ENQUIRY-BASED LEARNING USING PICTURES: THE GEOGRAPH PROJECT

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ABSTRACT
This paper discusses the rationale underlying enquiry-based learning in terms of problem-solving activity and the technical infrastructure needed to support it. Some of the issues underlying the implementation of this approach to learning are considered - giving particular emphasis to the use of interactive pictorial forms and the rich learning outcomes that can be achieved through their use. A case study is presented which illustrates some of the issues involved in using computer-based images to support interactive approaches to enquiry-based learning.

KEYWORDS
enquiry-based learning, pictures, problem solving, problem-based learning, picture pedagogy, pictorial information system, digital object repository, metadata

INTRODUCTION

All of human life, from 'cradle to grave', is beset with problems. Indeed, it is my contention that all human endeavour can be described in terms of a sequence of problems each one of which has to be solved - if this is at all possible. These problems may be small ones or significant ones - depending upon the impact that they have on the individuals, groups, communities or organisations involved. Bearing this in mind, 'problem solving' therefore needs to be considered as an important aspect of learning activity at all levels of education - both formal and informal. Fortunately, over the last decade its importance has been increasingly recognised and reflected by the growing impact that 'problem-based learning' (PBL) has had in relation to the design and implementation of modern-day curricula (Bligh, 1995; Boud and Feletti, 1997; Tan, 2004; ChanLin and Chan, 2007; Vardi and Ciccarelli, 2008). The role of problem-solving activity in relation to prior teaching and learning experiences and the development of pre-requisite skills and knowledge is depicted schematically, in a generic way, in Figure 1 (Barker, 2010a).

The diagram presented in Figure 1 is intended to depict the importance of appropriate skill and knowledge development as tools to facilitate problem-solving activity (see below). As is discussed elsewhere (Barker, 2010a), the importance of providing learning and teaching experiences that develop rich mental models is of paramount importance - as is the development of skills and techniques to manage large collections of digital information and knowledge.

Several authors have discussed the relationship between PBL and 'enquiry-based learning' (EBL) - see, for example, Price (2003) and Grandis et al (2003). In order to understand this relationship it is necessary to consider the nature of problems and the various issues involved in solving them.

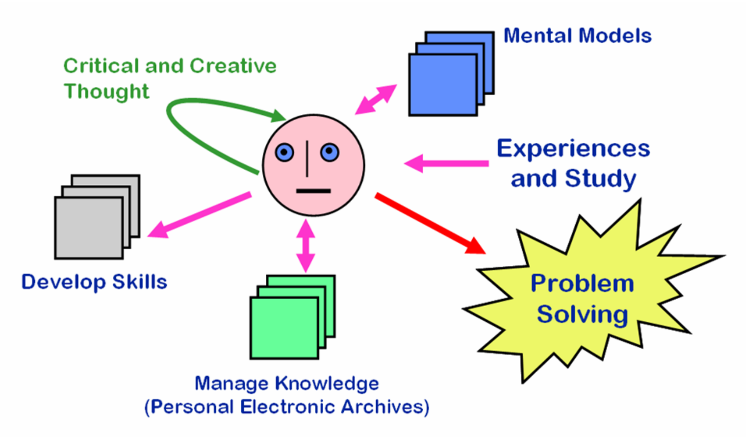

Figure 1. Problem solving as an educational resource

Naturally, the problems that humans experience arise as a result of the various endeavours in which they are involved. Most human endeavour can be thought of in terms of goal-seeking activity that involves a transition from one particular state of existence (the *initial state*) to some pre-defined or sought-after state (the *target state*). Using this simple model, a problem can now be thought of as a 'barrier' which prevents the realisation of a particular goal (or target state) that someone or something (such as a team or an organisation) wishes to achieve. The relationship between an initial state and a target state (and the barrier that exists between them) is illustrated in Figure 2.

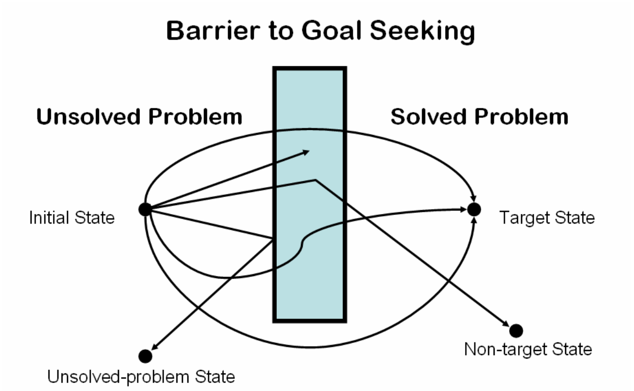

Figure 2. Barriers to goal seeking activity

In conceptual terms, the *height* of the barrier, its *thickness*, its *rigidity* and its *penetrability* determine how difficult a problem is to solve - if indeed a solution is at all feasible. Examples of solution pathways to a problem are represented in Figure 2 by different arrowed lines emanating from the initial state towards the target state. Many problems are, of course, intrinsically insoluble - as depicted by the arrow that fails to penetrate the barrier and the one that enters it but never emerges. Bearing in mind the barrier shown in Figure 2, problem-solving can now be thought of as an activity that involves finding ways by which the barrier(s) associated with a goal-seeking process can be removed, reduced or overcome.

At the very simplest of levels, problem-solving activity can be described in terms of three types of representational space: the problem space (**PS**), the problem-solving space (**PSS**) and the solution space (**SS**). The relationship between these is shown in a diagrammatic way in Figure 3. Every problem to be solved can be thought of as having a set of variants arising as a result of different assumptions, constraints, approximations or modifications that are made to it. In Figure 3, the box labelled **PS** corresponds to the representational space for a particular problem and its variants. The dotted line surrounding this box is used to represent the superset of all such problems - that is, all the problems in a particular *Universe of Discourse* that need to be solved. On the right-hand side of the diagram the solution space (**SS**) is used to represent various solutions to the problem under consideration. This space allows a variety of different solutions to co-exist - all of which may differ in various ways depending upon their quality, elegance, resource requirements and closeness of fit to the desired target state.

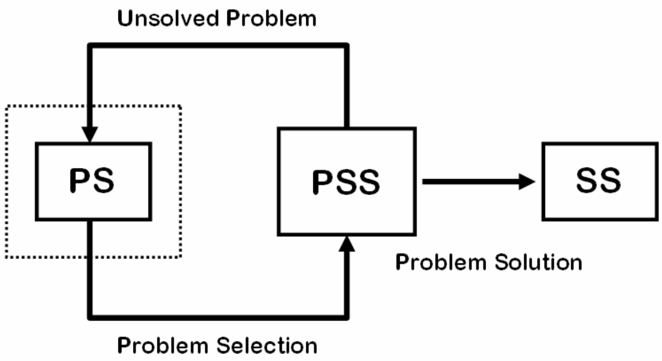

Figure 3. Representational spaces for problem solving

When comparing different approaches to solving a problem, the term 'problem solving efficacy' is often used; this refers to the nature of the constraints involved and the resources that are employed. Some important problem-solving resources are time, money, skills, knowledge and technology (Barker and van Schaik, 2010). Of course, each of these can also act as a constraint to problem solving in that any shortage of resource could influence the quality of the solution that is achieved.

The problem-solving space (**PSS**) shown in the centre of Figure 3 is used to represent the collection of states through which a problem may pass during the time it is being solved. From the perspective of enquiry-based learning, this is probably the most relevant one to consider. Its significance is therefore discussed in more detail in the following section of the paper.

ENQUIRY-BASED LEARNING

In the very simplest of terms, enquiry-based learning is concerned with 'asking questions' about a problem or issue - and then finding answers to those questions. This process of enquiry will usually involve collecting information and compiling evidence that will enable reliable decisions to be made about matters relating to the problem/issue that is the focus of the original enquiry process. Naturally, gaining access to appropriate information sources - be these human, paper-based or electronic - is therefore an important aspect of EBL. So too, is the ability to design and conduct relevant research investigations when these are appropriate.

According to Rachel Wood (2009) at the University of Birmingham in the UK, '*Enquiry-based learning (or EBL) can be described as learning that arises through a structured process of enquiry within a supportive environment, and which is designed to promote collaborative and active engagement with problems and issues'*. Three key phrases in this definition are: 'process of enquiry', 'supportive environment' and 'engagement with problems and issues'. Bearing these three requirements in mind, this section of the paper discusses the basic nature of enquiry processes in terms of problem-solving activity and the decision-making that takes place in relation to this. Subsequent sections of the paper will then discuss the nature of the supportive environments needed to realise this approach to learning and how collaboration and active engagement can be achieved.

Like many other authors - for example, Price (2003), Grandis et al (2003) and Wilkie and Burn (2003) - the position advocated in this paper is that enquiry-based learning is intimately associated with problem-solving activity and arises as a natural consequence of the questions that are usually asked when someone embarks on a problem-solving task. An important issue that therefore has to be considered in the context of enquiry-based learning is the problem of navigating through the problem-solving space (**PSS** in Figure 3) associated with any particular instance of problem solving. A generic representation of the navigation process is presented in Figure 4. In this diagram, black circles represent problem states and arrows denote transitions between particular states. Reasoned navigation through a problem space involves decision-making. The outcomes of this will depend critically on the quality and quantity of the information that is available at the time decisions have to be made.

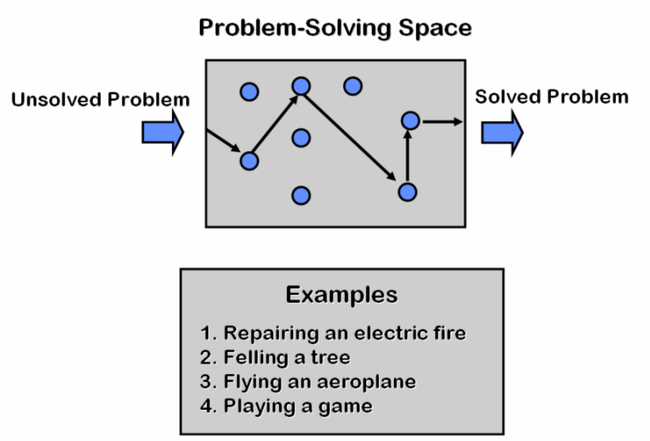

Figure 4. Navigating through a problem-solving space

Some examples of typical problems are also listed in Figure 4. Of course, each and every problem will have its own particular state space and may require different types of pre-requisite skills and knowledge to solve it. However, it is important to remember that problems can be categorised and classified into particular types and generic solutions for each category may exist. Obviously, the nature of the state space for any given problem will depend critically upon the volume and accessibility of the documented evidence, experience and knowledge that people have accumulated in relation to the problem being considered.

Essentially, navigating through a problem space such as that shown in Figure 4 will involve moving the overall solution-status from one state to another such that the transitions that are made will move this status nearer to a solution state within the **SS** domain shown in Figure 3. Naturally, navigating through a problem space like the one illustrated in Figure 4 will require important questions to be asked, each one of which will initiate a subsequent process of enquiry-based learning. Examples of the kinds of question that might be asked include:

- What type of problem is this?
- Is a solution to the problem possible?
- Does a generic solution exist?
- Is there a specific solution available?
- Can a solution pathway for a similar problem be adapted to meet the needs of the current problem?
- Where can I find information about this problem?
- Is there an expert available to ask?
- Is there a relevant community of practise to consult?
- What books/journals deal with this topic?
- What electronic sources of information are available?
- From any given problem-state, what is the next state to go to?
- How do I move the current problem-state into the next appropriate one?
- What resources are needed to achieve this?
- How close is the new problem-state to a solution state?

- If a solution is found, is it a reasonable one?
- Does a better solution exist?
- How can the quality of a given solution be assessed?
- What are the consequences of solving/not solving the problem?

The questions listed above are quite generic and will apply to a very broad range of problems. Ideally, in many practical situations, these questions would be complemented with appropriate questions that relate more specifically to the subject domain in which the problem lies - for example, physics, medicine, business, chemistry, psychology, engineering, and so on.

When using the EBL approach with students, it is very important to choose carefully the nature of the problems that are employed as a focus for learning. These must be tractable and relevant to the needs of the learning outcomes that are to be achieved. The relevance of the problems was an important factor reported by Oliver (2007) in his study of the use of EBL with large classes of first-year university students. The feedback he obtained from the students involved in the study indicated that problem selection was a fundamentally important factor both in relation to students' attitudes towards EBL and its overall effectiveness as a learning tool.

As well as giving consideration to the nature of the problems involved in using EBL, as Wood (2009) has suggested, due consideration needs to be given to the provision of an appropriate supporting infrastructure. Naturally, this should provide adequate access to information; it should also make available facilities to promote collaboration and knowledge sharing through dialogue. Interactive, networked computer technology will obviously play an important part in the realisation of this requirement. In many applications of EBL, portable mobile technology will also have a significant role to play (Barker, 2009a). Obviously, the way in which the underlying technological components are put together is only one aspect of support provision. Of equal importance is the design of the pedagogical support that is needed to utilise this approach to learning. Bearing this in mind, ample consideration should be given (when appropriate) to the roles to be played by tutors, fellow students and the target domain(s) in which the EBL problems are to be embedded. Undoubtedly, blended learning environments (Barker, 2009a; 2008; Bonk and Graham, 2005) are rapidly becoming a popular way with which to bring together the various agents and resources that are needed in order to initiate and sustain enquiry-based learning activities. Some of the ways in which this can be achieved are described in more detail later in the paper.

Having described the foundations of EBL, and described the background to this approach to learning, the remainder of this paper describes some of the blended approaches that we have been exploring for the realisation of enquiry-based learning.

USING PICTURES AS A LEARNING RESOURCE

For the majority of people, pictures play an important part in their everyday activities. Indeed, most people are continually being 'bombarded' with visual material from a wide variety of different sources. Three important categories of visual material are: first, *un-mediated* images that come from primary sources and which are processed directly by their recipient's natural (possibly augmented) visual system; second, *cognitive* (or mental) images that exist in a person's mind as a result of various thought processes; and third, *mediated* images that are derived from secondary sources (such as a television, computer screens, mobile phones, books, newspapers and magazines). Because of the importance of images in relation to survival, the human brain has developed a remarkable ability to analyse visual scenes and then extract relevant information from them.

A picture or visual scene can be thought of as a collection of objects (or picture elements) that exist within a given visual time-frame and which are arranged in either a two-dimensional or three-dimensional spatial array within a particular visual space. Given such a scene, the human brain is able to analyse it and then locate, and identify, both familiar and unfamiliar objects contained within it. The brain can also derive many of the properties of these objects (either directly or by inference) and also deduce some of the relationships that exist between them. Naturally, the efficacy with which any given individual can execute these processes will depend, to a large extent, upon that person's prior experience and his/her previous knowledge in relation to the objects that are embedded within the visual scene under consideration. Of course, within many pictures there are likely to be objects that a viewer can perceive, but yet, cannot identify, and so, learning processes will usually have to be initiated if these are to be successfully identified. In some situations, pictures might also contain 'hidden' objects; these are items whose presence is obscured by other objects or they may be items that are purposely hidden for some reason (for example, in order to facilitate a particular learning strategy involving a process of controlled revelation).

The properties and characteristics of a picture (or a collection of pictures) are often described in terms of the metadata items that are associated with them. An example of the decomposition of a picture into its component objects and some of the metadata associated with these is depicted schematically in Figure 5. The items included in this figure are intended to be illustrative rather than comprehensive.

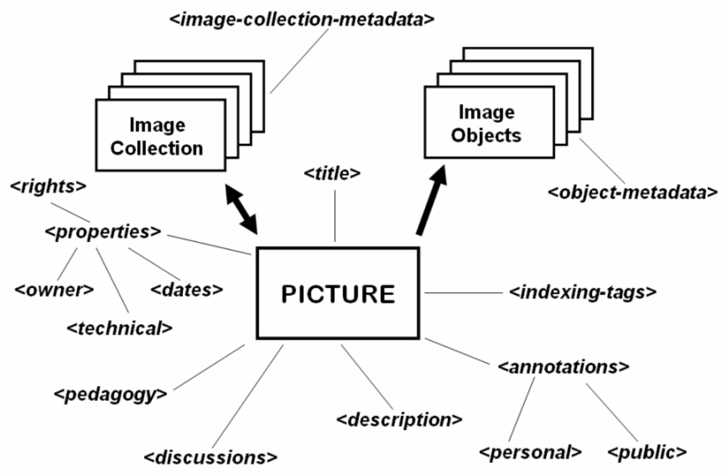

Figure 5. Characteristics of a picture and its associated metadata

Naturally, many of the items shown in Figure 5 will be important from the point of view of retrieving particular sought-after images from an image collection - be this electronic or non-electronic. For this purpose, items such as *<date>*, *<indexing-tag>* and *<accession-number>* would probably be used. Other items, for example, the *<title>*, *<keyword-descriptor>* and *<description>* may be more concerned with the semantics (or meaning) of the visual scene that the picture presents. In addition, the meaning of a picture will also depend upon the particular *<properties>* of its constituent objects and the *<relationships>* that exist between these. Metadata descriptions of images, such as those shown in Figure 5, and their related artefacts are an important issue to consider when designing interactive environments to support the use of pictures in relation to EBL. In this context, the *<pedagogy>* metadata item can be used to introduce particular types of pedagogical approach and learning schemes associated with a collection of images, an individual picture and with particular objects that are embedded within it. An simple example of a learning scenario that might be used in an EBL situation involving the use of a single picture is illustrated in Table 1.

Table 1. Simple Leaning Scenario for EBL

'I have uploaded an image to the digital object repository for the course. Its accession number is XXXXXX. Could you please have a look at this image and discuss the major issues that are implicit within it. What conclusions can you draw and what action would you take (both as individuals and as a group) in order to remedy the situation depicted in the picture?'

Of course, depending upon what learning goals are to be achieved, the pedagogy associated with an EBL learning strategy could involve the use of multiple pictures - as is illustrated in the scenario depicted in Table 2.

Table 2. EBL pedagogy involving multiple images.

'Examine the three pictures: A, B and C. What characteristics do they have in common? What are the essential differences between them? Use the annotation button underneath each picture in order to add a short textual narrative that would help someone to understand what is happening in each of these images. Your annotation should include a Web link to a relevant Internet site that gives more information relating to the issues portrayed in the three pictures that you have examined.

Of course, an important pedagogic property of pictures is the fact that the objects embedded within them can act as a visual stimulus for those who are able to perceive them. Visual stimuli provide an important motivation for the initiation of learning processes. People 'see' things in a visual space either *directly* (through their in-built biological visual system) or *indirectly* (by means of 'aided' perception - using a device such as a microscope or a telescope) and become 'curious' about the objects that they perceive in their field of view. Bearing this in mind, it becomes important to consider how pictures in the form of photographs (or indeed, any other form of imagery) can be used to facilitate learning processes. Obviously, the pedagogy of pictures depends to a large extent upon the stimulation and motivation that a learner can derive as a result of exposure to them - and, of course, the provision of a suitable learning infrastructure to support their use.

The stimulation effect of an object that is embedded within a visual scene will depend upon three important factors: the characteristics of the object itself (colour, size, shape, transience, etc); the viewing environment and mechanism by which an image is made visible; and the characteristics of the people that are able to perceive it (such as a person's interests, ability, knowledge, current situation and individual perceptual ability).

When using pictures to support enquiry-based learning, it is important to give ample consideration to the types of picture that are to be used - both in terms of their content and their behaviour. From a pedagogic perspective, images can take a variety of different forms depending upon how they are presented (for example, paper-based or screen-based) and what they are used to depict (a static scene or a time-varying scene). In this latter context, and based on their behavioural characteristics, there are two broad types of image to consider: *static* and *time-variant*. The objects that make up a static image have time-invariant properties and relationships with each other - that is, nothing in the picture ever changes. In contrast, within time-variant images, the properties and relationships of objects within a given picture (or collection of pictures) change with time. Animations and 'motion pictures' are sophisticated examples of time-variant pictorial forms.

As part of a pedagogic strategy, pictures can also be augmented in various ways with text, sound effects and reactivity. Indeed, a major attraction of electronic pictures is the fact that they can easily be made reactive through the use of embedded hotspots, action-based triggers, time-based triggers and various kinds of iconic form (Yazdani and Barker, 2000). Naturally, an attractive pedagogic feature of electronic pictures is their ability to change their size, visibility, content, position and form as a result of an end-user's interaction with them. This type of behaviour allows quite sophisticated types of pedagogic scenario to be implemented - such as exploratory learning and guided discovery-learning.

There are very many areas of discourse where the use of pictures and images of various sorts is an indispensable aspect of the teaching and learning strategies that are employed. Typical examples of such areas include art appreciation and the study of cultural works of art (such as paintings, costumes and furniture) and historical artefacts (for example, precious and valuable manuscripts, coins and weaponry) that are not available for 'first hand' inspection and examination. Other important 'visually demanding' areas of study include medicine, geography, cartography, architecture, journalism, drama, design and many branches of science and engineering. An interesting engineering example of the use of images of the 'built environment' within an electronic learning facility (the *CAL-Visual* system) has been described by Bouchlaghem et al (2002). Increasingly, pictures of many different sorts are now being used to support a wide variety of teaching and learning strategies within many different disciplines.

When using substantially large collections of images to support learning processes (in general) and enquiry-based learning (in particular), a useful approach to adopt is one which involves the creation and use of a 'pictorial information system' based on the use of a digital object repository or image archive. Such an approach is illustrated schematically in Figure 6.

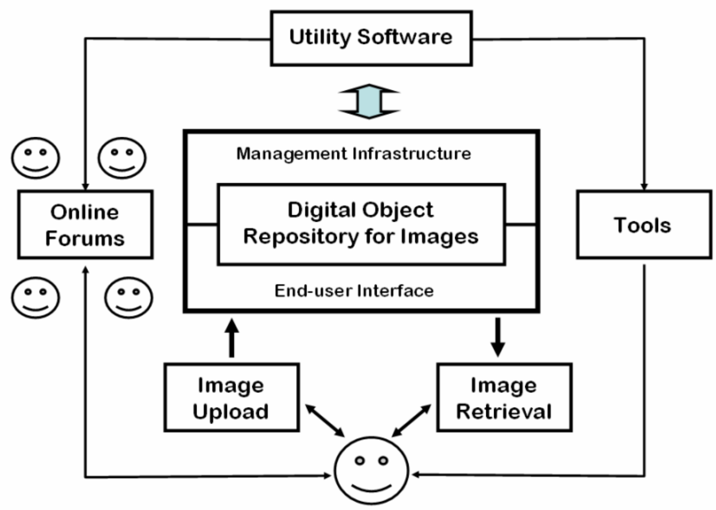

Figure 6. Pictorial information system to support enquiry-based learning

A basic pictorial information system similar to that depicted in Figure 6 will normally provide facilities for storing pictures and then subsequently retrieving them as and when they are required. Such a system would also provide appropriate mechanisms for adding any ancillary data associated with the pictures - such as the metadata items previously illustrated in Figure 5. The upload, retrieval and augmentation processes inherent in Figure 6 would normally be accomplished by means of the system's end-user interface.

When retrieving images from the digital object repository it would normally be possible to achieve this in two basic ways: first, by using the system's end-user interface in order to view pictures directly on a screen (or as a print-out); and second, by incorporating them into some other application package such as a custom-built CAL program or an online tutorial involving an application such as Microsoft's *PowerPoint*. In order to facilitate the latter approach, an application program interface (API) would normally be made available to facilitate this type of third-party development process.

An important part of the digital object repository for images depicted in Figure 6 is its search engine which, when given details of particular sought-after pictures, will retrieve those that match the specified search criteria. The way in which the search engine is designed will depend to a large extent upon the nature of the application that will use the image store. The metadata associated with an image collection will also strongly influence the design of the retrieval engine and how images are retrieved.

A basic pictorial information system can provide a useful infrastructure for managing visual resources for use in enquiry-based learning. However, the nature and quality of learning that takes place will depend critically upon the pedagogic support infrastructure that is used to augment the underlying image storage/retrieval facility. Appropriate tools (both generic and subject specific) therefore need to be provided in order to facilitate image manipulation and analysis and the provision of ancillary information to augment the pictures that are used in any given learning scenario. Communication tools (such as electronic mail, online conferencing and interactive chat facilities) are an important class of tool that should be provided in order to facilitate knowledge/information exchange between the members of a particular group of people or a given community of practice. For example, a team of students may wish to 'talk' electronically about a particular picture or group of pictures that are relevant to solving a particular problem that they are trying to solve.

Naturally, when using a resource such as that depicted in Figure 6, it will usually be necessary to consider the 'pedagogy of pictures' - that is, the way in which the pictorial resources can be used in order to 'seed', generate and sustain learning activities. Some simple examples of EBL strategies involving pictures are listed in Table 3.

Table 3. Examples of typical EBL strategies for using pictures

- Require an individual or a group of people to identify and discuss the objects in a picture.
- Ask an individual or a group of people to compare two images for similarities and differences
- Ask an individual or a group of people to find images containing particular artefacts.
- Find a collection of images to reflect a particular theme such as churches, bridges, rivers, and so on.
- Find an image to illustrate a particular point in a written report or essay.
- Prepare a *PowerPoint* presentation for a talk on a particular topic.
- Find images that support a particular argument.
- Find images that refute a particular argument.

Naturally, the types of learning strategy listed in Table 3 would need to be augmented with appropriate subject-specific enquiries and would require that learners had been exposed to an appropriate course of instruction on information literacy (Hepworth and Walton, 2009).

USING MAPS AND PHOTOGRAPHS

Two very important types of visual resource that are often utilised by and stored within a pictorial information system are *maps* and *photographs*. These often form the basis for quite sophisticated 'geographical' information systems. These resources can also be used to create personal information systems in which a *map* is used as the navigational tool that is used to access a collection of *pictorial representations* of an individual's visual experiences - such as sketches, diagrams, pictures, scans and, of course, photographic collections.

Maps are important because they can provide a navigational aid to facilitate accessing objects within a particular domain of discourse. Although it can have different meanings, the term 'map' is often used to convey the concept of 'a spatial representation of objects in a particular domain and the relationships that exist between them'. A *concept map*, for example, is used within an epistemological context to refer to a graph structure in which the concepts within a particular area of knowledge are represented by nodes and the relationships between them are denoted by directed arcs (Novak, 2010). Many other types of map also exist. A particularly important type of map is the conventional 'geographic map' that people use to navigate with when they want to travel from one point on the earth's surface to another.

Conventional maps, in both paper and electronic forms, are an important visual resource because they provide pictorial representations of particular geographical areas. These enable objects within these areas to be located and identified. Invariably, maps use iconic representations of real-world objects to symbolise their nature and relationships with other objects (Yazdani and Barker, 2000). Geographic maps are very rich knowledge structures in terms of the wide variety of information that they embed and the information that can be derived from them. For example, although it would not be explicitly stated, the distance between any two points on a map could be calculated (provided the scale of the map was known) and the height of a point above sea level could also be derived. The richness of a pictorial map is illustrated in the map segment presented in Figure 7.

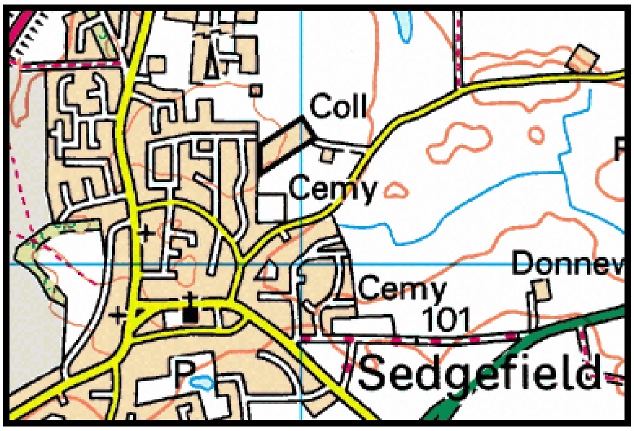

Figure 7. Section of a conventional map

Because the map segment shown in Figure 7 is printed on paper, it is an example of a static picture. However, if the same map was displayed on a computer screen, it could be made to change its form or 'react' to a person's interaction with it - using voice, tactile or motion-based techniques. Such maps are referred to as interactive maps. Through the use of interactivity, it would be possible to enable the scale of the map to be changed and, consequently, its area of coverage altered and the level of detail modified. Similarly, provided a map was designed to be 'multi-layered', different sorts of data could be super-imposed onto a particular base layer - thereby allowing different types of data to be displayed (such as climate details, population statistics, traffic-flow information and textual/iconic/graphical annotations).

Interactive maps and dynamic reactive maps are important in a wide variety of applications - for example, in 'sat-nav' systems that are used in motor vehicles, the maps that are displayed change dynamically as a vehicle changes its position. Interactive maps can embed 'hotspots' which can be used to display information related to the localities in which they are embedded. For example, a map with embedded hotspots could be used to display photographs of a particular area. This technique is illustrated in Barker (2009b) wherein a screen-based interactive version of a conventional map is used to provide access to a collection of pictures showing different scenes taken from the locations indicated in the map.

Photographs are important because they capture records of their owner's visual experiences. They therefore act as a powerful aid to an individual's memory of events and places. Of course, the concepts of reactivity and interactivity can also be applied to photographs. For example, objects in a picture could have hotspots associated with them so that when a mouse is moved over them, or someone touches them), relevant information is displayed or links made to other related images. An example of a reactive photograph can be seen at Barker (2010b) wherein a picture is made progressively larger as its viewer interacts with it by means of mouse-clicking operations.

CASE STUDY: THE GEOGRAPH PROJECT

An interesting example of a pictorial information system that combines the use of maps and photographs is that which forms the basis of the *Geograph Britain and Ireland Project* that is currently underway within the United Kingdom and Ireland (see *http://www.geograph.org.uk*). An overview of the project can be found in Wikipedia (2010). This project was initiated in March 2005. Its original intent was to create a collection of digital photographs that would provide a pictorial record and description of the geography of the British Isles and the activities of its peoples (English, Welsh, Scottish and Irish). The project is sponsored by the UK's Ordnance Survey - an organisation responsible for providing mapping services, products and facilities both nationally and internationally (see *http://www.ordnancesurvey.co.uk*).

The Geograph Project is an online system that is open to anyone who wishes to participate. Currently, there are more than 9,500 registered users. The picture database that underlies the operation of the system contains almost 2 million pictures - each of which has been contributed by a registered user.

The information architecture underlying the design of the Geograph project's pictorial information system is based upon a 'grid-square' referencing system that is overlaid onto the topological structure of the British Isles. This grid-square approach, which is known as the National Grid, is exactly the same as the one used by the Ordnance Survey as a basis for its paper-based and digital maps. Within the National Grid, each grid square occupies a rectangular area that measures 100 Km by 100 Km; every area has a unique two-letter alphabetic code (such as, NX, NY, NZ and SH) by which it is identified. In the Irish Grid system a single letter code is used.

Within the Geograph project, the basic unit of reference in relation to the pictures that it stores is a 1 Km square - each one of which is therefore identified by a code of the form:

<alphabetic-code><digit-pair><digit-pair>

In the above expression the first <*digit-pair*> refers to the *<easting>* and the second pair denotes the *<northing>* in relation to the parent squares that contain it. Although every picture is given a unique accession number as it is added to the image repository, pictures are collectively (logically) clustered in terms of the Kilometre-square that hosts them - for example, NZ2321 and NY4378.

Bearing in mind what has been said above, the overall goal of the Geograph project is to create a collection of digital images for every one-kilometre grid square within the British Isles. A competitive gaming-element is built into the overall operation of the system in that, when people upload pictures to the archive they are accredited with 'points' - providing certain requirements relating to the images are fulfilled. All images that are uploaded to the system are moderated by a team of moderators.

Registered users of the Geograph system can use the Internet and their web browsers in order to upload (and subsequently) retrieve and view digital pictures. During the submission process, a submitted picture is usually augmented with a title, a short narrative description (possibly with embedded hyperlinks) and a categorical specification of its primary geographical character. Descriptive keywords may also be included. When an image is submitted, three important location parameters must be specified: the grid-square in which the picture was taken, the physical location of the photographer at the time the image was captured and the position of the principal feature that is the focus of the photograph. The two latter spatial parameters can be entered either as alphanumeric grid references or as positional parameters on an interactive map of the relevant grid-square.

One of the most important features of the Geograph system is the powerful retrieval engine that is used to find and recall stored images that meet particular retrieval requirements. Searches can be based on picture number, geographical location, principal feature, name of owner, image content, title, description, date of submission, keywords, and so on. When a search is undertaken, any images that satisfy the search criteria are grouped together into a 'collection'. This collection can be viewed as a sequence of images similar to a *PowerPoint* presentation. Some simple illustrative examples of the types of search query that can be made are listed below.

Search term: *grid-square=SE2324*
- finds all pictures taken within grid-square SE2324

Search term: *photo-id = 1743789*
- retrieves the picture whose accession number is 1743789

Search term: *keyword=Redcar*
- finds all images whose descriptive data contain the word *Redcar*

Search term: *keyword=Redcar -sand -dog*
- finds all images whose descriptive data contain the word *Redcar* but do not include the word *sand* or the word *dog*

Search term: *Contributor=Philip Barker*
- finds all pictures submitted by Philip Barker

Search term: *Contributor=Philip Barker AND Date=03-20-2010*
- finds all pictures submitted by Philip Barker on the specified date

The examples given above provide an illustration of some of the types of image retrieval that can be undertaken. Of course, it is possible to execute much more complex Boolean searches by combining different values for the metadata items that are to be searched.

Undoubtedly, the Geograph system provides a powerful resource for the realisation of enquiry-based learning within the domain with which it deals. However, it is important to realise that the ideas, concepts and techniques that are embedded in the Geograph system are perfectly generic and could be transferred to and applied within any pictorial knowledge domain.

CONCLUSION

Human life is a 'never-ending' process of learning and problem solving. In this context, enquiry-based learning is a powerful mechanism for facilitating information and knowledge acquisition - especially when it is used in conjunction with image-based resources. Indeed, collections of various types of pictorial form (and people's ability to store and retrieve them) are an important aspect of many learning and problem-solving processes. Pictorial forms can also be used to overcome some of the limitations of the human mind in terms of the quantity and quality of information that can be retained. Indeed, a picture can often be an important source of detail that cannot usually be retained in human memory. However, with large collections of images, a pictorial information system will usually be needed in order to manage and retrieve the images that are required for particular purposes. This paper has discussed the utility of such a system for the support of enquiry-based learning. A case study has also been presented which illustrates how such a system might be used to facilitate this approach to learning.

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