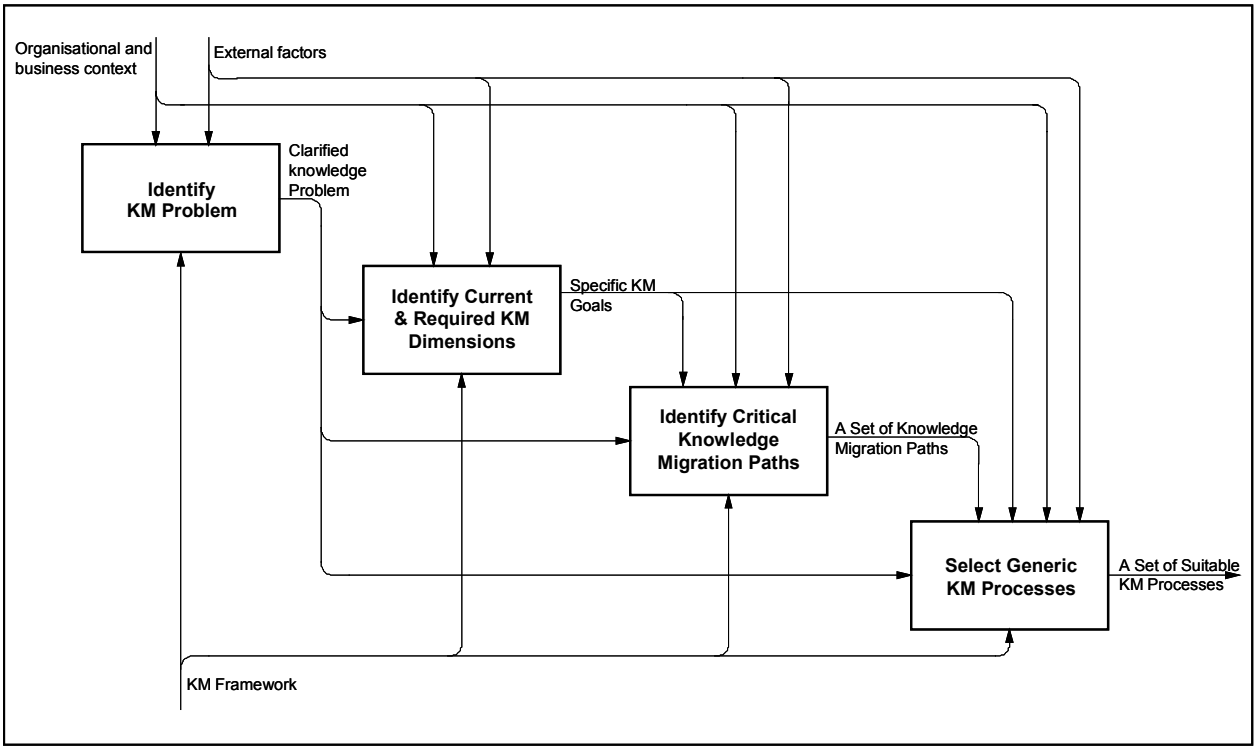

FIG.1: The CLEVER framework for implementing KM

Each of the CLEVER stages has an aim and outcomes. The specific aims and outcomes are shown in Table 1.

TABLE 1: Specific aims and outcomes of CLEVER

Stage	Aim	Outcomes
The Problem Definition Template	To define the overall KM problem within a business context	• Clarification of the KM problem • Distillation of a set of KM issues from the overall problem
Overview of 'To Be' KM Solution.	To identify required status on a range of knowledge dimensions and to highlight areas of future focus.	• Set of concerns or specific KM components of the overall problem on which focus is required
Critical Migration Paths.	To identify critical migration paths for each specific KM problem (or dimension of interest)	• Set of key migration paths for each specific KM problem • Overall set of migration paths for the whole KM problem
Appropriate KM Processes.	To help in selecting the appropriate KM process to move along each migration path	• Set of appropriate KM process(es), which, when tailored to a particular organisations need, will address the stated KM problem.

3.3 Need for automation

The developed methodology was evaluated using case studies. Evaluation took place at individual workshops with four industrial collaborators representing both construction and manufacturing industries. The evaluation workshops included directors, senior managers, and site personnel. The duration of the workshops ranged between half day and two days. Every workshop consisted of a presentation of the framework followed by guided use of the framework considering a specific problem on a consensus basis. At the end of workshops, participants completed evaluation questionnaires, although in one case, informal feedback was received. An evaluation questionnaire was prepared to elicit the views of participants based on five-point scale questions covering the following issues:

- ease of use;
- layout;
- relevance to the business; and
- appropriateness of the explanation provided.

Based on the comments received from the evaluation workshops, it is evident that the developed methodology provides a very useful way for developing KM strategies. It was also found to provide a generic framework that can be used by any industry sector. Furthermore, it was agreed that very little else exists to assist companies in developing KM strategies in this way. However, to be truly useful to an organisation, some modifications were suggested. Firstly, the format was seen as uninviting and not easy to use without guidance. Users thought that the guidelines included in the approach need to be much slimmer, simpler, and automated for the approach to be a readily usable tool. Secondly, it was felt that the worth of using the approach would be greatly enhanced by automating it through encapsulation in a software system. Without this, users could view its completion as a trivial exercise.

4. SYSTEM DEVELOPMENT

In order to address the comments received from the evaluation workshops, a prototype software system was developed. Several activities were involved in the development of the system including, setting its objectives, system architecture, selecting the implementation environment, and the final development.

4.1 System objectives

The aim of prototype is to simplify the format and use of the last three stages of the CLEVER framework. To achieve its aim, the prototype was designed to address the following objectives:

- allow easy entry, storage, viewing, and editing of information;
- provide ‘on-click’ user-friendly guidance for how to use system;
- provide single entry input and avoid its duplication;
- allow for interactive integration between the last three stages of the framework;
- allow for future integration of the system with the prototype developed for the first stage of the CLEVER framework and with other computer-based KM tools;
- facilitate the generation and printing of a report containing the KM goals, the migration paths, the KM processes, and the actual strategies for implementing these processes.

4.2 System architecture

To accomplish the objectives of the prototype, the system architecture, shown in Fig. 2, was developed. Three main stages provide a means for developing a KM strategy. These stages are 'Identifying KM Goals', 'Selecting Knowledge Migration Paths', and 'Identifying KM Processes and Strategy'. The user first reacts with the first stage through which the other stages can be interacted with. The solid arrows linking the three stages indicate that entry and viewing of information is done forwards. However the dashed arrows at the bottom of the stages show that the user can go backwards to edit previous input for any stage or part of a stage. The arrows linking the stages to the report show that the information, once entered, is immediately sent to the report and is instantly modified if input is edited.

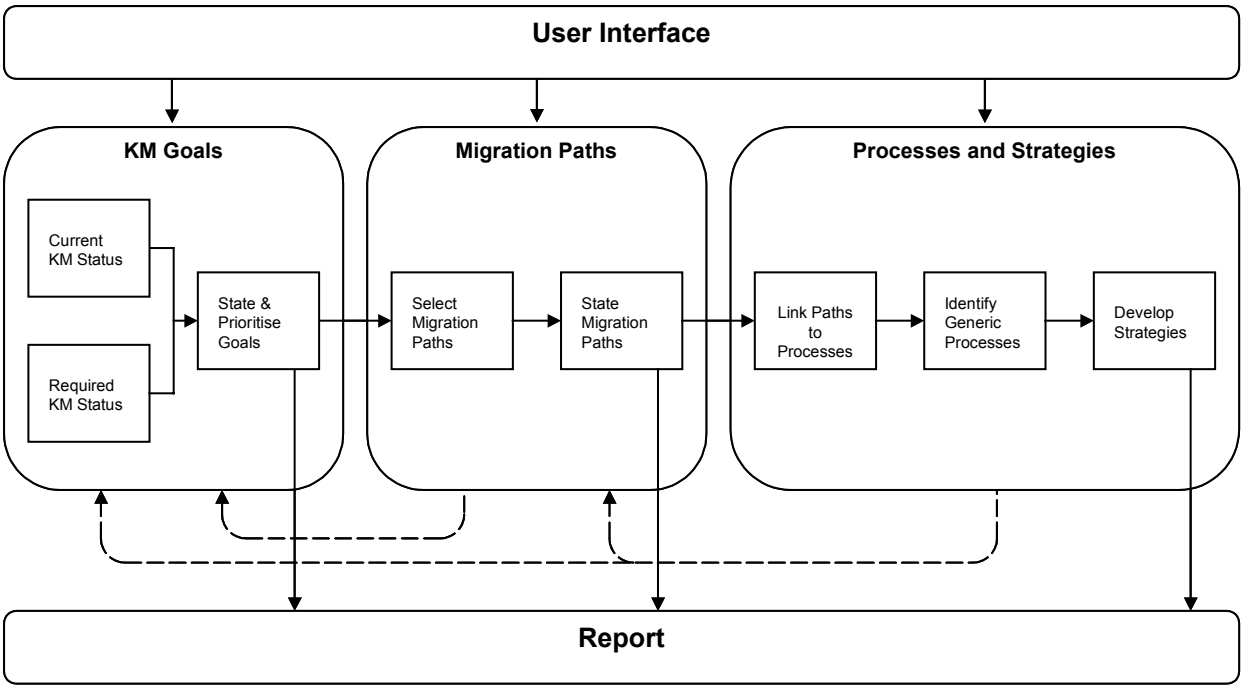

FIG.2: System architecture

4.3 Development within Visual Basic

The prototype was developed in Microsoft Visual Basic by means of creating, forms, macros, and reports. Forms are used to input, edit, and view the information. Three main types of forms were developed namely; input forms, output forms, and help forms. The help forms were embedded within the input forms to allow for effective guidance for using the system. Controls, event procedures and general procedures were used to design the forms. Sliders, command buttons, option buttons, labels, text boxes, and some drawing features were also used. A summary of the desired characteristics of the prototype and the way in which they were achieved is shown in Table 2.

TABLE 2: Activities for achieving desired characteristics of the prototype

Desired	How achieved
Allow convenient entry, viewing, and editing of information at any stage	• Designed forms allowed the display and editing of stored data • Command buttons inserted in the forms allowed easy navigation between the forms at any stage of the activity
Allow for visual comparison of current and required knowledge status	• Two sliders define every knowledge dimension

and required knowledge status	
Support on how to complete the forms	• Whenever required, help buttons where embedded within input forms to provide information and instructions on how to complete the forms
Allow for easy selection of migration paths	• Option buttons guided by arrows and written text help in identifying the knowledge migration paths
Individual investigation of every knowledge dimension against other dimensions	• A 'Go' button next to every goal links to the forms required to investigate the knowledge dimension corresponding to that goal against the other dimensions
Allow for entering KM strategies for every generic KM process	• 'Labels' describing the generic KM processes can be activated by clicking them. • Clicking a label would result in a pop up form for information entry, which once entered is immediately sent to a report
Facilitate the generation of a report that can be opened at the different stages	• A 'Report' button can be activated at the end of any of the following stages: identifying the KM goals, stating the migration paths, identifying the KM processes, and developing strategies for implementation
Allow for future integration with other KM frameworks and tools	• As an application of the MS Office group, Access can be easily linked to other packages

5. SYSTEM OPERATION

The system starts with a screen showing eight knowledge dimensions (Fig. 3). Two sliders describe each dimension, where the user can move the five-point-scale sliders to the appropriate locations of the 'current' and 'required' knowledge status within the organisation. Each dimension has an organisational impact at the strategic or policy level as shown below the sliders of each dimension. Every dimension is supported by a 'help' button, which gives detailed description of what it means. After the sliders are moved to the corresponding positions, the 'Show Goals' button can be clicked to call the program to state the organisational goals and impacts at the strategic/policy level. The system also prioritises these goals according to distance between the sliders. A 'Go' button next to every 'goal statement' can be clicked to investigate the relevant knowledge dimension against the other dimensions.

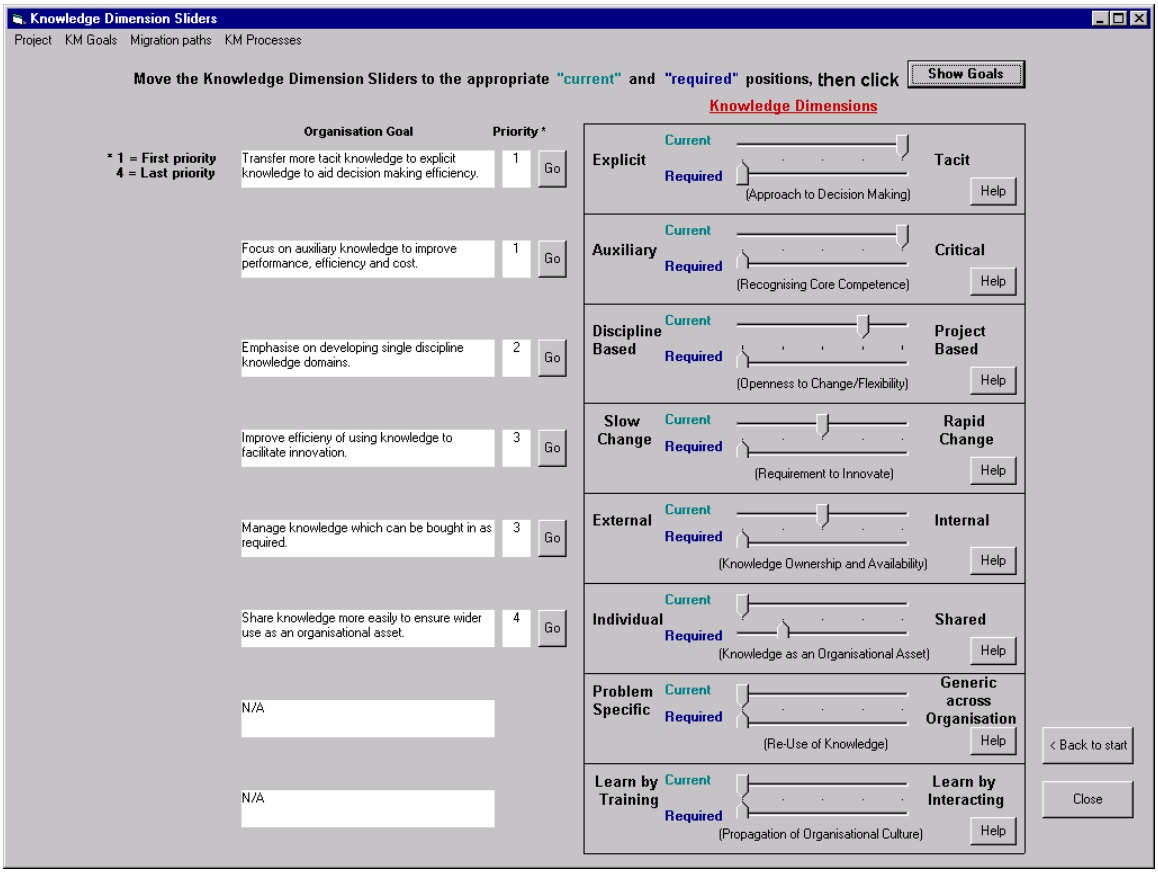

FIG.3: A sample screen showing the knowledge dimensions

Clicking the 'Go' button allows the system to present a set of seven squares, one at a time, to investigate the relevant knowledge dimension against the other seven dimensions in order to identify the most appropriate knowledge migration paths. The system displays descriptions in corners of the squares (Fig. 4), from which the user identifies the path. While completing the forms, the user can return to any previous form to modify the input. Clicking the 'next' button at the bottom of a form saves information on current form, closes it and opens the next form for information entry.

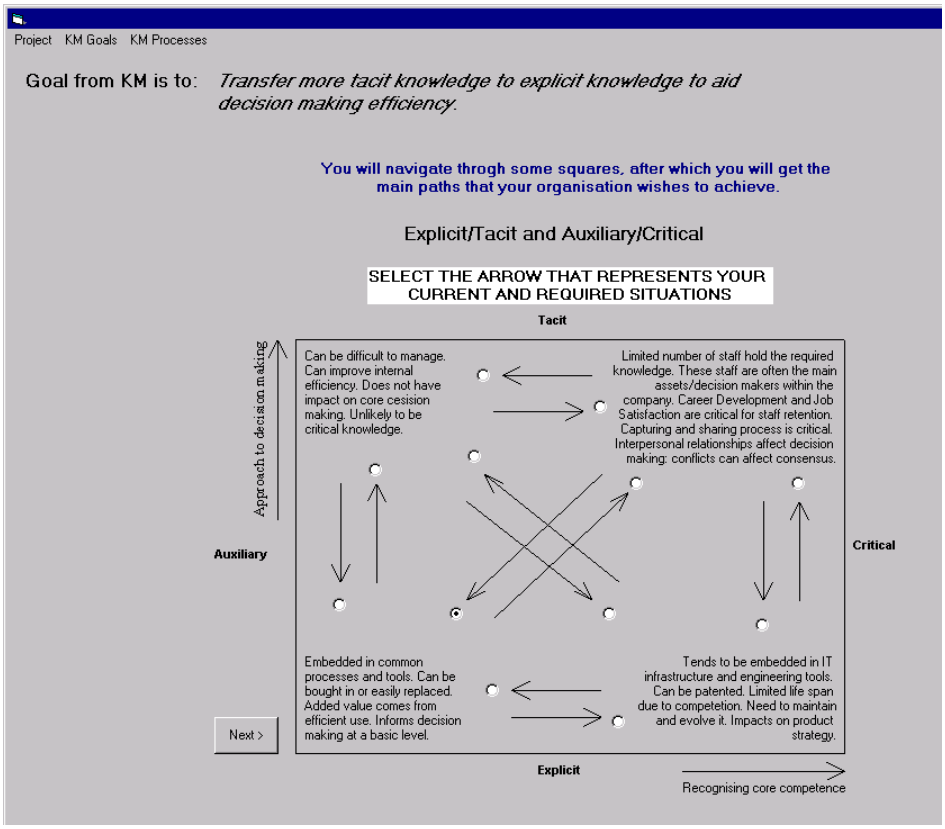

FIG.4: Squares used for identifying the knowledge migration paths.

Upon completing the seven squares, the user can click the 'Show Migration Paths' button at the bottom of the last square to see a set of migration paths for the selected KM goal (Fig. 5).

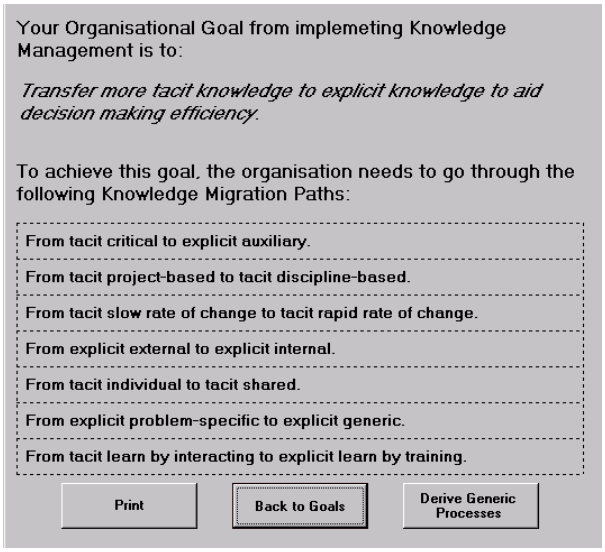

FIG.5: A set of knowledge migration paths for a KM goal

Below the list of migration paths the user can select from three options; print, go back to the knowledge sliders, or derive the KM processes. Selecting the latter allows the system to present a table of the KM processes (Fig. 6). The user needs here to identify the KM process relevant to each migration path by using option buttons.

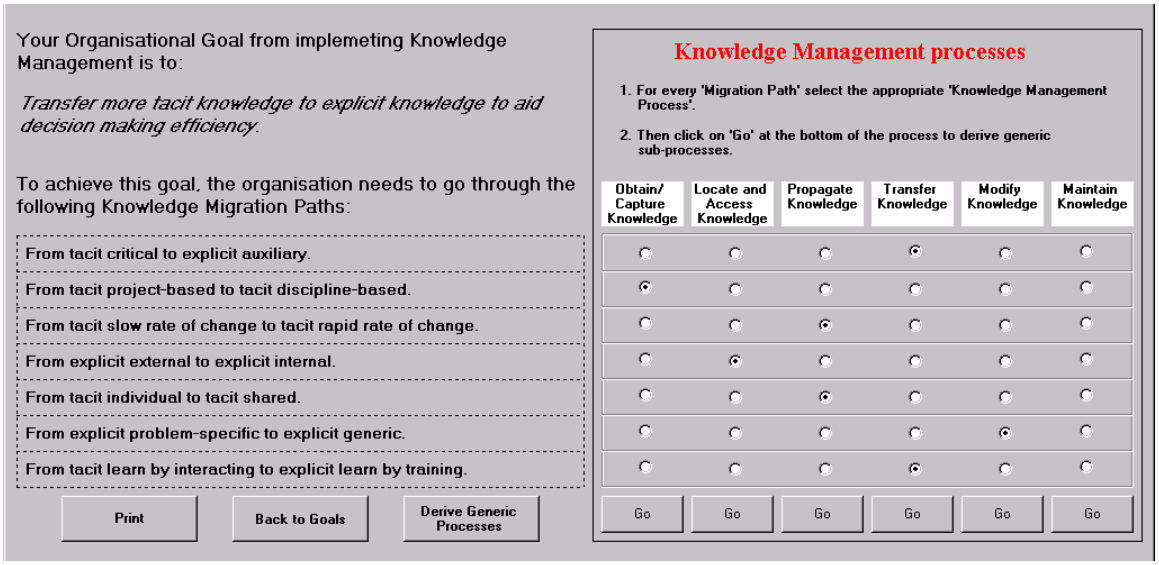

FIG.6: Knowledge migration paths and their relevant KM processes

For every KM process identified in Fig. 6, the system introduces a chart illustrating generic processes for the selected process (Fig. 7). Clicking any of the generic processes changes its colour and activates an input message box asking the user to enter the organisation's KM strategy for addressing that generic process.

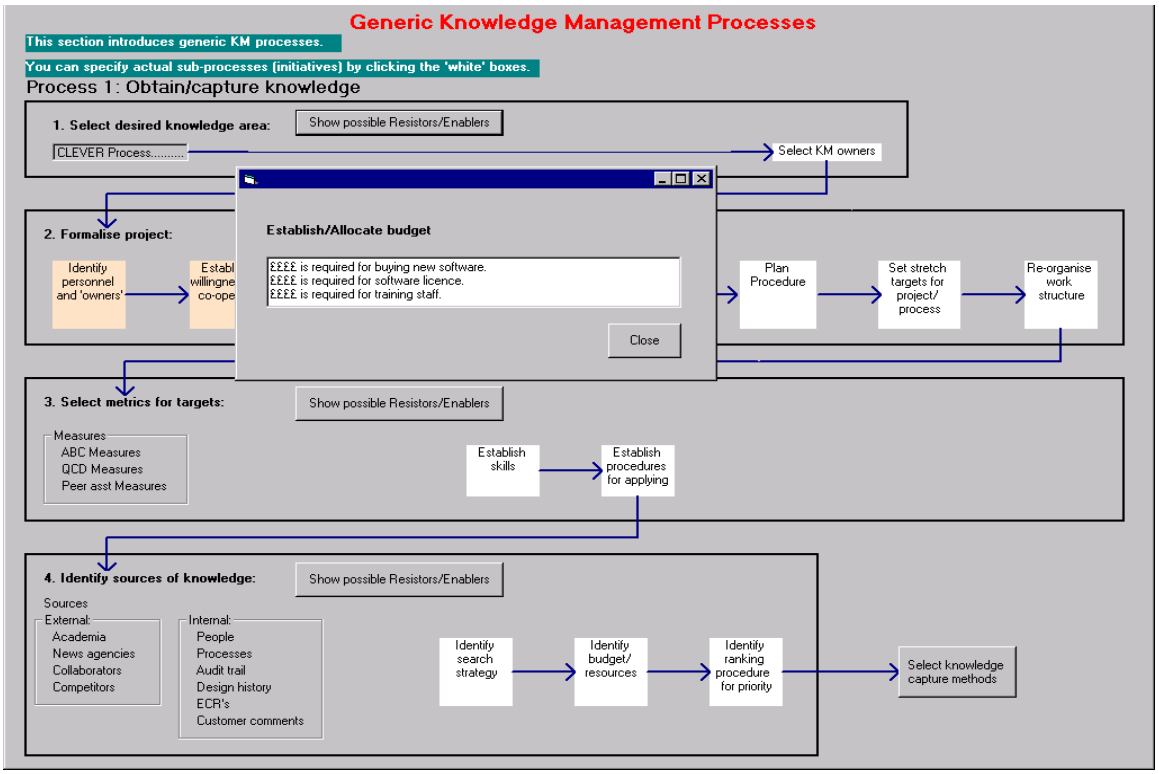

FIG.7: Generic processes of a KM process along with an input message box for developing strategies.

The prototype is able to produce a detailed report containing the KM goals and their priorities, the knowledge migration paths for every goal, the KM processes for every migration path, and the generic processes for every KM process alongside with strategies for implementing these generic processes. Fig. 8 shows a screen-shot of a generated report.

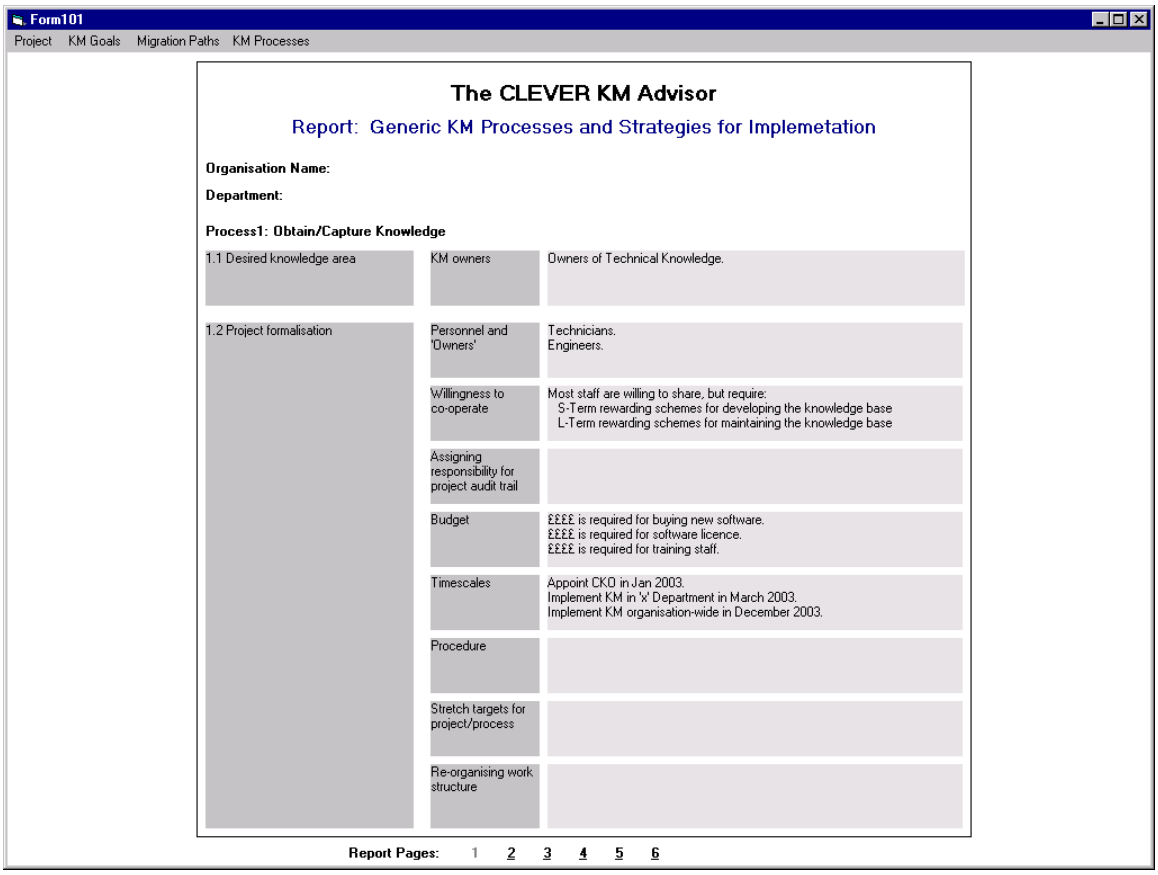

FIG.8: A screen-shot of a report generated by the prototype

The prototype was evaluated through a demonstration to industrial collaborators. The demonstration was followed by an open discussion and it was agreed that the prototype provides an important enhancement to the paper version of the CLEVER framework. The inviting format, simplified guidance, reduced input duplication, and automated report generation were found the most significant enhancements.

6. EVALUATION

The evaluation of the paper format of the CLEVER framework was described in section 3.3 where the participants involved in the evaluation suggested simplifying the use of the framework through automation. A prototype system was then developed. This section presents the process and outcomes of evaluating the prototype system.

6.1 Evaluation Strategy

Three construction organisations and one manufacturing organisation were involved in the evaluation of the CLEVER Prototype. The involved organisations were mostly large UK based organisations with international offices. Twelve participants were involved in the evaluation with experiences ranging between 6 and 36 years in the

construction and manufacturing industries. Participants ranged between people who were new to KM and others who are heavily involved in KM initiatives. The workshops started with a presentation on KM because some of the participants were new to the concept. This was followed by another presentation on the CLEVER Framework. A demonstration of the prototype system was then made. To evaluate the prototype's usefulness, participants were guided in using it to work through a specific problem on a consensus basis. They also completed an evaluation questionnaire at the end of the workshops. The duration of workshops ranged between two and four hours depending on the type of the KM problem the participants decided to investigate.

6.2 Evaluation Questionnaire

An evaluation questionnaire was designed to obtain the views of end-users on the usefulness of the prototype. The questions were based on a five-point-scale where one meant poor and five meant excellent. The questions covered the specific features of the system and how well they supported its functionality. They also covered issues on the management of the system interaction, its effectiveness, and clarity and accuracy of outcomes. At the end of the questionnaire, participants were allowed to suggest how the system could be improved and they were also encouraged to add further comments.

6.3 Findings

- It is evident from the response received from participants involved in evaluating the system that the CLEVER prototype:
- Has an inviting format that encourages its use;
- Is easy to use due to the on-line guidelines and help buttons;
- Simplifies understanding the way CLEVER methodology works;
- Eliminates efforts of searching piles of appendices;
- Reduces use-time and prevents input duplication;
- Generates a concise report; and
- Provides a new and useful KM tool for business organisations or units within them.

Participants also noted that the system requires a very short training time to be used conveniently. This training time was estimated at one to two days. In fact, all participants responded to the questions by giving scores between three and five with most of the questions given four scores. On the other hand, some further modifications were suggested with regards to simplifying the terminologies and the knowledge migration paths.

7. CONCLUSIONS

This paper has discussed the need for 'clear KM strategies'. It then introduced a methodology for developing a KM strategy through identifying the KM goals and their priorities, selecting the knowledge migration paths and identifying their corresponding KM processes, and finally identifying generic models within these processes for developing a strategy for implementation. The methodology was evaluated by means of case studies of industrial collaborators who considered the methodology a very useful way for developing a KM strategy but suggested that its worth would be greatly enhanced by encapsulation in a software system. The methodology was encapsulated into a prototype software system and it was tested through several workshops. The inviting format, simplified guidance, reduced input duplication, and automated report generation were found the most significant enhancements to the paper format. The evaluation proved that the prototype is useful for an organisation or a unit within it and that it will be highly welcomed by businesses.

The logic behind the development of this prototype is based on the fact that knowledge management is not properly supported at its strategic level (Carrillo et al; 2000; Patel *et al*, 2000; Al-Ghassani *et al*, 2001b) and that all existing IT tools focus on the operational/implementation level (Al-Ghassani *et al*, 2001b). This necessitated the development of a methodology that helps organisations develop clear KM strategies to gain real benefits and avoid critical losses. The developed framework and its associating prototype address this need with specific reference to the requirements of the manufacturing and construction organisations. This is due to the carefully designed 'knowledge dimensions'

which are used at the early stages of CLEVER e.g. the dimension of 'discipline/project –based' knowledge. The system provides one of the key tools that could be used at the strategic level of KM. Further work will be to link CLEVER to other frameworks, tools, and technologies of KM.

8. REFERENCES

Al-Ghassani A.M., Anumba C.J., Carrillo P.M. and Kamara J.M. (2001a). An innovative tool for knowledge problem definition, *Proceedings of the 1st International Conference on Innovation in Architecture, Engineering and Construction (AEC)*, C. Anumba, C. Egbu and T. Thorpe, eds., Loughborough University, Loughborough, UK, 18-20 July, 249-256.

Al-Ghassani A.M., Carrillo P.M., Anumba C.J. and Robinson H.R. (2001b). Software requirements for knowledge management in construction organisations, *17th Annual ARCOM Conference*, A. Akintoye, ed., University of Salford, Salford, UK, 5-7 September, 199-206.

Al-Ghassani A.M., Kamara J.M., Anumba C.J. and Carrillo P.M. (2002). A structured approach for identifying knowledge management problems, *The New International Journal of Innovation in Architecture, Construction and Engineering (ACE)*, (will be published in Jan 2002).

Anumba C.J., Carrillo P.M., Backhouse C.J., Brookes N.J. and Sinclair M. A. (2001). Cross-sectoral Learning in the Virtual Enterprise (CLEVER), *EPSRC Final Report Appendix (CD)*, Loughborough University, Loughborough, UK, October.

Britton C. and Doake J. (1996). *Software System Development: a gentle introduction*, McGraw-Hill, London, UK.

Carrillo P. M., Anumba C.J., and Kamara J.M. (2000). Knowledge management strategy for construction: key I.T. and contextual issues, *Proceedings of the International Conference on Construction Information Technology (CIT2000)*, G. Gudson ed., Reykjavik, Iceland, 28-30 June, Vol. 1, 155-165.

CIRIA (2000). Applying Knowledge Management to the Construction Industry: a workshop report, *Construction Productivity Network (CPN)*, London, UK.

Conheeney K., Stephenson P. and Griffiths A. (2000). Issues in knowledge transfer within a construction training and learning organisation, *Proceedings of the International Conference on Construction Information Technology (CIT2000)*, G. Gudson ed., Reykjavik, Iceland, 28-30 June, Vol. 1, 229-240.

Connell J.L. and Shafer L.I. (1995). *Object-Oriented Rapid Prototyping*, Yourdon Press, Prentice Hall Building, New Jersey, USA.

Davenport T. (1997). Secrets of successful knowledge management. *Issue of Knowledge Inc*., Feb, <http://webcom.com/quantera/secrets.html> 04/09/2000.

Davenport T.H., De Long D.W. and Beers M.C. (1997). *Building Successful Knowledge Management Projects*, Center for Business Innovation, Ernst & Young, Working Paper, January.

Kamara J.M., Anumba C.J. and Carrillo P.M. (2001). Selection of a knowledge management strategy for organisations, *Proceedings of the Second European Conference on Knowledge Management*, D. Remenyi, ed., Bled, Slovenia, 8-9 November, 243-254.

Kanter J. (1999). Knowledge management: practically speaking, *Information Systems Management*, Vol. 16, No. 4, 7-15.

Kazi A. S., Hannus M. and Charoenngam C. (1999). An exploration of knowledge management for construction, *Proceedings of the 2nd International Conference on CE in Construction (CIB Publication 236)*, M. Hannus *et al*. (eds.), Espoo, Finland, 25-27 August, 247-256.

Morris S. (1999). *Object-Oriented Programming for Windows 95 and NT*, Butterworth-Heinemann, USA

Patel M. B., McCarthy T. J., Morris P.W.G. and Elhag T.M.S. (2000). The role of IT in capturing and managing knowledge for organisational learning on construction projects, *Proceedings of the International Conference*

on Construction Information Technology (CIT2000), G. Gudson ed., Reykjavik, Iceland, 28-30 June, Vol. 2, 674-685.

Ribeiro F. L. (2000). Toward a technology for corporate memories in construction, *Proceedings of the International Conference on Construction Information Technology (CIT2000)*, G. Gudson ed., Reykjavik, Iceland, 28-30 June, Vol. 1, 742-752.

Robinson H.S., Carrillo P.M., Anumba C.J. and Al-Ghassani A.M. (2001). Perception and barriers in implementing knowledge management strategies in large construction organisations, *Proceedings of RICS COBRA Conference*, J. Kelly and K. Hunter eds., Glasgow, United Kingdom, 3-5 September, 451-460.

Scarbrough H., Swan J. and Preston J. (1999). *Issues in People Management: Knowledge Management: a literature review*, Institute of Personnel and Development, The Cromwell Press, Wiltshire.

Storey J. and Barnet E. (2000). Knowledge management initiatives: learning from failure, *Journal of Knowledge Management,* Vol. 4, No. 2, 145-156.

Tiwana A. (2000). *The Knowledge Management Toolkit*. Prentice Hall Inc., New Jersey.

Vail III E. F. (1999). Knowledge mapping: getting started with knowledge management, *Information Systems Management*.