

Potential Roles for Performance Support Tools in Electronic Learning Systems

Faculty of Economics
VŠB-Technical University
of Ostrava

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Philip Barker

University of Teesside, United Kingdom
P.G.Barker@tees.ac.uk

***Abstract:** Educational systems provide a vital resource that enable people to acquire the skills, knowledge and understanding that they need in order to conduct their lives. Increasingly, computer-based performance-support tools are being used in various ways in order to augment conventional educational provision. This paper discusses the fundamental nature of electronic performance-support tools and outlines how they can be used to enhance the educational opportunities that can be made available to their users. A short case study is presented which illustrates how the principles of performance support can be used to design tools to support the processes involved in personal digital knowledge management as part of a scheme to support online learning activities.*

1 Introduction

In his seminal work relating to establishing our current understanding of the underlying theory of ‘systems’, Checkland (1972; 2001) categorised such entities into five basic types. His important classes were: natural systems, transcendental systems, *human-activity systems*, designed physical systems and designed abstract systems. The two latter categories are important because they are each needed, to varying extents, for supporting the ‘activities’ involved within any given human-activity system.

In order to illustrate the interplay that exists between the different types of system mentioned above, consider the activity that is involved when two people communicate with each other. In an un-mediated face-to-face conversation, some form of language acts as a designed abstract system to facilitate the exchange of messages and ideas. However, in a technology-mediated conversation (say, using a mobile phone) the telephone (and its supporting infrastructure) act as a designed physical system while the spoken utterances and text messaging that can occur constitute designed abstract linguistic systems. In this situation, both the designed physical and the designed abstract systems are needed to facilitate the human activity that is involved in communicating by means of a mobile phone. Of course, in this example, the humans that are involved in the communication process form part of a natural system and, prior to the time of Alexander Graham Bell, a (mobile) telephone would have been an example of a transcendental system - that is, a system that was then beyond people’s present state of knowledge.

Of course, a mobile phone (as described above) is an excellent example of a *performance-support tool* because it allows its user to project his/her voice far beyond the proximal limits of the specific location at which its user happens to reside. Furthermore, the portability of this type of device ensures that it is always available when its user needs it - unlike a conventional phone. Naturally, this assumes that there is an appropriate service infrastructure (in terms of signal coverage) available to

facilitate the use of the mobile device. Undoubtedly, the two affordances outlined above (voice projection capability and device portability) explain, in part, why mobile phones have become so popular. Increasingly, the attractiveness of different types of mobile phone is strongly influenced by the range and nature of the various types of performance-support services that they can provide - such as *Google Maps* and satellite-navigation facilities. In addition, of course, mobile phones (and other types of portable device) can also be used to support various types of learning process (Barker, 2009a; 2009b) - as is discussed below.

It is within the area of human-activity systems that our work on electronic performance support is rooted. Human activity is fundamental to human existence. An important aspect of this existence is the *learning activities* that individuals use in order to build knowledge and skill banks that will facilitate their survival within an uncertain and unforeseeable future. The importance of learning is reflected in the prelude to a recently published book (Barker and van Schaik, 2009) where one of the authors writes:

*Every 'encounter' is a learning event.
Sometimes we learn something new.
Sometimes we change our beliefs about what we think we know.
Oftentimes we realise how little we really know.*

*Learning is fundamental to everything that we do.
It is as ubiquitous as the air that surrounds us.
It is a powerful agent for change.
It offers a mechanism for personal and social empowerment.*

*Learning is also important because:
If we know something, we can always know it better,
If we understand something, we can always understand it better,
If we can do something, we can always do it better.*

The prelude goes on to reflect the importance of technology in relation to the design and use of performance-support interventions within the context of learning, skill enhancement and performance improvement:

*Technology, thoughtfully used, can improve people's quality of life.
Using technology we can raise the limits of what people can achieve.
We can use it to enhance the capability of experts and novices alike.
This is the fundamental rationale underlying 'performance support'.*

Finally, the prelude moves on to make a more specific reference to the burgeoning role of electronic performance-support technology:

*Electronic technology provides us with many new horizons.
Each new generation extends the capability of what went before.
Digital technologies provide many possibilities for performance support.*

The role of technology in many human-activity systems is so ‘fundamental’ that people often do not even think about it. Consider, for example, the process of writing. How could someone write anything (that has a lasting physical existence) without the aid of some form of ‘*marking*’ technology (such as ink), a ‘*scribing*’ technology (for example, a quill, pen or hammer/chisel) and a ‘*recording*’ technology (such as paper, stone or wood)? Although it would be possible for someone to write symbols on a sandy beach using his/her finger (this would constitute an unaided writing activity), it is unlikely that these symbols would not be destroyed by the natural forces (rain, wind, waves) to which they would undoubtedly be subjected. Nowadays, the human activity of writing (of necessity) is therefore a technology-enabled process. Of course, depending upon the type of technology that people employ, writing can be *automated* to various extents (for example, by using macro facilities within a word-processor) and *improved* in a variety of different ways - for example, by changing its grammar, style, spelling and appearance.

Because of its growing importance within the sphere of learning and teaching, the remainder of this paper, discusses how different forms of digital technology can be used to create performance support tools for use in educational settings. However, before addressing this issue it is important to consider the underlying theory upon which electronic performance support and human performance technology are based.

2 Theoretical Basis

As a subject of study, human performance technology (HPT) covers a wide range of interests and disciplines. Writing in Pershing (2006; p. xviii), Stolovitch and Keeps suggest that ‘*the key mission of HPT is the leverage of human capital in the most efficient manner to achieve targeted, valued results*’. They then go on to propose that the key *process* of HPT involves ‘*the engineering of valued and effective individual and organisational performance based on systemic, systematic and scientific principles and demonstrated through credible measures*’. Neither of these statements makes any explicit mention of any particular type of technology that should be used to achieve these objectives; designers must therefore choose the most appropriate one(s) for the performance problem they happen to be addressing. Pershing himself later defines HPT as: ‘*Human performance technology is the study and ethical practice of improving productivity in organisations by designing and developing effective interventions that are results-orientated, comprehensive, and systemic*’ (p. 7). Again, this definition makes no explicit reference to the use of any specific technology. Furthermore, unlike Stolovitch and Keeps, Pershing does not consider the possibility that HPT can be used to enhance the performance of individuals - his perspective is essentially one of improving organisational performance. Despite their minor differences, the definitions provided by Stolovitch and Keeps and Pershing are both in accord with the fundamental view that was expressed in the previous section - that is, that people build abstract and physical systems in a holistic way in order to achieve measurable improvements in human ability and performance.

Human-activity systems in which some form of technology is used to augment and improve human performance are often referred to as *technology-enhanced* or *technology-aided* human performance systems. Because of their importance in relation to empowering students’ learning, these are the types of system with which this paper is

primarily concerned. The various sub-systems that make up a typical system of this sort, and the relationship between them, are depicted schematically in Figure 1.

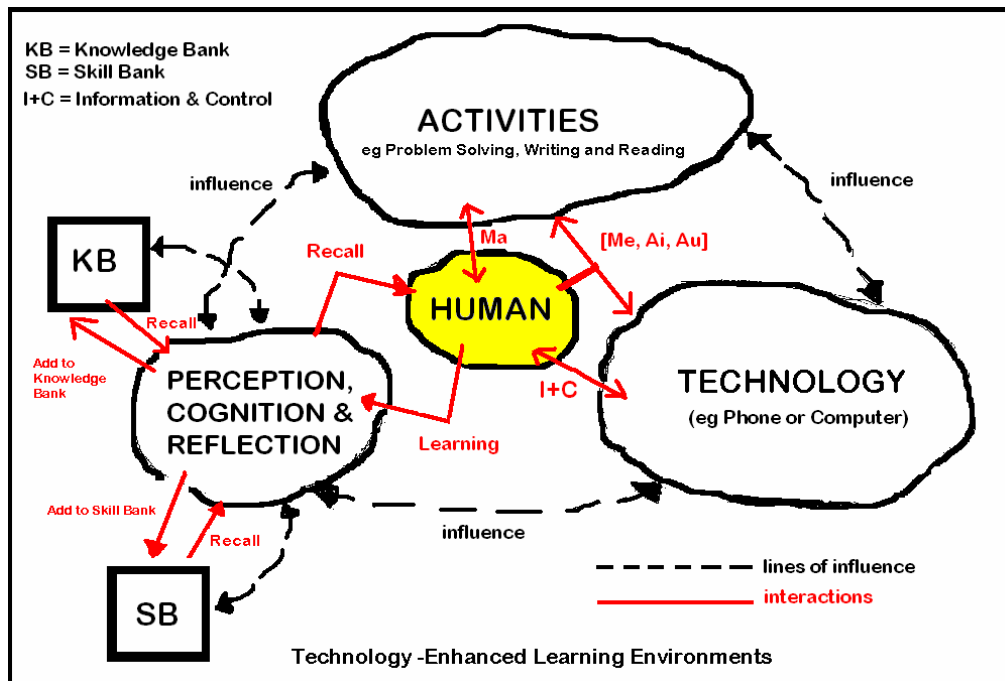


Figure 1: Rationale for technology-enhanced learning environments.

This diagram reflects the inter-play that exists between human mental processes (perception, cognition and reflection), the activities in which a person becomes involved and the technology that is used to support these activities. There are two important types of arrow contained in this diagram: broken-line arrows which denote various 'lines of influence'; and solid-line arrows - which identify different kinds of 'interaction' between the different system components that they inter-connect. Lines of influence are important because they reflect how one system component influences another. For example, the activities in which a person participates will influence the knowledge and skill that an individual develops. Similarly, the nature of the skills and knowledge that a person has will influence his/her ability to perform the activities in which he/she participates.

It is important to remember that the activities component shown in Figure 1 does not consist of a totally random collection of specific activities that an individual, group or organisation will undertake. Most activities are purposeful and are based on the 'demands' placed on the individual(s) involved in any given situation. More usually, particular individual activities will be grouped into meaningful 'activity sets' that reflect the goals and objectives that an individual, group or organisation needs to realise. Naturally, the nature of the available technology (in any given situation) will influence the characteristics of an activity (consider the writing example given earlier) while the technological requirements of an activity will influence how future technology is designed, developed and used.

Although lines of influence (as depicted in Figure 1) are important for understanding the relationships that exist in a human-activity system, the nature of the behaviour that a system component exhibits (at a more pragmatic level) is determined by the types of

component-level interaction that take place between the different system components. In Figure 1, the interaction labelled 'Ma' denotes the manual execution of an activity. Technology to support this activity may exist but the human component of the system may choose not to use it. Alternatively, the technology that is available may be too expensive to apply within the context wherein manual execution of the activity is being deployed. When technology is involved in the processes that make up a human-activity system, it can usually be employed in a variety of different ways and to different extents. Within Figure 1, the interaction that is labelled [Ai, Me, Au] denotes three possibilities: Ai denotes an 'aiding' situation (one particular example of which is mechanisation - denoted by the label 'Me'). Another, more powerful possibility is the use of automation - denoted by the label 'Au'. The rationale underlying the use of process automation is based on the principle of minimising the extent of human involvement in a process. Of course, the use of technology for process automation within a human-activity system creates an interesting paradox from the perspective of skill and knowledge acquisition. This paradox introduces some important educational and ethical questions in relation to de-skilling and re-skilling processes.

Naturally, an important consequence of the use of technology in a human-activity system is the need for the human component to interact with the technology for the purpose of gleaning information about and controlling the progress of what is happening - this is denoted by the label 'I+C' in Figure 1. A good example of this situation is one in which an aircraft pilot looks at the altitude and speed gauges in his/her cockpit display panel and then makes changes to the aeroplane's height and speed (through the use of appropriate controls) to meet the needs of the moment.

Two important pedagogic components depicted in Figure 1 are the *skill bank* (**SB**) and the *knowledge bank* (**KB**). These were briefly mentioned earlier in the previous section as being important in relation to learning activities and problem-solving strategies. Naturally, the human processes of cognition, perception and reflection will strongly influence the contents of these two resource banks. These processes will also influence how they (**KB** and **SB**) will be utilised within the context of problem-solving processes (Barker, 2008a; 2008b). Of course, problem solving is one generic type of activity that all humans become involved in during their life times.

An important implication arising from Figure 1 is the fact that the support technology available to a problem solver will strongly influence the nature of the activities that he/she becomes involved in. The nature of this technology will also influence the nature of the cognitive and perceptual processes that are activated in any given context and, subsequently, the contents of the skill and knowledge banks. Increasingly, digital technologies are becoming more widespread within the context of education (Laurillard, 2008; Gourley, 2008). It is this area with which the remainder of this paper deals.

As was mentioned above, digital technologies are playing an increasing and important part in relation to the realisation of the underlying goals of performance support - as described by Pershing (2006). The modern-day practice of electronic performance support is, to a large extent, based on the early foundation work of Gery (1989), Banerji (1995) and, more recently, that of Barker and van Schaik (2009). As was suggested in the previous section of this paper, performance-support interventions are examples of either designed abstract or designed physical systems that are intended to facilitate and/or augment some form of human activity.

Bearing in mind the relationships depicted in Figure 1, it is easy to understand why the theory and practice of performance support is perfectly generic. In his recent research, Banerji (2009) has therefore referred to the concept of a ‘unified model of electronic performance support’. This model recognises the importance of human-computer interaction within the context of using digital technologies for the creation of performance interventions. A general representation of this model is presented in Figure 2.

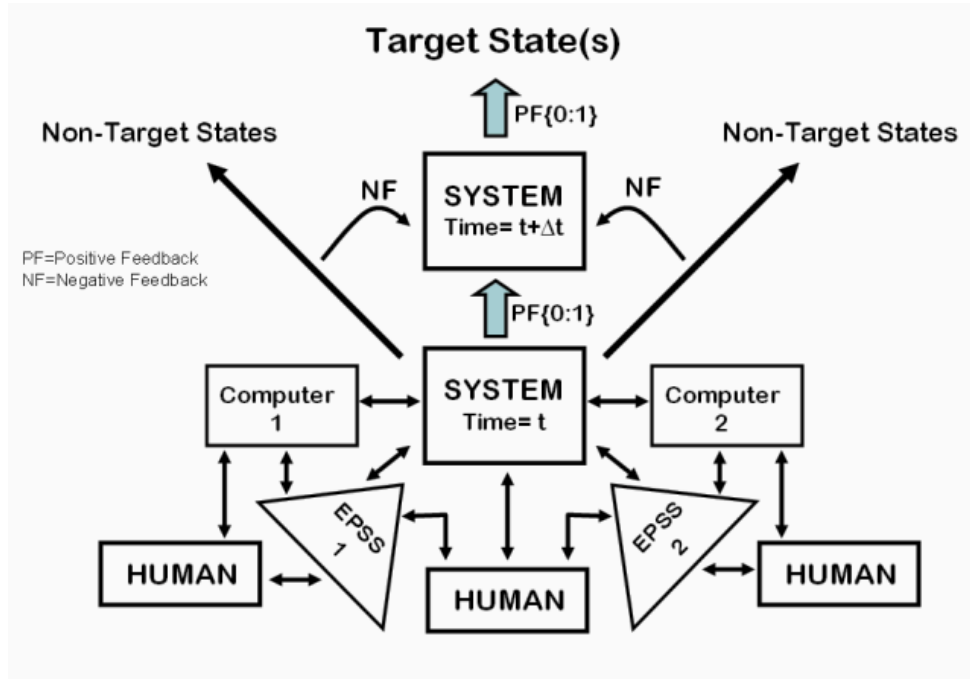


Figure 2: Human activity and the unified model of EPSS.

This diagram depicts how a combination of human and electronic (performance support) resources can be used to ‘steer’ the progress of a human activity towards the realisation of some sort-after state - be this a learning process, a manufacturing process, a management process or any other type of process. In this diagram, the system navigation that is inherent in the movement between states within the state space is achieved through the judicious application of positive and negative feedback - denoted by PF and NF in Figure 2.

3 The Scope of Performance Support

As was discussed in the previous section, the scope of performance support (in general) and electronic performance support (in particular) is perfectly generic and can, in principle, be applied to any subject, discipline or activity. Table 5.1 lists some examples of generic educational human activities to which the principles described in the previous section have been applied (Barker and van Schaik, 2009). In reality, like problem solving, each of the activities listed in this table is an example of a meta-activity - which is why they are so powerful. As suggested in Figure 2, in its most general sense the role of an EPSS facility is essentially one of steering a human-activity process towards an optimal outcome - bearing in mind the various factors that can influence that outcome. This requirement is depicted schematically in Figure 3.

Within Figure 3, acceptable outcome states are shown collectively within an elliptical containing boundary. Any system state that does not reside within this area is deemed to be an unacceptable state. The different states within the ellipse reflect different ‘quality of solution’ outcomes for the transition that has taken place in moving from the state $S(t)$ to the state $S(t+\Delta t)$ within the state space for the activity in question.

Much of our recent work into EPSS applications has been focussed on two types of human activity related to ‘*accessing information and knowledge*’ and ‘*managing collections of digital information and knowledge*’ (see Table 1) Our *Epsilon* research project has been addressing issues relating to the first of these areas (Famakinwa, 2009; van Schaik et al, 2002; 2006; 2007). The second area is being explored in our ‘*Digital Knowledge Management for All*’ initiative that is briefly described in the case study that is presented in the following section (Barker, 2009c).

Table 1: Examples of Generic Educational Activities

observing
measuring
analysing
reading
speaking
writing, drawing, presenting and publishing
designing
calculating
deciding
simulating
gaming
constructing
manipulating
researching
accessing information and knowledge
managing collections of information and knowledge
interacting and collaborating with peers
sharing resources

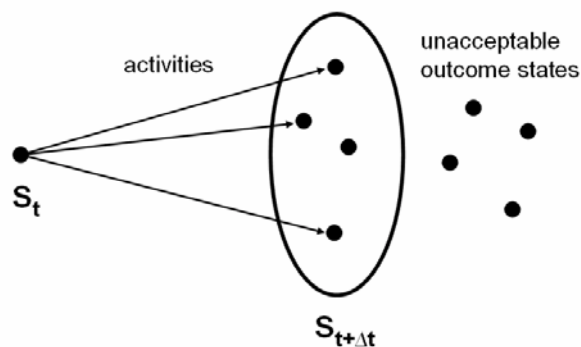


Figure 3: State navigation within the state space for an activity.

4 Case Study - an EPSS for Digital Knowledge Management

As the availability of low-cost computers, portable digital storage and Internet access becomes more widespread, there is likely to become a growing need for ‘easy to use’ mechanisms, strategies and procedures to achieve the facile storage and management of personal collections of digital data, information and knowledge. This requirement will become even more important as many aspects of everyday life (such as shopping, health-care, entertainment, commerce and education) take advantage of the many benefits associated with the use of global digital communication and its associated support technologies.

One approach to achieving the above requirement is through the use of webs, wikis and weblogs as extensions of the human mind (Barker, 2008a; 2008b). Software of this type can be used in an effective way to model human knowledge. Such software can also be employed both in a private and in a public context in order to store and, when it is appropriate, share digital knowledge with colleagues and organisations that need to have access to it. Of course, the sharing of knowledge is both an important and a fundamental aspect of collaborative problem solving activity. It is also a pre-requisite for success within virtually all knowledge-based industries.

Our work to date in the area of personal digital knowledge management (DKM) has been based on the use of three underlying components. First, a digital object repository in which collections of primitive digital knowledge objects are stored; second, a knowledge management tool based on the use of a low-cost open-source wiki engine; and third, an electronic performance support system that is intended to help people understand and use digital toolsets to facilitate and realise their personal knowledge management requirements. Using these components, a range of mechanisms and procedures has been devised in order to facilitate the development of personal digital knowledge management tools for use in a number of different application areas. Considerable emphasis has been given to portability issues so that access to knowledge resources can be achieved in an ‘on demand’ fashion - in any place at any time - using whatever computing resources are to hand (a desktop computer, a laptop, a pocket PC, a PDA, a mobile phone, and so on).

The underlying logistical architecture of the DKM system is depicted schematically in Figure 4 (Barker, 2008c). This shows the important relationships that exist between the underlying digital object repository and the object management system. An important aspect of this latter system is the allocation of a unique *digital object identifier* (DOI) to each item that is committed to storage in the knowledge archive. Another important process that the management software handles is the allocation of user-specified *tags* and *keywords*. These are used in conjunction with an object’s DOI in order to facilitate the retrieval of a particular knowledge object (or a cluster of relevant objects) from within the digital archive.

A screen dump showing the main page of the EPSS component of the DKM system is presented in Figure 5 (Barker, 2009c). As was mentioned above, the digital knowledge management system is based upon the underlying use of a digital object repository containing collections of *simple* items of knowledge/information (these are referred to as ‘**nuggets**’ in Figure 5) and more *complex* ‘**aggregate**’ objects.

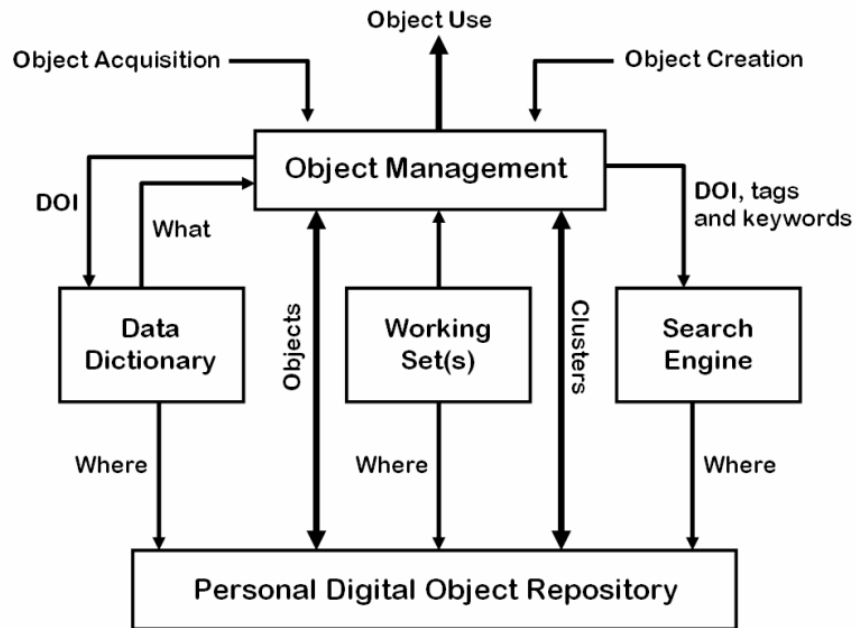


Figure 4: Underlying architecture of the DKM system

Knowledge aggregates are essentially collections of nuggets that have been clustered together (using, for example, hyper-linking techniques) in order to create richer knowledge objects. Of course, nuggets and aggregates will most often be embedded within some parent **domain** (or **sub-domain**) that provides both a semantic and logistical framework for its contained objects. For example, in a tele-shopping situation, a user of our system might create a number of different domains to represent the various types of shopping that he/she undertakes - such as a domain called *Groceries* or a domain called *Electronic-Gadgets*. Within these broad domains, particular organisations at which the user shops may be represented as a collection of sub-domains - for example, *Groceries*{*Tesco*, *Wal-Mart*, *Sainsbury*}.

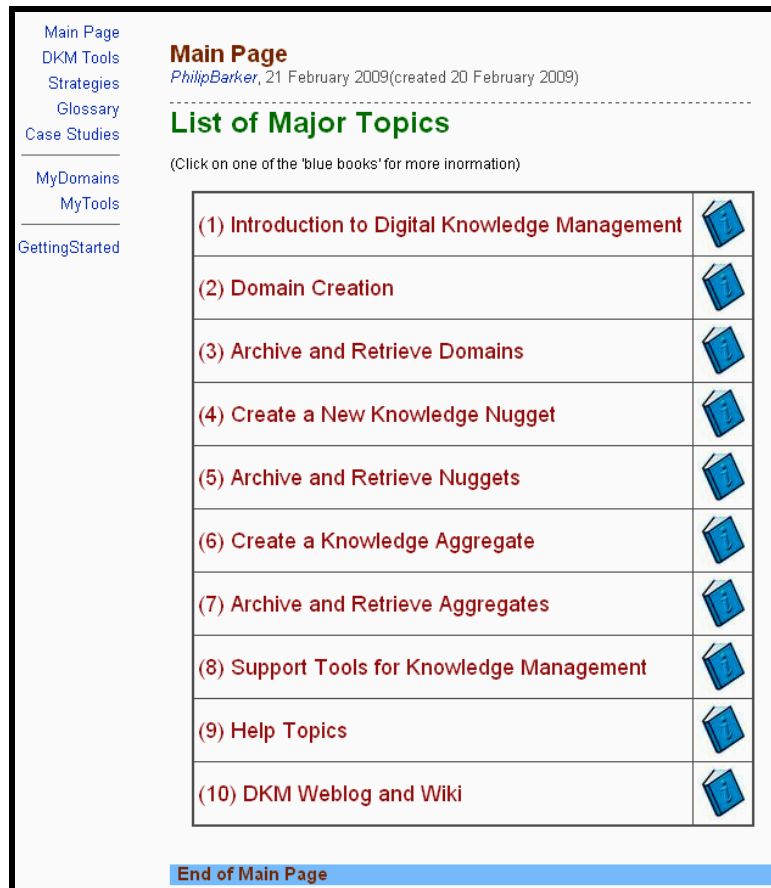


Figure 5: Opening screen of the EPSS for DKM

Each domain or sub-domain that a user creates would consist of a relevant collection of knowledge nuggets and aggregates that reflect that user's involvement with the organisation concerned (or, more generally, with an event or artefact that forms part of that user's span of interests). For example, embedded within a domain relating to a tele-shopping organisation (X), there might be an image of a company logo (a nugget) that might be used as a reactive icon within the user's graphical user interface to the DKM system. Similarly, organisational details such as web address, telephone number and online logon details might form part of a knowledge aggregate relating to organisation X. Details of the orders placed with company X would also be represented as an aggregate of nuggets - each nugget representing a purchasing transaction.

In order to support the e-learning activities involved in using the DKM EPPS depicted in Figure 5, a collection of 'wizards' is provided which can be used to help people undertake the basic operations involved in using it. These are augmented by an online electronic reference book that can be used as a source of instruction on the system and how to use it.

5 Conclusion

Laurillard (2008) has described the importance of digital technologies in relation to the realisation of educational objectives within nations, societies and individuals. Within this context, my own particular specialism is the application of electronic performance

support concepts for the support of educational activities. This involves two major initiatives based on the techniques and technologies that have been described earlier in this paper. First, their application for the support of teaching and learning processes; and second, their use for the creation of effective infrastructures to facilitate the activities that are involved in these processes. From an individual's perspective, education is primarily concerned with acquiring knowledge and skills - and using these to solve problems of various sorts. Inherent in this is the need to communicate and to share ideas and resources that facilitate learning. Increasingly, people will also need to remember more; they will need to collect, archive, organise and manage collections of digital objects that facilitate what they do and how they learn. Because learning never ends and never stops, my vision of the future for electronic performance support in education will be its use for the provision of electronic tools that will enable individuals to overcome the limitations of the human mind in relation to coping with increasing knowledge demands for solving different types of problem - either on a day-to-day or a long-term basis. As has been discussed elsewhere (Barker 2008a, 2008b, 2009c), this will involve the development of performance support and enhancement aids that will enable people to organise, manage, share and use their own personal digital object repositories in flexible ways to build knowledge structures that reflect the activities in which they are involved and in which they wish to participate.

References

1. Banerji, A., (1995). *Designing Electronic Performance Support Systems*, unpublished PhD thesis. Middlesbrough, UK: University of Teesside.
2. Banerji, A., (2009). Science and Engineering, Chapter 10 in Barker, P.G. and van Schaik, P., (Eds), *Electronic Performance Support: Using Digital Technology to Enhance Human Ability*, London: Gower Publishing.
3. Barker, P.G., (2008a). Using Weblogs and Wikis to Enhance Human Performance. In Bonk, C.J., Lee, M.M. and Reynolds, T. (Eds), *Proceedings of the E-Learn 2008 World Conference on Electronic Learning in Corporate, Government, Healthcare & Higher Education* (pp 581-588), Las Vegas, Nevada, USA. Chesapeake, VA: Association for the Advancement of Computing in Education.
4. Barker, P.G., (2008b). Using Wikis for Knowledge Management. In Luca, J. and Weippl, E.R.(Eds), *Proceedings of the ED-MEDIA 2008 World Conference on Educational Multimedia, Hypermedia and Telecommunications* (pp 3604-3613), Vienna, Austria. Chesapeake, VA: Association for the Advancement of Computing in Education.
5. Barker, P.G., (2008c). Blended Electronic Learning - Managing the Blend. In Miller, H.J. and Jefferies, A.L. (Eds), *Proceedings of the Third International Blended Learning Conference - 'Enhancing the Student Experience'* (pp 45-53), 18-19 June 2008. Hatfield, UK: University of Hertfordshire.
6. Barker, P.G., (2009a). Using Mobile Technology to Support Learning. In Fulford, C. and Siemens, G. (Eds), *Proceedings of the ED-MEDIA 2009 World Conference on Educational Multimedia, Hypermedia & Telecommunications* (pp 1426-1431), Honolulu, Hawaii, USA. Chesapeake, VA: Association for the Advancement of Computing in Education. Available online at: <http://www.philip-barker.info/EDMEDIA2009/Paper.pdf>.
7. Barker, P.G., (2009b). Mobile Blended Learning. Paper to appear in *Proceedings of the 4th International Blended Learning Conference - Engaging Students in the Curriculum'*. Hatfield, UK: University of Hertfordshire.

8. Barker, P.G. (2009c). *Digital Knowledge Management for All*. Workshop and Lecture specification. Available online at: <http://www.philip-barker.info/DKM-for-All/DKM-for-All.pdf>. [Accessed on 11th February, 2009.]
9. Barker, P.G. and Schaik, P. van, (2009). *Electronic Performance Support: Using Digital Technology to Enhance Human Ability*, London: Gower Publishing.
10. Checkland, P.B., (1972). A Systems Map of the Universe. In J. Beishon and G. Peters (eds), *Systems Behaviour* (pp 50-55). London: Harper & Row Ltd.
11. Checkland, P.B., (2001). *Systems Thinking, Systems Practice*. Chichester, UK: John Wiley & Sons Ltd.
12. Famakinwa, O., (2009). *Using Electronic Performance Support Systems to Facilitate Information Access*, Draft PhD Thesis. University of Teesside: Middlesbrough, UK.
13. Gery, G. (1989). *Electronic performance support systems. How and Why to Remake the Workplace Through the Strategic Application of Technology*. Boston, MA: Weingarten Publications.
14. Gourley, B., (2008). Scholarship in the Digital Age. Council and Staff Address, 26th September, 2008. Available online at <http://stadium.open.ac.uk/berrill>. Accessed on 20th February, 2009.
15. Laurillard, D. (2008). *Digital Technologies and their role in achieving our ambitions for education*. Inaugural Lecture, 26th February, 2008. London, UK: Institute of Education, University of London.
16. Pershing, J.A., (2006). *Handbook of Performance Technology: Principles, Practices, Potential* (3rd Edition). San Francisco, CA: Pfeiffer.
17. Schaik, P. van, Barker, P. and Famakinwa, O., (2006). Potential Roles for Performance Support Tools within Library Systems. *The Electronic Library*, 24(3), 347-365.
18. Schaik, P. van, Barker, P. and Famakinwa, O. (2007). Making a Case for Using Electronic Performance Support Systems in Academic Libraries. *Journal of Interactive Learning Research*, 18 (3), 411-428.
19. Schaik, P. van, Pearson, R. and Barker, P., (2002). Designing Electronic Performance Support Systems to Support Learning, *Innovations in Education and Teaching International*, 39(4), 289-306.