Developing a digital library on ceramics

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Abstract

Purpose – The objective of the present study is to discuss the need for developing a digital library on ceramics.

Design/methodology/approach – The rapid growth of digital libraries together with professional publications and the popular press have created a lot of hopes as well as myths about digital libraries. Research on digital libraries began about a decade ago and a number of digital libraries were created as a result. The article begins with giving an overview of digital libraries, and then discusses the need for a digital library on ceramics, highlighting the importance of ceramics on society.

Findings – The paper shows that a digital library on ceramics is needed to provide students, scientists, artist and industrial community with an open and interoperable platform to help facilitate research and education, to promote ceramic art, to promote global cooperation, to foster economic development – including rural development, and to help facilitate archaeological research.

Originality/value – It is a paradox that, under circumstances where economic activity takes place at an increasingly global level, individual countries must give increased attention to their performance at the national level so that they can find a favored position within the world community. Since there has been little or no discussion on a digital library on ceramics in the library literature, the study would help developed and developing countries to develop digital library on ceramics.

Keywords Digital libraries, Ceramics, India

Paper type Conceptual paper

Introduction

The impact of the information age is stimulating the formation of new habits in all of us. It seems essential that we learn to ride the ribbons of change leading to the future. An imperative of these new practices is to try to speak to a wider audience, to try to close the gaps that have grown amongst us through distance and limitation of print world. The amount of information published in electronic format and the number of users accessing it to satisfy their daily information need is growing at a tremendous rate. This is the building block of the digital information age. Remarkably, though more information is easily reachable and in smaller amounts of time than a decade ago, it is becoming increasingly difficult for individuals to control and effectively seek for information among the potentially infinite number of information sources available on the internet. Ironically, just as more and more users are getting on-line, it is getting increasingly difficult to find relevant information in a reasonable amount of time, unless one knows exactly what to get, from where to get it and how to get it. New

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emerging services are urgently needed on the internet to prevent computer users from being drowned by the flood of available information. Among the various digital information sources, digital libraries (DLs) will play an important role not merely in terms of the information provided, but in terms of the services they provide to the information society (Fox and Marchionini, 1996).

The provision of information resources and services is now readily available online via digital libraries furnished by a wide variety of information providers. Information is no longer just text and pictures, and is now available in a wide variety of multimedia formats. Digital libraries represent a new form of information technology in which content management, service delivery and social impact matter as much as technological advancement. In addition, for digital library researchers there is a need to transform information access to knowledge creation and management. Developments in information technology have changed the concept of the library from one of print and paper media. Today we stand at a transition from the traditional library to a global digital library. The idea is to provide universal access to digital content available only in a digital library environment. In the Information Age, we require a digital library because the emergence of digital technology and computer networks has provided a means whereby information can be stored, retrieved, disseminated and duplicated in a fast and efficient manner. On a global level, DLs have made considerable advances both in technology and its application.

Digital library: an overview

Informally, DLs can be defined as consisting of collections of information which have associated services delivered to user communities using a variety of technologies. The collections of information can be scientific, business or personal data, and can be represented as digital text, image, audio, video, or other media. This information can be digitized paper or born digital material and the services offered on such information can be varied, ranging from content operations to rights management, and can be offered to individuals or user communities. An essential technology component of DLs is that they are networked, meaning that access is increasingly becoming shared and collaborative. The fundamental purpose of a digital library must be to provide access to information along with appropriate reference tools for identifying and evaluating the possible sources and types of information. Thus, the many kinds of information that constitute the intellectual capital of post-baccalaureate learning must be digitized and organized in a manner that can be searched intelligently and reliably, using technologies that do not require undue technical training. Perhaps most difficult of all, a sustainable business model to support the digital library must be identified. Digital libraries can be explored in an information society from two not entirely compatible dimensions: intellectual property and evolving technologies to serve communities of learning.

A new conservation is necessary among libraries, library users and officials responsible for funding libraries to ensure that the library of the future serves the intellectual needs of diverse users and fields. This is in some sense a collection. This may be personal, group, organization or widely public, it may be a combination of physical and electronic, or purely online, it may be represented by hyperlinks; it may be mutable. But an unstructured, unindex aggregation of documents (such as the web writ large) dose not constitute a library. The collection is not exclusively bibliographic or exclusively a set of pointers to other materials but includes full form online material encompassing a large of media and intended uses, such as articles, books, simulations,

formulas, datasets, financial or medical records newsgroup archives, e-mail messages, sound clips, images and the like. As does a physical collection, there is a concern to link audience, group, patron or community with attributes of the collection in an efficient, satisfying manner. However, because of the unique characteristics of online media, collection development may also include group or community develop next or at least provide a virtual space for linking those with common interests. There is in some sense a set of services (human and computer based) that links people to one another. The technologies involved in digital library services are those that support document creation, retrieval, transfer, dissemination, manipulation and management of the digital library as well as social interactions; and there is in some sense an institution in which digital library collections, services, and social interactions are embedded. The institution may be geared exclusively to the creation and maintenance of the digital library itself, or it may be any type of organization that provides digital library tools, resources, and services to support other activities (Bishop and Star, 1996).

Bernie Hurley, the Director for Library Technologies at U.C. Berkeley quoted in Digital Library Technology Trends (Sun Microsystems, August 2002, www.sun.com/products-n-solutions/edu/whitepapers/pdf/digital_library_trends.pdf) that "Digital libraries are different [from traditional library automation] in that they are designed to support the creation, maintenance, management, access to, and preservation of digital content". Sun Microsystems defines a digital library as "the electronic extension of functions users typically perform and the resources they access in a traditional library". These information resources can be translated into digital form, stored in multimedia repositories, and made available through web-based services. The emergence of the digital library mirrors the growth of e-learning (or distance learning) as the virtual alternative to traditional school attendance. As the student population increasingly turns to off-campus alternatives for lifelong learning, the library must evolve to fit this new educational paradigm or become obsolete as students search for other ways to conveniently locate information resources anywhere, any time (www.sun.com/products-n-solutions/edu/whitepapers/pdf/digital_library_trends.pdf).

The Digital Library Federation (DLF), a consortium of libraries and related agencies, defines a digital library as that "Digital libraries are organizations that provide the resources, including the specialized staff, to select, structure, offer intellectual access to, interpret, distribute, preserve the integrity of, and ensure the persistence over time of collections of digital works so that they are readily and economically available for use by a defined community or set of communities" (www.diglib.org/about/dldefinition.htm).

Research on digital libraries began about a decade ago and a number of DLs were created as a result. Much of the research during the initial stages was on digitizing existing sources. Indeed, DLs answer queries crudely rather than, for instance, learn the long-term or short-term requirements idiosyncratic to a specific user or, more general, specific to an information-seeking task. In practice, what happens is that users use the same information resources over and over and would benefit from customization in a broad sense: the time consuming effort that the user put in searching documents and possibly downloading them from the DLs is often forgotten and lost. Later, the user may wish to perform a search on the same topic to find relevant documents that have, for example, appeared since the last time a search was performed. This requires a repetition of the manual labor in searching and browsing to find the documents just like the first time. As DLs become more commonplaces and the range of information they provide services upon increases, users' expectations will

increase and users' are expecting more and more sophisticated services from their DLs. A "quick and dirty search" facility is normally an integral part of any digital library, but users' frustrations with this increase as their demands become more complex and as the volume of information managed by digital libraries increases. There is a need for DLs to move from being passive with little adaptation to their users, to being more proactive in offering and tailoring information for individual users. If a DL is not personalized for individuals or communities of users then a digital library is defaulting on its obligation to offer the best service possible.

The emerging generation of DLs is more heterogeneous along several dimensions. The collections themselves are becoming more heterogeneous, in terms of their creators, content, media, and communities served. The range of library types is expanding to include long-term "personal" DLs, and well as DLs that serve specific organizations, educational needs, and cultural heritage that vary in their reliability, authority, recency, and quality. The user communities are becoming heterogeneous in terms of their interests, backgrounds, and skill levels, ranging from novices to experts in a specific subject area. The growing diversity of digital libraries, the communities accessing them, and how the information is used requires the next generation of DLs to be more effective at providing information that is tailored to a person's background knowledge, skills, tasks, and intended use of the information. Digital libraries are not only suitable for large and diverse collections, they are also ideal for specialist subject areas such as ceramics.

Ceramics and its impact on society

The word ceramic can be traced back to the Greek term *keramos*, meaning "a potter" or "pottery". *Keramos* in turn is related to an older Sanskrit root meaning "to burn." Thus, the early Greeks used the term to mean, "Burned stuff" or "burned earth" when referring to products obtained through the action of fire upon earthy materials. However, modern usage of the term broadens the meaning to include all inorganic non-metallic materials. They are typically crystalline in nature and are compounds formed between metallic and nonmetallic elements such as aluminum and oxygen (alumina – Al_2O_3), calcium and oxygen (calcia – CaO), and silicon and nitrogen (silicon nitride – Si_3N_4). Ceramics is used in everything for dinner plates to bowling balls to the space shuttle. Again to understand the importance of this digital library, one has to first understand the importance of application of ceramics or role of ceramics in society. Since the ancient times, the technology and applications of ceramics (including glass) has steadily increased. We often take for granted the major role that ceramics have played in the progress of humankind. Lets us look at a few examples of the importance of ceramics in our lives (www.acers.org, www.newi.ac.uk/buckleyc/ceramics.htm):

- *Refractories*. Modern iron and steel and non-ferrous metal production would not be possible without the use of sophisticated refractory materials that are used to line high temperature furnaces, troughs and ladles. Metals make automobiles, machinery, planes, buildings, and thousands of other useful things possible. Refractory ceramics are enabling materials for other industries as well. The chemical, petroleum, energy conversion, glass and other ceramic industries all rely on refractory materials.
- *Construction industry*. Much of the construction industry depends on the use of ceramic materials. This includes brick, cement, tile, and glass. Cement is used to

make concrete which in turn is used for roadways, dams, buildings, and bridges. Uses of glass in the construction industry include various types of windows, glass block, and fibers for use in insulation, ceiling panels and roofing tiles. Brick is used for homes and commercial buildings because of its strength, durability, and beauty. Brick is one of the few building products that will not burn, melt, dent, peel, warp, rot, rust or be eaten by termites. Tile is used in applications such as flooring, walls, countertops, and fireplaces. Tile is also a very durable and hygienic construction product that adds beauty to any application.

- *Lighting*. An important invention that changed the lives of millions of people was the incandescent light bulb. This important invention by Thomas Edison in 1879 would not be possible without the use of glass. Glass's properties of hardness, transparency, and its ability to withstand high temperatures and hold a vacuum at the same time made the light bulb a reality. The evolution of lighting technology since this time has been characterized by the invention of increasingly brighter and more efficient light sources. By the middle of twentieth century, methods of lighting seemed well established – with filament and fluorescent lamps for interiors, neon lamps for exterior advertising and signs, and sodium discharge lamps for streets. Since this time, light-emitting diode (LED) technology has been developed with applications in watches, instrument panel indicators, telecommunications (optical fiber networks), data storage (CD technology), and document production (laser printers).
- *Electronics industry*. The electronics industry would not exist without ceramics. Ceramics can be excellent insulators, semiconductors, superconductors, and magnets. It's hard to imagine not having mobile phones, computers, television, and other consumer electronic products. Ceramic spark plugs, which are electrical insulators, have had a large impact on society. They were first invented in 1860 to ignite fuel for internal combustion engines and are still being used for this purpose today. Applications include automobiles, boat engines, lawnmowers, and the like. High voltage insulators make it possible to safely carry electricity to houses and businesses.
- *Communication*. Fiber optic fibers have provided a technological breakthrough in the area of telecommunications. Information that was once carried electrically through hundreds of copper wires is now being carried through high-quality transparent silica (glass) fibers. Using this technology has increased the speed and volume of information that can be carried by orders of magnitude over that which is possible using copper cable. The reliability of the transmitted information is also greatly improved with fiber optic fibers. In addition to these benefits, the negative effects of copper mining on the environment are reduced with the use of silica fibers.
- *Environmental applications*. Ceramics play an important role in addressing various environmental needs. Ceramics help decrease pollution, capture toxic materials and encapsulate nuclear waste. Today's catalytic converters in vehicles are made of cellular ceramics and help convert noxious hydrocarbons and carbon monoxide gases into non-toxic carbon dioxide and water. Advanced ceramic components are starting to be used in diesel and automotive engines. Ceramics' lightweight and high-temperature and wear resistant properties, results in more efficient combustion and significant fuel savings. Ceramics are

also used in oil spill containment booms that corral oil so it can be towed away from ships, harbors, or offshore oil drilling rigs before being burned off safely.

- *Space application*. Reusable, lightweight ceramic tile make NASA's space shuttle program possible. These thermal barrier tile protect the astronauts and the shuttle's aluminium frame from the extreme temperatures (up to approximately 1600°C) encountered upon re-entry into the earth's atmosphere.
- *Medical*. Ceramics are becoming increasingly useful to the medical world. Surgeons are using bioceramic materials for repair and replacement of human hips, knees, and other body parts. Ceramics also are being used to replace diseased heart valves. When used in the human body as implants or even as coatings to metal replacements, ceramic materials can stimulate bone growth, promote tissue formation and provide protection from the immune system. Dentists are using ceramics for tooth replacement implants and braces. High-temperature superconductors are now finding application in magnetic resonance imaging machines.

While the list of examples could go on and on, I think you can get the picture of how important ceramics has been, and will continue to be to humankind. To further highlight the importance of ceramics, the contribution of the ceramics to the top 20 engineering achievements as listed by the US National Academy of Engineering is given as an Appendix (Housemann, 2001).

Need for a digital library on ceramics

A digital library on ceramics would be an institutional as well as a repository for the ceramic community. This digital repository would contain collections on ceramic resources. The overwhelming need for the creation of this digital repository is to provide students, scientists, artist and industrial communities with an open and interoperable platform for the following activities.

To help facilitate research and education

The function of a traditional library in an R&D set up devoted to ceramics collections is to meet the information needs of the researcher by collecting, organizing and preserving information resources from different sources. Like other subject collections, the collection of a research library on ceramics of any country is a remarkable enterprise. Although research libraries have been individualistic, local institution, in that they serve the immediate research needs of their researcher and students, they attempt to provide national and international publications and other information resources that support curricula comprehensively and offer sufficiently deep research resources to satisfy a wide range of specialized interests. In the aggregate, they comprise a national asset that is unsurpassed. The digital library on ceramics containing the riches of information repositories of research library collections on the subjects could provide information to anyone, anywhere at any time. Again, the cost of building the collection of a research library to serve information needs of the researcher is enormous. The facts about spiraling costs of journals are well known. Ostensibly, the traditional research library of this field has become costly. The digital library would be used to provide information or research product in a new way. It would help to exchange and share scholarly publications much more effectively. This, along with the repository resources, could be a gateway to the many information resources that would

be available electronically containing database on primary publications, secondary publication, free electronic journals and institutions including societies and associations and human resources of different countries. Institutional repository would be linked wherever available. New ideas can be generated bringing together interested researcher creating discussion group and forum on various issues. Collaboration in research activities thus could be increased among regional, national and international institution.

Education. Recent initiatives in digital library research have suggested new models for the creation and organization of digital information and its dissemination to virtual communities. The digital library on ceramics could provide access to the collective experience of teachers, students and administrators in public schools in building lesson plans and using curriculum materials. The digital library on ceramics also would improve the quality, quantity, and efficiency of teaching and learning about the ceramics at all levels involving educators, students, and scientists. The digital library would include electronic materials for both teachers and learners, such as lesson plans, maps, images, data sets, visualizations, assessment activities, curriculum, online courses, and much more. Using the world wide web as a platform, this digital library could provide educators with access to multimedia resources and tools to create new lesson plans and presentations, and to modify existing ones. Educators could share resources with their colleagues that they have developed or found to be effective. It would support education by providing access to high-quality collection of educational resources, support services to help educators and learners effectively create, use, and share educational resources and communication networks to facilitate interactions and collaborations across all dimensions of ceramic education.

Content for the database could be collected from government agencies, institutions and educational resources web sites, as well as from participating teachers. Once incorporated in the repository, materials can be organized in frameworks that would form the basis for lessons, tutorials and presentations. Supported by the link-to-learn program, the system will function as a resource for educators. Ceramic Education Programs Database listing the institutions offering degrees in ceramics art and science could be served for students. Many universities and colleges in the USA and elsewhere have been luring students with advertisements offering coveted degrees as new technology has brought long-distance education online. With computer and internet access, students can pursue an academic course on ceramics without being present in the classroom. As a consequence, many students and professional with varied profiles who want to further their careers could opt for online degrees. It is now possible to earn a higher education from a university abroad while remaining at home. Through the internet, text material can be sent anytime, anywhere according to convenience. The transfer of text and graphics is faster and more reliable than through the mail, making student part of a global community. As in a classroom, student in online courses are formed into groups where they can discuss the subject and share notes. Students also could interact with teachers.

To promote ceramic art

Ceramics is one of the most ancient of all arts. It is also the most universal. Its existence is evidenced in relics of ancient man in the Stone Age of 10,000 to 20,000 years ago. It is found in the remains of nearly all tribes, races, and civilizations, from the most primitive to the most advanced, in all parts of the globe. The crude bowls of the prehistoric mound building Indians of North America, the funerary ware of

pre-dynastic China, the brilliant votive globes of antique Egypt, the magnificent vases of the Etruscans and of the early Greeks, the savage god-figures of Maya, and the tiled-floors of imperial Persia attest to its universality, and the degree to which the ceramic art had progressed at the dawn of recorded history. Ceramics made possible the magnificent glazed brick palaces of Ur, Babylon, and Nineveh in that cradle of civilization where the Tigris and Euphrates flow. It was here that clay became the medium of the written word in the form of cuneiform writing. Each tribe, each race, each culture – from the early beginnings to the present, developed its own peculiar ceramic forms and methods of decoration. Perhaps, the development of form and decoration of ceramics among the early culture more by chance than by determination, preferences for certain shapes and decorative motifs arose in different parts of the world, and these were refined through the ages. Influenced occurred as one culture reacted upon another. But such was the persistence of custom and religion – as well as the tradition of the craft as it was transmitted from father to son – that age-old preferences were often retained. Thus, we can say that certain shapes are peculiarly Chinese or Greek or that decorative styles reflect a Japanese flavor. Among some early peoples, characteristic forms and decorative artistry progressed to a point unequaled to this day. Many authorities contend that the degree to which the ceramic art was advanced is an index of the cultural level attained by each civilization (de Vegh and Mandi, 1949).

The digital library would help to promote art bringing together the product of artist imagination and various forms of ceramic arts. This could collect, preserve, interpret, and exhibit works of art and present related educational programs in support of the teaching, research, and public service missions. The digital library with its digital information resource that facilitates and provides access to materials such as manuscripts, photographs, and works of art held in libraries, museums, archives, and other institutions across the world would be able to promote art. This would be an environment where information about ceramic artifacts would be as important as the collection themselves. It would be available to a broad spectrum of user – students, teachers, and researchers of all levels. Through this all would have access to information previously available only to scholars who traveled to collection sites. In this context we should remember that ceramic is a technology based art, again art could inspire technology developments of this field sharing related information of the field globally.

To promote global cooperation

Ceramics has grown in international scope in every respect within the past decade. With the daily use of electronic mail and the worldwide dissemination of information on the internet, one can no longer dispute the global nature of ceramic science, engineering and technology, except possibly on the basis of the level of internationally which its character has attained. With the ceramic discipline assuming such a global nature, it should not be any surprise that ceramics educators, scientists and students are also assuming a global or international disposition, one, which is indeed peripatetic. This global character of ceramic education, as well as all aspects of materials education has many different characteristics, proposing at various levels. One feature is simply the increased frequency of educator travel to international symposia and visiting colleagues at universities in other countries. Longer sojourns include academic sabbaticals, many for more than a single year. Numerous "permanent" positions have been established for visiting professors and scientists in laboratories about the world,

as much government have created formal programs to host these itinerant individuals. International interactions of an even greater intensity are the funded collaborative research endeavors. The scientific funding agencies of most governments have special programs for international cooperative efforts.

Richard Bradt in his study "Peripatetic ceramic educators and scientists in a global environment/collaborative research publications" quantifies the international relationship in the ceramic literature. This measured the depth of interactions in international ceramic education and research is quite different from quantitative measures of touristic interactions or global manufacturing. The globalization of ceramics has created an international community of scholars whose work is not bound by national borders. On an intellectual level, when authors jointly write a research report they plan and carry out laboratory research together, developing a closer relationship than a mere acquaintanceship. Bradt found that as recently 1980 only one out of fifty published papers had authors of at least two nationalities. But by the 1990s Bradt found that authors of at least two nationalities wrote some 10 percent of the papers in principle ceramic science and technology journals. Bradt's analysis of the ceramic literature gauged how deeply these scholarly international interactions run in the educational and scientific ceramic communities (Bradt, 2000).

The general atmosphere for the globalization of ceramic technology and education is an encouraging one from practically every perspective that can be imagined. Obviously, there are different ways to promote the globetrotting activities of ceramic educators and scientist. But, in addition to these a digital library on the respective field would help to promote global cooperation or activities in this area.

To foster economic development including rural development

The economic importance of ceramic industry in any national economy is well recognized. Ceramics is the most ancient industry, which has gone through several stages and phases of development with the human civilization. The ceramic industry, which flourished as an art of potter for ages, has attained the higher status of ceramic science. It has grown with civilization and contributed substantially to the growth of any national economy. Even at the stage of advanced technology, the labor-intensive character of this industry has in no way diminished. Millions and millions of people of the world are dependent directly or indirectly on the ceramic product manufacturing or trade. It has a singular distinction of being of equal importance to both developed and developing nations, because of its linkage with the development and economic welfare of human race. The prospect of a truly global economy after the Cold War has compelled companies in many industries to reappraise how they do business.

Changes in the local and global business environments are transforming the way companies are managed. Although technology and manufacturing process capabilities remain critical to the industry, a key driver has been the way that suppliers and customers have become linked and interdependent. The movement of people, goods, information and services across borders is not only increasingly rapid and reliable, but facilitated by a world wired for communications and business transactions. The result is a major transformation in how business is conducted throughout the world. Increased porosity of national borders provides domestic companies with new opportunities abroad. It may provide them with larger market share and profits, economies of scale, learning opportunities, and faster growth opportunities. It also gives companies the flexibility to establish industrial production bases closer to suppliers, customers or end users. Finally, it allows access to new sources of raw

materials, labor, technology, and capital, potentially making the company more competitive against domestic and international rivals.

Increasingly borderless economy provides opportunities for foreign competitors as well. The result is intensified competition from a stream of new types of rivals with different organizational structures, corporate cultures, business strategies, core capabilities, cost structure, as well as market scope and scale. These competitors may enjoy protected home markets. Or they may enjoy long-standing, channel relationship with suppliers or customers that may be difficult to breach. These competitors may often follow their suppliers or customers overseas and seek to replicate this established relationship abroad. To compete, companies may also need to offer an increasing variety of products customized to more closely meet the need of increasingly sophisticated customers, with more education and easier access to information. The result is product proliferation and smaller production runs as heightened international competition leads to shorter product life cycles. At the same time, the increasing convergence of consumer tastes across borders makes it possible for firms to leverage R&D costs by expanding into overseas markets, thereby mitigating in part the high costs of producing new and improved products at lower costs. Finally, companies may also need to enter into strategic alliances, joint ventures, or cross-licensing arrangements with other companies (including foreign rivals) (Purrington and Bowen, 2000). Globalization has impacted industries, depending on the nature of products and markets. Globalization requires examination of business practices, customization of products, regulation of distribution.

The digital library can monitor the major events of the globe in order to keep ceramics manufacturer fully alert of the market trend and developments that could have an influence on their potential markets both domestics and overseas. It could promote cooperation amongst ceramics industries. Even close collaboration between academia and industries can be established to discuss various issues related to technology and technical aspects of the production. This digital library would help ceramics industry to work in a global economy in which customers, suppliers, and competitors are no longer simply national or regional firms. It would serve the companies with information necessary to compete on a global scale. It would be a tool or instrument of economic and social development of the world developed properly. Consultants or highly qualified professionals would be able to provide independent, technical evidence and advice on a broad spectrum of industrial problems and applications. Expert Witness Service extends from minor claims; report reading/writing; providing opinion through analytical investigations to high court actions could be provided to industries.

Rural development. Long distance, poor infrastructure, highly seasonal income and wide spread poverty characterize the challenges in rural areas. There is a definite advantage to ceramics for rural development. Ceramic raw materials such as clays and other non-metallic materials are available in large quantities in the crust of the earth. Ceramics permit the employment of all the plastic arts-design, composition, color, and painting, sculpture. Anybody of average ability or talent can construct creditable pieces. The procedure is simple, readily understandable, and provides a wide range for creative ability. The play of imagination is without limit. Rural brick and tile production that provides construction materials made from local raw material and that they provide rural employment thus contributes to the rural economy. However, rural brick industry is facing a major hardship.

The digital library could work as an online learning center for rural potter. This would provide access to a large variety of resources and online training materials covering a wide range of subjects related to rural pottery. People working in the field of rural pottery would have access to online information and training materials, which would help to impart them better training and serve them better information needs. Across the USA, e-learning has changed from technological curiosity to an integral part of rural public school education, offering more class options to students and even educating teachers. For the rural brick and tile production to expand and to be beneficial to rural areas, the constraints need to be overcome and information on the various issues on production would be provided to the community through the digital library. This unique environment would help to teach rural people ceramic articles production skills such as products made to be given as gift, decoration, children toys, religious requirements and that could be immediately marketed and could bring cash as they study.

To help facilitate archaeological research

The digital library would be used for archaeological research too. This could serve the archaeological science by providing result of laboratory investigations of ceramic artifacts analyzing choice of raw materials, manufacturing techniques and vessel functions. Working with these data in combination with studies of vessel shapes and decorative elements, it is possible to shed light on questions concerning provenance and distribution of prehistoric and medieval ceramic materials (Olivier, 2003). By combining the results of several independent analyses, it is possible to gain information concerning handicraft as well as contacts and relations between different groups of people. Well-established collaboration with archaeological institutions and museums throughout the world would be established and improved and ultimately an international network would be developed. The digital library would be used for the documentation of ceramic artifacts, all kinds of ceramic objects from prehistoric and historic contexts from the respective countries. In relation to type of material and to the specific culture basic data on macroscopical variables such as form, ware, color, surface treatment etc. could be documented.

Other benefits

Some others important benefits could also be achieved, for instance to provide perpetual access to the collections, act as a preservation archive for digital material in the field of ceramics, promote the study of local and regional collections on ceramics, promote an understanding of ceramic materials among the user community and the public at large, nurture scientific ideas and to honor ceramics as a product of human minds of human beings, regardless of nationality, provide a superb opportunity to bridge the gap in understanding and diminishing the boundaries between societies and technologies, represent the cultural heritage of ceramics of various countries, and understand the culture and societies of others

Implementing a digital library in ceramics

It is a paradox that, under circumstances where economic activity takes place at an increasingly global level, individual countries must give increased attention to their performance at the national level so that they can find a favored position within the world community. Therefore, each country may bring together all their national activities related to ceramics developing digital institutional repository as well as

community repository on ceramic. The premier institutes responsible to carry out research activities in the field of ceramics of the various countries need to take steps to design and develop infrastructure for the digital repository. For example, the Central Glass & Ceramic Research Institute (CGCRI) is the premier institute in India mainly responsible for carrying out research activities in the field of ceramics. It also imparts training and it also procures publications from within the country and abroad and is having a sound collection on this field, which could be treated as a national asset. This national asset could be shared easily amongst student and scientists wherever it is required. Therefore, CGCRI needs to take steps to design and develop the infrastructure for India. Indian government departments (e.g. DST/DSIR) also need to come forward to support CGCRI in this endeavour.

Setting up a digital library/repository in ceramics is also not a trivial task for the institutions. Many institutions and organizations are setting up open access digital repositories using open source software, following open standards. The Open Access and Open Source Software movements have gained rapid momentum world over. There is various free open source software available for developing digital libraries and the four most important are *Eprints* (from Southampton University), *DSpace* (from MIT), *CDSWare* (from CERN), and FEDORA (from Cornell and U. of Virginia). DSpace (www.dspace.org) is one of the most popular software developed jointly by MIT Libraries and HP labs. DSpace, a digital asset management system, can be used to build either institutional or discipline-based repositories or e-prints archives. DSpace helps create, index and retrieve various forms of digital content and is adaptable to different community needs. Interoperability between systems is built-in and it adheres to international standards for metadata. Using DSpace the institutions would decide the communities and the collections and sub-communities within them bearing in mind the aim of assisting research and education of ceramic art and science.

Regarding the cost factor, Dspace software is open source, so the major initial cost that institutions must bear is only the purchase of hardware. The system is designed to run on the UNIX platform, and comprises other open source middleware and tools, and programs written by the DSpace team. All original code is in the Java programming language. Other pieces of the technology stack include a relational database management system (PostgreSQL), a web server and Java servlet engine (Apache and Tomcat, both from the Apache Foundation), Jena (an RDF toolkit from HP Labs), OAICat from OCLC, and several other useful libraries. All leveraged components and libraries are also open source software. Libraries are bundled where possible (exceptions are described in the installation instructions). The system is available on SourceForge, linked from both the DSpace informational web site and the HP Labs site (Smith, 2003).

Staff time in loading and configuring the software must also be factored into the cost equation. The significant ongoing cost is staff time in maintaining and publishing the repositories. Attendance at forums (departmental meetings, seminars and workshops) is time consuming. Staff time is also required in negotiating intellectual property rights. The cost of creating additional metadata, particularly that associated with the preservation and administration of eprints (James *et al.*, 2003), is another aspect to be considered in developing strategic and economic plans for the preservation and usability of resources over time. Irrespective of scope, all the institutional repository projects so far have observed that the effort and organizational costs required to address repository policy, content management, and faculty marketing issues dwarf the technical implementation effort. These tasks include: developing content accession policies;

deciding on what metadata to store and present; creating digital document identifiers (DOIs); crafting author permission and licensing agreements to disseminate work indefinitely; developing document creation and input guidelines suitable to long-term archiving and proper presentation; training staff and authors in using the software to submit content; creating document submission instructions; and marketing the repository concept to prospective depositors (Crow, 2002).

It is also required to develop a metadata scheme on ceramic information resources to describe, locate, evaluate and manage ceramic information resources of the repository or to solve the problem of organizing information resources of the digital repository of ceramics.

In India, after the advent of independence, technological developments are taking place in leaps and bounds. Obviously, ceramic industries also have kept pace with other technological developments and are thus fulfilling the growing demands. It is a matter of pride to say that within such a short period India has almost achieved self-reliance in the ceramic needs of the country. In India there are organizations that carry out R&D activities in this area and naturally they need literature on the subject. The collection building of a library nowadays suffers from shortage of funds already mentioned. No library can procure all the documents or can satisfy their user needs just using their own collection only. Therefore, digital repositories containing the resources of organizations that are involved to carry out R&D activities in this area could link them to share information resources for their research activities. The proposed digital library on ceramics would be to provide an integrated resource where diverse information sources on the topic on ceramics may be brought together in a single navigable web site. This would bring together the wealth of information resources that is scattered in the different places.

The intent is to use the site as a learning tool to support exploration of research and development activities associated with ceramics, and to facilitate end user interaction with the content of these various resources. The focus of this digital library site would be also on accessing ceramic art collections as well as information resources related to the study of ceramics art. It would be designed so as to provide a single window access/gateway to the information resources on ceramics. As such, the digital library would be segmented into three distinct but integrated sections: ceramics art product collections, ceramics information resources including industrial information and link to ceramics related web sites. On the other side, in India, millions of traditional potters spread over lakhs of villages are still struggling hard for a meager livelihood with their ago-old experience in pottery industry. As such, this technique of traditional potters was handed over to them from their ancestors. It has an enlightening history and perhaps India was the first and foremost to invent the use of plastic clay, and for this enough of proofs are there in old scriptures of this country. Many agencies, including those of the Government of India, have been set up in villages to train these potters in improved technology. The technologies have been developed in such a way that it could help the potters on a decentralized basis. Scores of field workers are trained and sent to villages to teach and introduce the new methods of pottery (Mirmira, 1973). The digital library in this respect may help them to carry out their activities effectively.

Conclusions

Ceramics have developed around the world through the centuries as a result of how human beings think and act within their unique cultural environments. The development, manufacture and use of ceramics are social activity as much as

technological process. The history of ceramics is the history of human beings who created and used technical process and products. Even before the electronic age of rapid communications, glass and ceramic scientist and industrialist spanned the globe with their ideas and research collaborations, creating ceramic materials and products that would serve the society. Whether as basic clay products or as sophisticated electronic components, ceramic materials have encased the globe. The ceramist has formed global bonds that neither wars nor culture nor language barriers could break. Wars, rather than discourage the interactions of ceramists, have only encouraged scientific minds to collaborate in the development of more and more sophisticated materials for mankind. When the men and women from all over the world combine the power of their minds to pursue the problem of ceramic materials, the strong bond formed by the search for knowledge cannot be easily broken by wars, by political isolation, by geographical distance or even by trade dispute. Globalization has affected all of our activities to create international bonds in ceramic education, research and development, industrial management, production and trade. From countries around the world, scientists and engineers, educators and industrialist, historian and museum curators, and artist are interested to share international knowledge and information of the ceramic world. In one way, this would be possible developing digital library on ceramics. But, developing a digital library on ceramics is also not free from certain problems. These problems are cost, copyright, political barriers, technical barriers and attitude of the community.

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Appendix. Ceramic materials: contribute to NAE's top 20 engineering list

The 20 engineering achievements, www.greatachievements.org/, that have had the greatest impact on the quality of life in the twentieth century was announced on February 22, 2000, at the National Press Club in Washington, DC as a kickoff to National Engineers Week. Astronaut/engineer Neil Armstrong made the announcement on behalf of the US National Academy of Engineering www.nae.edu. Table A1 shows the top 20 achievements with examples of how ceramic materials make these technologies possible.

Top achievements	Examples of how ceramics contribute
1. Electrification	Electrical insulators for power lines, insulators for industrial/household applications
2. Automobile	Engine sensors, catalytic converter, spark plug, windows, engine components, electrical devices
3. Airplane	Anti-fogging/freezing glass windows, jet engine components
4. Safe water supply and treatment	Filters
5. Electronics	Substrates and IC packages, capacitors, piezoelectrics, insulators, magnets, superconductors
6. Radio and television	Glass tubes (CRTs), glass faceplate, phosphor coatings, electrical components
7. Agricultural mechanization	Refractories make melting and forming of ferrous and non-ferrous metals possible
8. Computers	Electrical components, magnetic storage, glass for computer monitors
9. Telephone	Electrical components, glass optical fibers
10. Air conditioning and refrigeration	Glass fiber insulation, ceramic magnets
11. Interstate highways	Cement for roads and bridges, glass microspheres used to produce reflective paints for signs and road lines
12. Space exploration	Space shuttle tile, high-temperature resistant components, ceramic ablation materials, electromagnetic and transparent windows, electrical components, telescope lenses
13. Internet	Electrical components, magnetic storage, glass for computer monitor
14. Imaging: x-rays to film	Piezoceramic transducers for ultrasound diagnostics, sonar detection, ocean floor mapping and more, ceramic scintillator for X-ray computed tomography (CT scans), telescope lenses, glass monitors, phosphor coatings for radar and sonar screens
15. Household appliances	Porcelain enamel coatings for major appliances, glass fiber insulation for stoves and refrigerators, electrical ceramics, glass-ceramic stove tops, spiral resistance heaters for toasters, ovens and ranges
16. Health technologies	Replacement joints, heart valves, bone substitutes, hearing aids, pacemakers, dental ceramics, transducers for ultrasound diagnostics, ceramic scintillator for X-ray computed tomography (CT scans) and many other applications
17. Petroleum and natural gas technologies	Ceramic catalysts, refractories and packing media for petroleum and gas refinement, cement for well drilling, drill bits for well drilling
18. Laser and fiber optics	Glass optical fibers, fiber amplifiers, laser materials
19. Nuclear technologies	Fuel pellets, control rods, high-reliability seats and valves, containerization components, spent nuclear waste containment
20. High-performance materials	Ceramic materials were cited for their advanced properties such as wear, corrosion and high temperature resistance, high stiffness, lightweight, high melting point, high compressive strength, hardness, and wide range of electrical, magnetic, and optical properties

Table AI.

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