LEARNING SYSTEMS FOR INFORMATION AND KNOWLEDGE TRANSFER

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ABSTRACT
This paper explores the relationship between water, education and capacity building from the perspective of learning, and especially learning systems. It highlights the contextual and personal nature of knowledge and the need for knowledge that is transferred from one context to another to be re-engineered in the new context such that the recipient comes to own it. The underlying system that supports such a process involves a stress on both the provision of information and knowledge and the capacity of the recipient to assimilate it. The latter is an issue of learning, whereas we may consider the former as an educational issue. The integration of the two facets of knowledge transfer comprises what we term a learning system. Effective use of appropriate learning systems can bring significant benefits in knowledge transfer.

KEYWORDS
Capacity building, knowledge creation, knowledge management, knowledge transfer, learning systems.

INTRODUCTION
The growing world water crisis is in part a failure of human society to be aware of the problem and its possible solutions. This can be interpreted as a consequence of too little being done to ensure the knowledge base on water resources management. The issue resolves into one of improving the situation through better knowledge creation and transfer, and, in particular, better understanding and assimilation of such knowledge by a wide variety of stakeholders.

We can give many examples of the difficulties that arise. The development of human society in many parts of the world has involved an intimate relationship with seasonal rains and river flows. A symbiosis has developed between communities and water supply, often reinforced by religious and cultural values. Modern science gives no place for such values in that it does not need them to fulfil its objectives. Correspondingly, many societies have come to regard water as a purely physical commodity that they can treat apart from religious and cultural tradition. An example of the consequence of this development is the construction of dams in some parts of the world. These provide enhanced capacity for water supply, irrigation, power generation and flood control, yet remove responsibility for water harvesting and management from the local communities placing them in the hands of impersonal and remote boards of management.

Another example concerns the conflicts that arise between different stakeholders over the allocation of water resources. Different groups generate such conflicts through their competing objectives and values assumed, even though they are operating with the best of motives, as they perceive them. For example, environmentalists point to the need for society to reduce water consumption by 10% over the next 25 years so that we can protect the aquatic habitats on which we depend. Agriculturists state that the production of adequate food supplies to avoid starvation for the world population will require a 20% increase in water use. Both are right from the perspectives they have, but a solution has to be found that respects the concerns and ambitions of both (if not, all) parties. Another major cause of conflict concerns the management of multi-national rivers. Underlying these and similar conflicts is a basic need for better data and information, and also for improved understanding of the situation as seen from different points of view, with a strong willingness to have an open attitude to problem solving. There is an urgent need for all users of water ‘to share information, understand data and work together to solve
problems... to provide a holistic cross-sectoral water management’ (Margaret Catley-Carson, Chair of the Global Water Partnership). Knowledge of water resources is only as good as the available data, and all too often, the relevant data are not available. Similarly, the identification and adoption of appropriate solutions to problems requires knowledge on the complex interrelationships between different aspects, and more than a little wisdom on how to select and implement a preferred solution. Just as the freshness of water is dependent on its progress through the hydrological cycle, stakeholders from the same and different sectors generate relevant knowledge through its exchange and transfer as a dynamic entity between them. The generation and refinement of knowledge about sustainable water resources management in all its aspects is the key to successful implementation of such management.

MULTI-DISCIPLINARY INTEGRATION
It was scarcely less than a half century ago that the knowledge base for, say, a water supply organisation consisted primarily of design drawings, operation and maintenance manuals and the inherent knowledge of the system residing in the insights, skills and experiences of the engineering staff. Since then there have been two far-reaching trends affecting such a knowledge base. The first has been a ‘horizontal’ expansion to take into account a more holistic approach to water supply. Analysis and allocation of water resources, assessment of demand by customers, higher standards of treatment, improved concern for public health, acknowledgement of urban planning needs, introduction of metering, and better operations and maintenance have all required a wider consultation with other professionals. These have included hydrologists, health specialists, planners, sociologists, and economists, as well as a range of product suppliers. They have extended the knowledge base such that they can talk sensibly with each other. The second ‘vertical’ trend has been to bring the engineers and others responsible for water supply more in touch with the stakeholders, namely the local community and particularly the customers. These include not just domestic users but industry, commerce and public services. Politicians, business leaders and members of informed pressure groups can be involved too. Clearly, the knowledge base now includes information and knowledge that is relevant and available to lay people.

However, such a position has not been achieved ‘over night’. It has involved the evolution of ideas, much hard talking and extended, patient education and in-depth responsible assimilation or learning by all sides. Consequently, it has become apparent that the knowledge base on water resources and their management, reflected largely in the growing understanding and experiences of the human actors involved, has to be deliberately supported and extended through two primary actions. These include first the provision of existing (or recently generated) knowledge and information, and then the corresponding education and learning systems support. Both actions are equally important. We need to transfer and present knowledge in a structured form using appropriate delivery and increasingly innovative methodologies. From the point of view of the supply side, this is an educational task. However, the success of such an educational process depends on the capacity, capability and motivation of the recipients to assimilate the knowledge into their world-view, that is, to learn what they are provided with. It is the means of knowledge provision and the method of assimilation, which form the learning systems environment that is the primary concern of this paper.

KNOWLEDGE AND INFORMATION
Before we look in more detail at the nature of the delivery mechanisms and the corresponding learning systems, we need to consider the nature of knowledge. For the purposes of this paper, we agree with Nonaka and Takeuchi (1995) on the definition of knowledge originally proposed by Plato as ‘justified, true belief’. This has the value of stressing that knowledge is personal and context dependent. A person has to ‘own’ the knowledge for it to ‘come to presence’. People generate knowledge in the form of concepts that they verify through their experience of the world.
Such knowledge is justified based on relevant, valued information, which in turn is derived from particular structured data. Wisdom may follow further reflection and wide experience of the efficacy of the knowledge acquired. In other words, there is the possibility of personal change in one’s actions following the assimilation of new knowledge. This is the basic assumption about the value of education, and is directly relevant to the issue about transferring knowledge about water.

Sharing knowledge is however, a complex and multi-faceted process that depends on the nature of knowledge itself. Nonaka and Takeuchi distinguish between tacit knowledge that resides in the minds, experiences and competencies of individuals, and explicit knowledge that was originally tacit knowledge, but which has since been encapsulated in documents, methods, procedures, models, tools and other human artefacts. Only a small proportion of tacit knowledge is made explicit, whether by default or intention, primarily because it is mainly embedded in what may be termed the 'unconscious' rather than the 'conscious' mind of an individual. Any discussion about knowledge must recognise these forms of knowledge and therefore the (primary) importance of people and their tacit knowledge as well as explicit knowledge.

![Diagram](image)

**Figure 1. Transfer and transformations of knowledge (after Nonaka and Takeuchi, 1995)**

**KNOWLEDGE TRANSFER**

Nonaka and Takeuchi provided a simple template for the transfer and accompanying transformations of knowledge (see Figure 1). Encoding is the process of making knowledge that resides internally to a person external and formalised such that others can access it independently of the originator. Once we make knowledge explicit, the process of synthesis can lead to the combination of knowledge from different sources to generate new knowledge. Then there is the process of an individual internalising particular explicit knowledge to make that knowledge part of his or her worldview. This assimilation of knowledge is a vital part of the learning process and is a function of both the way in which we present the knowledge and the capability and background experience of the receiver. Finally, tacit knowledge is transferred between individuals through socialisation that is best done face-to-face in that communication then includes body movements, gestures and facial expressions as well as words and language. None of these four transformations is trivial in that each is dependent on the complex psychological make up of every human being involved.

**KNOWLEDGE MANAGEMENT**

Knowledge management concerns the institutional procedures and processes, whether formal or informal, that governs the transfer and transformations of knowledge. In particular, knowledge
management is heavily dependent on the people concerned, complemented by access to and manipulation of monitoring data, meta-data, indicators, methodologies, models or case studies. Information and communication technologies have radically changed the way in which we can facilitate knowledge management. In particular, the Internet has opened up access to people and organisations as well as the data archives, digital documents and tools of the various agencies world-wide. Increasingly powerful search engines enable users to navigate through an ever-changing information space. Email, chat groups and video conferencing put people in touch with each other. Collaborative working platforms facilitate the functioning of dispersed groups of people. Such innovative technologies enable the knowledge management process as a cycle of activities, triggered by external demands and subject to internal drivers.

An especially important means of communicating knowledge is through instantiated models. Given a model for a given situation (river basin, urban area, coastal region etc) available over the Internet, then any stakeholder can in theory access the instantiated model and explore options that are of direct interest to them. All such stakeholders have a common model of reality (that is hopefully accepted by all) such that it generates consistent information. Jonoski (2000) have developed such as system that is coupled with what they call ‘judgement engines’ in support of decision making.

Particularly important entities that facilitate knowledge management are ‘communities of practice’ (CoPs), which are groups of people ‘informally bound together by shared expertise and passion for a joint enterprise’ (Wenger and Snyder (2000)). We can identify such groups at the local, regional, national and international levels.

**LEARNING SYSTEMS**

*Learning is the ability to identify the deficiency between what is intended to be achieved and what currently exists, and then to take action to correct it.* For an individual, learning is the ability to identify the need for particular explicit knowledge to achieve some purpose and then to internalise (or assimilate) it. With the availability of new forms of communication and knowledge delivery, we are implementing innovative learning processes, such as the involvement of group processes in micro-communities or communities of practice (which enable existing knowledge on good practices to be refined dynamically by appropriate feedback). We are also exploring new organisational structures and other support facilities, which have a strong bearing on such issues as the education of the public and continuing professional development.

Our concern is for the necessary learning systems to be in place such that we can sustain and enhance the knowledge base on water into the future. We can consider this as a matter of educating people to acquire relevant knowledge, skills and experience, complementing them with the necessary explicit data, information and knowledge resources supported by relevant information and communication technologies, and enabling them to operate within appropriate institutional arrangements. The primary goal is to network people, organisations and their knowledge and information resources in such a way that learning takes place effectively.

The need for education and learning occurs at different levels in society. Water is vital to each human being and is therefore everybody’s business. This means that there is a basic need for the public to be aware, whether it is matter of continuous ongoing attention to good hygiene, or the maintenance of an underlying preparedness for rare flood events. Other groups in society such as farmers and environmentalists need different, more specialised knowledge, information and skills. Then there is the need for skilled professionals in different disciplines to do with water, in education as well as engineering or scientific practice.
AWARENESS CREATION
The creation of an improved awareness of the value and importance of water resources management at all levels of society is of key importance. This is because the demands made on the knowledge base are a function of the needs of society and of the environment for freshwater resources, and the extent to which society is aware of these needs. Normally those directly affected are best placed to identify the need. They do this according to their value system. Others may, however, express the need in another way, depending on how different their value systems are. A poor community may be more focussed on exploiting a natural water resource to meet its desire for adequate drinking water and food in the short term, while another group wants to preserve the resource because of its consequences for the local environment. A reasonable debate between the opposing parties depends on the level of education and access to knowledge resources. The awareness of different groups in society is therefore a function of their needs, the relevant knowledge they have access to and the level of understanding that they are able to achieve through assimilating the knowledge into their own worldviews. Awareness creation within all levels of society, whether young or old and whatever occupation, is an important aspect of ensuring the knowledge base on water in the future. In this respect, growing public awareness depends on the information provided, as well as straightforward analyses of important issues. Educational organisations and non-government organisations (NGOs) can play an important part here, as can the media including radio, television, films and newspapers. We can use techniques such as story telling, games and role-plays to build awareness. Internet is also of growing importance, though access is still limited in many parts of the developing world. The learning systems in this case are a sophisticated blend of a wide range of means and facilities.

CAPACITY BUILDING FOR KNOWLEDGE TRANSFER
Whereas there is knowledge that can be regarded as generic, specific knowledge emerges in applications ‘on the ground’ within the parameters and boundary constraints peculiar to the local presenting problem (behind which there may be a number of more fundamental problems). Fukuda-Parr et al. (2002) point out that the use of ‘experts’ from developed countries to fill gaps with a quick injection of know-how does not appear to produce an effective transfer of knowledge. Indeed, they criticise much technical co-operation on several counts. It undermines initiatives to develop local capacity in that the technical co-operation often sidelines local management and ignores their wishes. It focuses on high profile activities involving expensive methods and techniques that lead to a distortion of priorities. It makes the underlying assumption that it can ignore the existing capacities in developing countries and replace them with knowledge and systems produced in developed countries. The alternative is to put a high premium on local rather than international expertise such that local individuals and organisations take ownership of their problems and situations while benefiting from explicit knowledge from elsewhere. Such a premium may go so far as to take the risk and leave the responsibility for recognising and solving the problem to the local expertise. Too often organisations involved in technical co-operation have in effect ‘stolen’ the problem and used it to preserve their technical advantage. Although letting go responsibility (and taking it up) requires a delicate balance of communicative action and reaction by both parties, it results in an expansion of the recipients’ capabilities and skills, an enhancement of the choices they develop themselves and the freedom to make and learn from their own mistakes. The use of case studies to demonstrate the applicability of its indicators, methodologies and models is an important basis for transferring knowledge by example rather than prescription.

The transfer of knowledge should therefore come from giving the recipients the opportunity to relive the knowledge creation experience, even if in a modified manner. According to Krogh et al. (2000) the basic elements of the knowledge creation process appear to be based on at first a vigorous exchange of tacit knowledge through which various innovative concepts can be allowed

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to emerge. These concepts are then refined through a process of justification. The best or emerging concept(s) is subsequently tested through prototyping. Stakeholders and others then assess the prototype for its value and accept or modify it accordingly. It is important however, to note that the knowledge gained is dependent on the context and the people involved, and the justification they have used to inform their beliefs about the knowledge. This means that we can best achieve an effective transfer of the resulting knowledge through a similar process in which the recipients retrace the same steps for themselves. Their objective is to reach a similar or modified conclusion that they apply to their context and such that the justification of the consequent knowledge informs their own belief system. In this sense, they can come to ‘own’ the knowledge for themselves.

![Figure 2. The knowledge creation (and recreation) process (after Krogh et al, 2000)](image)

Krogh et al discussed knowledge transfer within the context of a company. However, we can adapt their model for the dissemination and application of knowledge created in a developed country context to other countries and cultures. Such a transfer is primarily a learning experience for the recipients of the knowledge. Their failure to appreciate and learn new knowledge means that they will not experience ownership of the knowledge and reject or at best neglect the knowledge products in whatever form. Because all knowledge is context dependent, it is vital that we help the recipients to assimilate new knowledge in their own particular context. They need to be encouraged to make their own ‘story’ about the knowledge that informs their beliefs concerning the knowledge and its value. For this to be a learning experience for the recipients they need informed assistance by researchers including, if possible, those who were involved in the original development. Generally, this will involve a measure of education and training to assist the end users in gaining the necessary background knowledge and in coaching them to reflect on their own experience. Feedback from the experiences of end users will again be valuable for informing the development of new research issues and questions.

The ability to collect, structure and analyse data, followed by a correct diagnosis of the presenting problem and its solution requires people with the necessary experience and skills, often operating according to appropriate procedures within a particular organisation and supported by suitable tools and facilities. However, if local people are to take on more responsibility for their water resources problems and their solutions, they require a measure of understanding and intellectual
ability. As well as an affinity or motivation to address the presenting problem, they need a necessary level of education that respects their cultural integrity. Whereas there is knowledge on water resources that is transferable from one location to another, it does not follow that solutions to problems elsewhere are directly appropriate to a particular presenting problem. Indeed, it is more likely that they have to devise an appropriate solution for the given problem while drawing on the lessons learned from elsewhere, such as through the case studies. Often local wisdom that is largely based on long, and even generations of experience, may contain the germ of a solution to a problem that is more appropriate than an imported 'solution'. Consequently, education should empower individuals to take the best from elsewhere and formulate their own solutions in an innovative manner. This requires a degree of independence of thought and position with regard to ‘cook book’ approaches developed for other countries. Fukuda-Parr et al (2002) use the phrase ‘scan globally, reinvent locally’ in referring to the need for people in developing countries to take advantage of the huge information and knowledge resources available through the Internet and other networks while having the courage and determination to innovate appropriate solutions themselves.

Important components of the knowledge base therefore are informed and educated local communities. These demand improvements in education and training of human resources at all levels of society. A country needs to develop its own national policy concerning water resources education based on an objective assessment of its needs. They should work out particular programmes at the different levels of formal education, namely from school through to university. The higher the level, the more attention can be given to specialist courses, bearing in mind the need for manpower development, the role of women at all professional levels and especially in local communities, and the place of national specialists in different aspects of water resources management.

All of this is consistent with the UNDP view of capacity building as 'the sum of efforts needed to nurture, enhance and utilise the skills and capabilities of people and institutions at all levels, - locally, nationally, regionally and internationally - to make better progress towards sustainable development'. In this case, capacity building is about empowering people and organisations to solve their own problems, in other words, according to the principle of subsidiarity. There are a growing number of organisations, associations, and aid agencies committed to ensuring that they should apply and develop further the knowledge base of sustainable water resources management through capacity building in developing countries. Whereas there is a need for skilled experts to collate and analyse data for water resources, the consequent applications by local people seeking solutions to their presenting problems.

**ICT’s SUPPORT OF INNOVATIVE LEARNING SYSTEMS**

Many emergent phenomena of our present world are the direct consequence of the enormous advances made in Information and communication technologies (ICT) during the last 50 years. For example, globalisation, which is seen as such a threat to many local communities, owes its pervasiveness to the world-wide networks that provide instant communication, including Internet. Along with the disadvantages come the advantages of the ‘death of distance’ (Cairnercross (1995)) as a determining factor in human communications. More routinely, there has emerged the ability to access data, information and knowledge in ways that would have astounded our grandparents. Video conferencing is commonplace. We can work and learn together in a collaborative way remotely from each other. New e-learning tools mean that we can experience a sophisticated, interactive learning experience in the comfort of our own homes. Gradually we are seeing the take up of the merger between television, the mobile phone and the computer. Huge changes are in prospect for the next generations of learners.
Universal access to data, information and knowledge clearly does not yet exist however, and for many developing countries, it is still a distant aspiration. In 1997, Internet was accessible by almost 200 countries. Inside Africa, for example, there are large differences in the installation of phone lines facilitating access to Internet, with rapid advances in the Maghreb and South Africa. However, despite problems access by developing countries to the World Wide Web is growing fast. Latin America is a case in point. Here there is rapid growth in connections to the World Wide Web with more than 100 million connected to Internet at the turn of this century. It is questionable, though, how much use is made of the Internet by education.

**POST GRADUATE EDUCATION OF WATER SPECIALISTS**

In the past, an important way of educating water professionals from developing countries has been to do so in the donor countries. This has the value of removing the professionals from their home environment and exposing them to expert practice elsewhere. The approach enlarges the appreciation and understanding of participants of what they can do and how they can achieve it. However, many excellent post-doctoral professionals from developing countries then fail to return home, depriving their countries of their hard-earned expertise and skills. There is also the problem for those who do return that they may have adopted the mindset of the developed country professional in such a way that they become estranged from the real presenting problems that face their communities or be biased towards inappropriate solutions. In this sense, it may be preferable to educate and train people as well in their own countries within their own educational institutes. This, of course, requires adequate capacity in their home institutes. Donor countries and agencies have recognised the importance of building appropriate educational capacity in developing country academic institutes as well as water resources management capacity in responsible organisations.

We have to see the growing need for water resources specialists in the developing countries in terms of higher education at post-graduate level, including research training as appropriate. We need to complement traditional approaches of up-front lecturing by the increasing use of innovative methods of creative learning that take advantage of incremental discovery. This leads to the notion of blended learning in which we use different traditional and innovative techniques in an integrated manner to bring about an improved learning environment. Learning should also take place more in a group context, giving the chance for professionals in training to share their wide experience and knowledge in a multi-disciplinary context as well as to learn from the explicit knowledge base that the academic institution provides. Each person should be encouraged to be committed to life-long learning in the context of continuing professional development whether on-the-job or in project teams, supported by distance education and e-learning. The cultivation of self-dependence and personal responsibility should empower individuals or organisations to initiate the process of learning. Indeed, it is only when the learner has motivation and appetite that learning takes place.

**Virtual seminar**

A unique seminar was held in the Netherlands in 2002, which was scheduled over a two-month period. The seminar addressed the subject of Water and Human (In) security. More than a hundred overseas and Dutch post-graduate students met together on the first and last days, and during the intervening period worked collaboratively over the Internet. Working in groups, they accepted the challenge to come up with innovative ways of addressing the subject of the seminar. Each group reported successfully their achievements on the final day. In this case the learning system involved a blended mix of group bonding, collaborative working, facilitation and incentives.
Collaborative engineering
An innovative way of working pioneered between a number of European institutions has been a form of collaborative engineering in which groups from different academic institutions have been given the experience of working collaboratively over the internet with people they have not met in order to solve specific engineering problems. Here the groups had access to a computational hydraulic model, which they used to develop solutions to complex problems, much as they would in a commercial consultancy environment. The learning system made extensive use of collaborative working, video conferencing, facilitation and academic incentives.

Communities of practice make an important contribution to the education process for an individual, especially those individuals recognising the value and importance of life-long learning. Alongside these informal groups are the more formal partnership networks that bring together organisations with similar activities and goals. For example, UNESCO-IHE is forming a network of partnerships, linking educational organisations and regional networks into a world-wide network dedicated to building capacity in water education. In addition, UNESCO-IHE has the responsibility to its alumni to ensure that they carry on into their professional career any collaborative working experience they have had while studying at IHE such that they can readily continue discussing topics and working together to solve problems with their friends and colleagues. Another organisation, the International Water and Sanitation Centre (IRC), focuses on establishing and building links between a number of resource centres world-wide that provide information on water supply and sanitation for the poor. The aims of these networks are far reaching as they address the transformation of society by encouraging acquisition of knowledge at the local level rather than by transfer from elsewhere in a drive towards reducing the asymmetry currently in favour of the technical co-operation agencies.

UNESCO-IHE - partnership in water education:
Its mission is to contribute to the post-graduate education and training of capable professionals and to build capacity of knowledge centres and other organisations in the fields of water, the environment and infrastructure in developing countries and countries in transition. IHE does this through a partnership network of academic centres and professional organisations offering demand responsive and duly accredited educational programmes at the local and regional level. UNESCO-IHE encourages all those involved in the water sector, including its 12000 alumni from more than 100 countries, and scientists and professionals in public, private and civil society organisations, to participate in this dynamic network of partnerships. Through international projects, regional refresher seminars for alumni, symposia, international forums and contacts over its alumni community platform, UNESCO-IHE is able to fine-tune its education, training and research programmes in order to ensure that they continue to meet changing demands. UNESCO-IHE is continuously seeking to identify opportunities for collaboration with new partners in both the North and the South in order to extend and improve its network.

LEARNING SYSTEMS REVIEWED
We make much in this paper of the responsibility that we lay on the recipient of knowledge to assimilate it effectively if it is to be used safely. This is a learning issue while respecting that there are other major issues concerning knowledge creation, delivery and dissemination. As far as we are concerned, learning is best done in the correct environment and with appropriate help. As such, we can speak of learning systems that provide such an environment and assistance to the learner. The following important aspects are noted:
• Learning is the ability to identify the deficiency between what is intended to be achieved and what currently exists, and then to take action to correct it.
• Learning is also a process in which organisations optimise their access to and the application of their internal and external knowledge.
• The success of the learning is seen in the consequences for choice and change in the individual or the group.
• The transfer of knowledge is partly a matter of information or knowledge supply in an appropriate format (tacit and/or explicit knowledge) and partly the ability of the recipient to assimilate it (internalisation of knowledge).
• Awareness in society of the value and care of water involves the use of a range of different means of delivery and format in order to reach the public.
• Knowledge transfer is best done in a situation in which the recipient can relive the knowledge creation process in their own context and in such a way that they can justify the knowledge in terms of their own belief systems (so that they come to ‘own’ the knowledge).
• ICT provides new ways of creating learning environments that enable the construction of virtual environments of real world counterparts in which learners can explore the nature of these environments and the consequences of intervention.
• Collaborative working platforms provide ways for groups of people to share knowledge and to solve problems collaboratively.
• Present day e-learning systems such as Blackboard and Learning Space (IBM) give new ways of managing the learning environment.
• Learning systems can range from on demand, on-the-job provision of knowledge with support for learning (including user profiling) to educational courses utilising e-learning with multi-media communications supported by sophisticated digital libraries and information systems.

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