Creating Effective Management Support Systems for the Learning Organisation

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Introduction

Effective adaptation in response to rapid changes in the competitive environment is a critical capability for many present day business organisations. The recognition of increasingly rapid change has led many businesses to promote the idea of organisational learning. This is concerned with creating, acquiring and transferring knowledge, and modifying organisational behaviour to reflect new knowledge and insights. Through the facilitating of individual learning and the embedding of the resulting knowledge in organisational structures and culture, changes in processes, innovative products and new approaches to manufacturing and services can emerge which enable the organisation to remain competitive. The growth of knowledge-based organisations where the manipulation of knowledge drives the business has added further impetus to the interest in organisational learning. McGee and Prusak (1993) suggest that "learning has become a central task for organisations that hope to compete effectively in today's business environment [p204]."

In theory, the support of organisational learning should be an ideal function for management support systems (MSS). Functions such as the capturing, structuring and combining of information, the storing of knowledge and the dissemination of that knowledge should be well-supported by MSS. However, it can be argued that it is often the case that MSS are unsuitable for learning organisations. Indeed, the effect of MSS with fixed datastructures, complex presentation of information, and over-attention to numerical and statistical information can be stifling. New ideas are inhibited, set processes and patterns of thought are fixed through their enshrining in an information system and variety is replaced by uniformity and standardisation. Information systems seem incapable of supporting knowledge creation and the range of activities and thought processes needed for individual and organisational learning.

This paper looks at the nature of learning within an organisation and identifies the functionality required from MSS if they are to support organisational learning.

Establishing the environment of a learning organisation

Organisational learning involves the creation and acquisition of knowledge, its transfer within the organisation and the modification of organisational behaviour to reflect the new knowledge and insights (Garvin, 1993). It is dependent on individual learning but requires that such learning is embedded in the organisation through communication, action and storage. While organisations only learn through individuals that learn, individual learning does not guarantee organisational learning. The latter requires that members of the

organisation work together. It also requires mechanisms to enable organisational memory to persist beyond the contract of individual members (Stata, 1989).

Successful organisational learning depends on a number of factors. Clearly, an organisation can only learn as fast as its slowest member. Resistance from the individual, lack of enthusiasm and inability to adapt will stop organisational learning. Such individual resistance may be overcome by the establishing of organisational norms which encourage new ideas, innovation and learning. Organisational learning will depend on the adaptability of the organisation's culture. Cultures where tradition and routine are highly valued will not promote organisational learning. New organisational forms may need to adopted and structures changed in order to get ready to learn. The organisation should promote the sharing of tacit knowledge, personal understanding which is often difficult to articulate and communication, as well as the explicit knowledge represented by formal data, rules and standards. (Polanyi, 1966; Nonaka, 1994).

Successful organisational learning involves the challenging of organisational assumptions and norms. Individual mental models must be examined and reshaped. Double loop learning must occur (Argyris and Shon, 1984). Experimentation with new ideas and the use of trial and error should be encouraged. Failure should be used as an opportunity for learning rather than being censured. Members of the organisation should be encouraged to think holistically and consider entire systems within the organisation and not just those aspects with which they are directly concerned.

Effective team participation should be encouraged. Members of the organisation should be skilled in group working in order to allow for effective organisational learning. Redundancy of information should be accepted (Nonaka, 1994) and multiple solutions to problems encouraged. The satificing approach to decision making (March and Simon, 1958) should be avoided. Team members will need to understand each others view and recognise that there will be many individual interpretations of a concept or idea (Tensaki and Boland, 1995). Personal interpretations must be articulated and a rush to a consensus avoided.

For organisational learning to take place within a business, some cultural and contextual prerequisites are necessary. In their absence, no amount of IT will affect organisational learning. If an organisation is appropriately primed, then IT can be of value in supporting and extending the learning process. The rest of the paper looks at what characteristics a MSS that supports organisational learning should have and seeks to identify some candidate system types that might provide elements of an organisational learning MSS. It should be noted that the term 'MSS' is being used generically to cover a variety of systems which provide management support including decision support systems, management information systems and executive information systems (Fidler and Rogerson, 1996).

MSS support for individual learning.

Within the learning organisation, the first function of MSS must be to support individual learning. Such support may be centred around an information infrastructure within which a variety of information can be gathered from a variety of sources and combined to meet individual's needs.

While the process of learning is a complex one, some activities may be identified which have a bearing on the way in which MSS might support learning. Individuals search for information, they extract material relevant to their tasks, they interpret that information and structure it in a form that will be easily retrieved. The learning will then result in changes in the way the individual behaves. The following outlines the process by which individual learning occurs.

Information Searching. Searches for information will involve both internal sources and sources external to the organisation. Successful searching will require knowledge of what sources are available. It will also require a tacit understanding of what one is looking for. Often the criteria for a search are difficult to articulate. The use of keywords may exclude some vital and unexpected sources. A key element in successful searching may be the provision of a variety of sources of relevance to the individual. Information sources such as the Internet provide variety, but the lack of screening of irrelevant information produces an information overload and reduces the value of the search task. Serendipity may play a role in the discovery of useful information sources.

Information Selection. Selection of relevant information from a sea of information noise is the second important activity. Information may be selected on the basis of relevance, but may later be found to be irrelevant when interpreted. Of equal importance is the process of discarding information. Learning will occur through the rejection of some information in favour of other information. Level of detail will also vary. Often summary data will be of more value than detailed figures. It should be noted that the information selected will be in a variety of forms. It may be numerical, text, graphics or video.

Information interpretation. For learning to take place, information gathered must be incorporated into the individual's mental model. It is at this point that information can be transformed into knowledge. Information from varied sources will be combined to form new sources tailored to the individual. Information may be summarised or restated in a way that places the individuals interpretation on it. New ideas may be layered on existing sources. Furthermore generalisation will occur, drawing out new concepts from the different sources which can then be applied in new domains (Nonaka, 1994). Links will be established between different sources. Through these links concepts and themes of value to the individual are established. The addition of the individuals ideas and personal knowledge creates new knowledge and may lead to its exploitation in new products, process or behaviour. It is important to recognise that the processes by which the information is recombined, restated and linked into new concepts is of values it itself and should be recorded to form part of the new information base.

Information Storage. Information interpreted, combined and reformulated must be stored in structures that enable its easy recall and review during subsequent searches and when action is taken. Information storage is also important to support its transmission to other members of the organisation. Storage enables concepts and links to be revisited after a period of reflection and changes made in the light of further individual learning.

The structures used for representing individual knowledge may be judged on their ability to simplify the information, generate new propositions and increase the manipulability of the

body of knowledge (Bruner, 1966). This will depend on the information structures providing optimum mode, economy and power of representation.

Mode of representation. Information or knowledge can be presented in a variety of forms. It could be represented as a set of actions appropriate for achieving a certain result, a set of summary images or graphics which stand for the concept without defining it fully, or a set of symbolic or logical propositions. The representation must be optimal not only for the type of information, but also for the individual learning. For example, a computerised procedure may be represented as a flow diagram, a set of English language instructions or a formal specification in Z. The suitability of each representation to support analysis and interpretation will depend on the knowledge background of the learner.

Economy of representation. The optimum representations are also those that minimise the amount of information that must be held in the mind to achieve comprehension. A set of journey times between towns is easier to comprehend if represented as a cyclic graph rather than an alphabetical list. Summaries are more economical than detail. Economic representations should remove noise and allow easy interpretation.

Power of representation. Powerful representations structure knowledge in such a way that new propositions or valid conclusions can be generated from it. The most powerful representation will not necessarily be the most economic. Again, power of representation will depend on the user and the match with the user's mental models.

MSSs such as Executive Information Systems (EIS) and Decision Support Systems (DSS) often provide neither economy or power. Modes of representation are inadequate and driven by considerations of the data rather than the user. EIS, for example, are often singularly unsuited to executives, providing detail numerical information and expecting significant analysis effort of the part of the user. Graphical and, more importantly, text-based information is ignored. Report structures are driven by existing or available data sources. Such systems are aimed at particular types of executive who are at ease with numbers and ignore the modes of learning which many executives adopt.

The functionality for a MSS to support organisational learning should take these issues into account. Using the four steps in individual learning discussed above, the following identifies the expected functionality of a organisational learning MSS. Information searching, selection interpretation and storage are all part of the individual learning process. The MSS should support the individual in establishing his or her own personalised information environment. The individual should be able to draw on a number of knowledge sources and link them together to create new concepts.

Functionality for MSS to support individual learning

A MSS to support individual learning within an organisations needs to address information searching, selection, interpretation and storage. Furthermore it should be tailorable to suit the information needs of the individual.

Information searching.

The MSS:

Supports searches of a variety of internal and external sources across different media including graphical, video and text;
Enables content analysis of text documents and other media such as image and voice;
Allows the search a problem space through the use of models. This may involve links to neural net or genetic algorithm-based applications;
Extracts linked data from large pools of information, whether numerical, text, image or voice. (neural net, GAs);
Offers intelligence guidance to the searcher as to useful sources and valid search paths;
Analyses and records the process by which the individual has conducted the search.

Information selection.

The MSS:

Selects and extracts data items at various levels of abstraction regardless of media;
Records the pathways by which the relevant data has been reached;
Offers intelligent advice to aid the selection of information.

Information interpretation

The MSS:

Supports the creation of dynamic links between items of information;
Enables the creation of flexible classifications of information;
Facilitates the layering of information in order to create more generalised concepts, perhaps through a hierarchical approach;
Holds to hold variants of a single information source. The requires mechanisms for version control. It enables the user to take various view of information and ask, have we looked far enough and what other solutions are there to a particular problem;
Records the process by which linking and combination of information occurs.

Information storage.

The MSS:

Generates new models based on analysis of information sources;
Structures information dynamically. This should be done easily but the resulting structure should clarify concepts;
Generate multiple representations of information and translates between representations;
Provides an intelligent assessment of the effectiveness of different modes of representation, perhaps in the form of a ‘costing’ of each representation.

Tools to support individual learning

It is not proposed that one MSS application should cover the entirety of the functionality outlined above. This would not only be impractical, but would also go against the philosophy of individual learning. Individuals should create information environments tailored to their own needs (Davenport, 1994). These individual information environments will reflect the employee's expertise and interests. Support for particular tasks may be provided. In addition, information sources should be structured in ways that suit the individual.

There is little support currently available for such tasks. Decision Support Systems are good at managing well-structured data and provide for the application of statistical and numerical analysis methods. However, they do not support the management and analysis of non-structured data very well. Nor do they support or record the process by which data is selected.

The following review some tools that may have a role in an MSS environment which supports individual learning:

Search tools and intelligent agents

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Search engines,. such as those available of the Internet provide a valuable tool for identifying relevant information. However, such searches can be long-winded and fruitless. There is a need to target information searches. Intelligent agents have been developed which, given a profile of the users interests will roam around the Internet identifying relevant documents and returning them to the user.

Data mining tools

The purpose of data mining tools is to extract new knowledge from existing data sources. Many large databases now exist with millions of records. Relationships within the data may exist which are neither immediately apparent nor easily discovered by manual searches. Data mining tools search large data sources for significant relationships. For example, in a patient database, there may be unexpected relationships between ward stays, patients history and outcomes of treatment. Within a retail database there may be relationships between purchases and timing of purchases. Men purchasing nappies in early evening also purchase beer, so the placing of the two next to each other increases sales. Tools for data mining use statistical techniques, genetic algorithms and neural networks to identify relationships (see Piatetsky-Shapiro and Frawley, 1991).
In some recent empirical studies conducted by one of the authors, suggested that some companies that recognised the importance of IS/IT to business effectiveness and competitive advantage were adopting a data warehousing approach to the recording of operational data. Some standard periodic reports were pre-defined. However, flexible multi-dimensional analysis tools provided users with relatively easy "point and click" access to the underlying data. This allowed users to mine the data of interest and perform comparative and trend analyses as and when appropriate.

Content analysis tools.

Content analysis tools enable the searching of text for phrases relating to a particular topic. They also enable the structuring of concepts. Commercial products of this kind are rare. In research, content analysis tools have been developed to support research methods. The COPE (COgnitive Policy Evaluation) software package supports the analysis of interview notes (Eden, 1988; Cropper et al, 1990). These tools support research methods such as repertory grid analysis (Hunter, 1993) and grounded theory (Rouse and Dick, 1995). Their value lies in their attempts to analysis qualitative data based on text, articles and interviews. These tools should be modified to form part of an MSS to extend the support of analysis beyond numerical and well-structured data.

Hypertext Knowledge storage environments.

The advent of the Internet and the widespread use of HTML to produce home pages offers a possible approach to the establishing of personalised information environments. The user can construct a personalised home World-Wide Web (WWW) page, reflecting a personalised view of the world. Lotus Notes offers a similar facility, where users can construct their own information bases. The use of Lotus Notes within two companies known to the authors - one a outsource provider company and the other a process control systems manufacturer - has allowed each employee to develop a personalised knowledge base. In these environments, information can be stored in a wide variety of formats, links can be established dynamically between pieces of information. Links can also be established with external sources of information without importing a copy of the data. Masaki et al (1995) discuss the idea of a hypermedia EIS in which the user constructs an interconnected web of domains of interest.

Subjective object-oriented environments.

The implementation of MSS as object-oriented systems provides advantages in terms of extendibility and reuse. For example, a customer class may be constructed which represents the data and processes (or behaviour) expected of a customer for a particular organisation. This organisation-wide view of a customer may then be used as a basis for the user to construct new sub-class which reflect his or her own interpretation of a customer. This may involve the addition of data items which are only of importance to the individual and the addition of new behaviour. This process, called subjective programming, allows individuals to construct their own view of corporate objects. The use of object-oriented systems in this way may enable individuals to surface and explore their individual theories of meaning, to recognise differences in their knowledge frames of reference and to begin to construct a shared understanding which does not consist of the lowest common denominator stored in a corporate database, but rather involves a sharing of unique understandings and an expansion of the frame of reference (Tenkasi and Boland, 1996). Typically, organisations attempt to restrain individual differences by defining a standardised set of terms which is then embedded within computerised systems. For example, the Lockheed Georgia company underwent a process of identifying a standard meaning for each important business term prior to MSS implementation (Houndeshel, 1992; Turban, 1993). In a learning organisation,

however, the rich diversity of personal views is vital in bringing variety into team-based knowledge creating activities. In this context, MSS should promote, rather than restrain, personal interpretations.

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MSS support for organisational learning

An organisation can be considered as a network of nodes. The nodes are the individuals who are acquiring, generating, accumulating and transferring knowledge. Clearly, organisational learning requires the spread of knowledge amongst the nodes. As projects develop, links are made between individuals and knowledge networks develop. these networks incorporate experts, who provide specialist knowledge to the project team. Through discussion within the team and amongst the experts, a shared understanding of a problem emerges and ideas are generated for solutions. Such knowledge networks may express emergent properties and become holistic systems in which 'the whole is greater than the sum of the parts'

Organisational learning does not involve conformity to one view, but expansion to incorporate many interpretations into a larger and richer picture of the problem. Many MSS tend to act against this process, demanding a uniform interpretation of data and a single definition of each item. Such restrictions debilitate organisational learning. MSS to support organisational learning should therefore support multiple interpretations of data. That there are different views should be made explicit so that it can lead to understanding amongst the team of the different interpretations.

A further key function of organisational learning must be to support communication. Organisational learning is established through communication of knowledge. It should be noted that communication between two individuals occurs at several levels. At its weakest, it may involve simply the exchange of explicit data. This requires little bonding or understanding between the participants, and could involve a transaction without a face-to-face meeting. Stronger bonds are formed if there is an exchange of tacit knowledge, and through dialogue, a shared understanding is achieved. This requires not only an understanding of the knowledge, but a meeting of culture values, norms and viewpoints. Communication between two individuals may range from very weak to very strong. The stronger the communication connection is, the more likely that long-lasting organisational learning will be achieved.

Communication will be influenced by cultural, political and contextual issues. If departmental barriers exist, then knowledge transfer may occur within the departments, but not between them. The fixed mental models of some individuals and the resistance to change of norms may inhibit organisational learning. Disagreements between two individuals or even dislike will reduce the quality of communication. Organisational learning will not occur efficiently knowledge transfer is inhibited for what ever reason.

Organisations may be considered as knowledge systems (Richer, 1994; McBride, 1995) in which knowledge is acquired from the environment, distributed within the organisation and used for innovation. Information systems then have a key role in transmitting the knowledge.

Information systems should be a key element in the construction of the organisation's knowledge base (Nonaka, 1994) but should also support the project layer in which self-organising project teams develop and create knowledge.

Organisational learning requires that individuals within the organisation connect and exchange knowledge. In essence the organisation knowledge framework of the organisation consists of a dynamicly connected network of knowledge nodes. MSS which support organisational learning should support and encourage the establishing of knowledge connections, and provide a means for recording the knowledge such that the organisation is less adversely affected should individuals move on. The process of organisational learning may be broken down as follows:

Establish the communication pattern. Connections must be established between individual knowledge nodes. This requires that each individual is aware of who else is around, what their interests and expertise are and how it matches to their interests and needs. The right person to answer a question needs to be found, or the person needs to be integrated into the knowledge generating team. Within a large organisations, or a virtual networks, a search for the right person may take some time. Furthermore, some obligation to provide or exchange must be established. Introna and Whiteley (1996) argue that loss of face-to-face communication creates a lower sense of obligation. Therefore the social nature of the connection between two individuals must be addressed as well an the technical connections. Users of a organisational learning MSS might have to meet each other face-to-face and establish cultural understanding before the organisational MSS can be used effectively. The use of video conferencing links may help in this regard.
Establishing the communication will involve the identification of experts and the identification of ownership of knowledge sources. This will be made easier if individuals have their own individual information environments and are using MSS support for individual learning. In a large organisations, information maps and guides may be necessary (Davenport, 1994). Information maps are computerised catalogues which direct the user to useful information nodes. Information guides are personnel who act as a first point of contact for establishing a link with an expert or someone with complementary interests. Once connections are built up a knowledge network is established around project teams, problem areas or specialist interests.

Transfer knowledge. Once a connection is established, a transfer of knowledge should occur between the knowledge nodes. Firstly, an agreed understanding of what knowledge is required must be established. This requires the opportunity for extensive question and answer sessions to establish a shared understanding of the problem or information request. Once the requirements are clear, information can then be exchanged. Finally, each participant attaches his or her own interpretation to the information that has been transferred and the process by which it has been transferred.. This will require the multiple interpretation of single facts and the externalisation, the making explicit, of different interpretations through the exchange of cognitive maps. diverse understandings will need to be represented separately, exchanged and analysed. (Tenkasi and Boland, 1996). This process will involve redundant information, perhaps both participants holding copies of data which are slightly different. In transferring knowledge, there will also be a need to establish various links within the information. Just as the individual learner established links within information, cross-links between participants in organisational learning will need to be established.

Modify personal and organisational knowledge base. The result of transfers of knowledge will be that both recipients alter their personal knowledge bases to reflect the learning and the change of viewpoint or the expanded understanding of the problem. This will require the ability to modify individual knowledge bases to show the changes, which in turn necessitates version control. however, there will also we a need to establish jointly agreed representations of the knowledge independently of the personal knowledge bases. Recording of transfers requires that both the knowledge transferred and created is stored, and the process by which the transfer is done is recorded. This is the equivalent of storing meeting notes which explain what actions were agreed and carried out and how the decision was reached. All interactions should be recorded to provide an audit trail of information requests, information exchanges and the dialogue between the participants. i.e. storage of results of knowledge change - both product and process.

Functionality of MSS to support organisational learning

It is important that in developing functionality requirements for organisational learning MSS considerable emphasis is put on the capturing of the process of organisational learning as well as the product. For example, existing data warehousing and data mining facilities rarely provide for the systematic recording of knowledge gained from analyses performed. Furthermore, the analysis processes themselves are rarely captured. They remain with the individual rather than being used to inform others. Over time, they may be forgotten, simplified and altered.

Establishing the communication pattern

The MSS:

Records the interests of the user and generates advice on who to contact with a particular problem;
Records who owns what information;
Records all steps by which contact is made with an information provider;
Provides integrated video-conferencing facilities;
Provides catalogues or information maps which indicate the contents of personal information environments within the organisation;
Record links and generates dynamic maps of connection between knowledge nodes.

Transferring knowledge

The MSS:

Enables links to be established by participants between their individual knowledge bases;
Supports the development of joint cognitive maps;
Enables multiple interpretations to be recorded in individual knowledge bases and in a joint organisational knowledge base;
Supports the review and recording of the knowledge-generating or learning process;
Enables the modelling of large problems and the simulation of change over time.

Modifying knowledge bases

The MSS:

Enable the recording of jointly agreed interpretations of knowledge in a shared location;
Records audit trails of information and message exchange between participants;
Supports version control of both individual and organisational knowledge bases.

Tools to support organisational learning

Organisational Memory Systems

MSS should enable past experiences and operations to be recorded and analysed using flexible tools. Earl (1994) suggests that all types of computerised systems contain knowledge sources, either potential or actual. He cites examples of how the recording of previous actions at Shorko Films together with flexible analysis tools, skilled users and the right business culture allowed the company to use process knowledge to enhance production activities.
An organisational memory system is an information system that stores information from the organisation's collective history that can be brought to bear on current decisions (Walsh and Ungson, 1990). These systems attempt to store process information concerning, for example, meetings and email exchanges as well as domain knowledge to support the organisation's tasks. Some attempt to store more informal knowledge and to identify experts. For example, the word-of-mouth emulator (Harvey et al, 1996) allows users to register interests and expertise. This data is used to identify links between experts within a chemical company through the analysis of on-line laboratory notebooks. While organisational memory systems meet some of the criteria of an organisational learning MSS, the forms of data they use can tend to be restricted. To able to manage the rich variety of organisational data, relationships, insights and processes, support systems need to be more free form in nature.

Cognitive mapping tools

Cognitive mapping tools enable knowledge representations to be built up by users. COPE was mentioned in the context of individual learning, but these systems should also enable the sharing of ideas and the establishing of organisational learning. These systems enable knowledge maps which reflect users unique understandings to be built up. Ideally they should enable diverse understandings to be represented separately. SPIDER uses a hyperlink environment to develop cognitive maps. Links to spreadsheets, graphs or text are used so that underlying assumptions can be revealed layer by layer (Boland et al, 1994). As such, SPIDER meets the important organisational learning MSS criteria of supporting multiple interpretations of information.

Group Decision Support Systems

Description of GDSSs. Extent to which they support the criteria of an organisational learning MSS, and the extent to which they don't, including ...
While GDSS capture information exchanges between individuals, they do not record or analysis the processes leading to information exchange. For example, a leading group decision making support package allows the minutes of any meeting to be output as a text file. However, there is no in-built capability for capturing the meeting processes undertaken and any intermediate outcomes in a form amenable to subsequent analysis. As a result, employees cannot review the decision stages and processes adopted by others. Previous meeting processes cannot be analysed against member satisfaction ratings and other measures of meeting quality. The most commonly used techniques and the variability of techniques employed with company meetings cannot be analysed

Intranets

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A hyper-media environment allows different media objects to be captured, linked, analysed and used. This may provide a basis for a free form organisational memory support system. A simple object may be a text file. A more complex object could comprise a series of video clips which capture an organisational process. An even more complex object could be a knowledge-based system which, including video and sound for example, illustrating a plant fault, its diagnosis, causes and rectification.
Organisations with Intranets, in which each employee has an individual home page, reflecting their particular interests and tasks, may find that organisational learning can be better supported.

Summary and Conclusions

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