Knowledge Management for Collaborative Exhibition Development

Theano Moussouri

UCL Institute of Archaeology
31-34 Gordon Square
London WC1H 0PY
UK
Tel: +44 (0)20 7679 4938
Email: t.moussouri@ucl.ac.uk

Bio
Theano Moussouri is a lecturer in Museum Studies at University College London. Her research focuses on the role of informal learning environments in family life, visitor experience and meaning-making and the impact of museum experiences on different visitors. Another research strand looks at collaborative learning among visitors and exhibition teams using qualitative methodologies. Theano has a BA in Early Childhood Education from the University of Athens and an MA and PhD in Museum Studies from the University of Leicester.

Abstract
Museums increasingly develop exhibitions through collaboratives, a trend that demands the investigation of novel ways to facilitate the exchange of ideas and the documentation of knowledge gained. Current knowledge management technologies and tools can support such cross-organisational activities, yet they are limited in that they do not adequately cater for the particular requirements of this activity. In this paper we show how the Mirror Knowledge Management (MKMS) system, specifically designed to support collaborative exhibition development around a three-dimensional web-based environment founded upon the communities of practice concept, can facilitate geographically distributed collaboration and advance exhibition development practice. Through user studies we identify the key elements of the MKMS that add value to face-to-face interaction or enhance existing collaborative exhibition development practices. Moreover, we show how the MKMS supports professional development and on-the-job training, both recognised as highly desirable features in this setting.

Key Words
Collaborative exhibition development
Knowledge exchange and management
On-line collaborative tools
Knowledge management system
Communities of practice

Introduction
One of the core functions of museums lies in the exchange and management of knowledge derived from the study of their collections/subject matter, and the dissemination of that knowledge to a wider audience. Exhibitions – along with programs and websites – are the main means through which knowledge is shared with museum audiences. With the emergence of new types of exhibitions that address a wider range of themes that cut across traditional disciplines and are approached from different angles (Dillenberg, Friman and Sims 2001), the challenge for museums is to bring together people from diverse backgrounds, with

different training and experience to work on exhibition teams. Indeed, an ever-increasing number of museums seem to adopt a team approach to exhibition development (Morris 2002). At the same time, there is an increased demand for wider public access and a decrease in resources available to museums. This is particularly a challenge for small to medium-size museums that have to balance the need to stay relevant with limited resources available for exhibition development. Museums have responded to this demand by forming partnerships to produce exhibitions (Morris 2002, Coats 1994, Pacific Science Center and SLi 1997).

Such partnerships are more commonly found in North America, predominantly amongst science-rich institutions, and started appearing in the mid 1980s. Owing to the geographically distributed nature of these cross-institutional teams, information and communication technology has increasingly been used to facilitate communication, knowledge exchange and management. Considering the cost, resources and effort invested in such ventures, a relatively small number of publications have examined exhibition collaborative (Coats 1994, Pacific Science Center, and SLi. 1997, Eriksen 2005).

The aim of this paper is to apply the concept of "community of practice" (CoP) to the development of collaborative exhibitions, where technology plays a key role. Specifically, it looks at the role of CoP in setting up and supporting a geographically distributed *community* of exhibition developers working with natural history collections (*domain*). It will also discuss the use of on-line collaboration tools as a way of facilitating long-distance collaboration and advancing their *practice*. The first section gives some examples of existing exhibition collaboratives in the US and Europe and discusses the benefits and challenges for their museum members. It is followed by a section which looks at knowledge management and how the CoP concept can be used to understand better and facilitate the work of informal structures or communities that already exist within organizations. The third section looks at a range of on-line collaborative tools used by existing exhibition collaboratives and introduces the Mirror Knowledge Management System (MKMS), which was developed using CoP principles. It is followed by a detailed presentation of the main features of the MKMS and a discussion of key findings from the research and evaluation carried out with the exhibition developers who tested it. In the closing section, we discuss the implications for museums of the use of on-line collaboration tools such as the MKMS.

Exhibition Collaborative: Evolution, Benefits and Pitfalls
The first two exhibition collaboratives appearing in the literature were the Science Museum Exhibit Collaborative (SMEC), which was formed in 1984 with funding provided by the participating museums, and the Exhibit Research Collaboration, formed a year later with grant support from the National Science Foundation (NSF) (Coats 1994). Other similar initiatives have followed since, including: the Travelling Exhibits At Museums of Science (TEAMS) collaborative, a consortium of small science museums funded by NSF in the US [1]; and the Youth Museums Exhibit Collaborative (YMEC), made up of eight youth museums located in metropolitan areas in the US and Canada. More recently, another NSF-funded initiative has appeared, the Nanoscale Informal Science Education Network (NISE Net), a US-wide community of researchers and informal science educators. In Europe, the oldest formal exhibition collaborative is the Common Approach for Scientific Touring Exhibitions (CASTEX) and it was funded by the Raising Public Awareness Programme of the European Commission (O'Connell 2004). In the mid 00s, the British Museum started being involved in a number of collaborations at a local, national and global level [2]. An informal exhibition development collaboration worth noting has been developed between the Institute of Archaeology (IOA) at University College London (UCL) and the Geffrye

Museum of the Home located in East London with the aim to train graduate students and to produce integrated exhibition projects.

The perceived benefits from setting up collaboratives for the co-development of exhibitions are considerable. Being part of a museum collaborative can help museums develop innovative products at lower cost, raise their profile while advancing their field, and build capacity within their organization. Small museums, in particular, face numerous challenges, including lack of exhibition development staff and/or staff performing multiple roles; limited opportunities to share ideas - due to the small size of their exhibition department, if it exists; geographic isolation; and operating on small budgets (Dillenberg, Friman and Sims 2001, Cheney and McSweeney 2005). In the US alone, small museums make up an estimated 75 percent of all museums, while, at the same time, they have no access to public or private funding bodies and their staff have limited opportunities for development and networking (Eriksen 2005). Hence, small to medium-size museums can benefit from and are, indeed, often more keen to take advantage of the opportunities that collaborations can provide to share expertise and resources. They can also reach out to a wider audience and use local expertise to test out ideas and adapt/translate these ideas for different types of venues and audience groups. Collaboratives can share and incorporate this kind of 'intelligence' in more effective ways, as opposed to organizations that build and offer travelling exhibitions, for example (Adelman 2001). Coats (1994: 1) also argues that 'membership in a collaborative enhances the prestige and credibility of the participants and increases the likelihood of funding both for the collaborative and for future projects'. Indeed, a number of the early pioneers of the collaborative approach, such as the Museum of Science in Boston, the Franklin Institute Science Museum in Philadelphia and the Science Museum of Minnesota, have been in the same and/or many other collaboratives until the present day.

On the other hand, collaboratives face huge challenges, with communication being one of the – if not the - biggest challenge. Exhibition developers are in the business of communication: they need to communicate with a wide range of internal and external audiences (Horowitz and Krile 1998). Communicating with colleagues who represent different organizations – sometimes in different geographical locations and/or cultures, with different institutional agendas and audiences - poses an extra challenge. However, despite their differences, the members of these cross-organizational teams often belong to the same professional organizations or more informal groups/networks, some of which are centred on the same subject matter (i.e. natural sciences or history), while others are unique to the type of work produced by groups of people from diverse backgrounds (i.e. exhibition design or web resource development).

The Management of Knowledge within Exhibition Collaboratives
A collaborative approach to exhibition development has made the need to manage not only the knowledge produced but also the exhibition development process more effectively. This is not unique to museums. Both profit and non-profit organizations recognize the value of knowledge and the need to invest in exploring the knowledge practices that exist within work environments. To this end, current knowledge management approaches increasingly adopt a user-centred perspective by focusing on value at the individual, group, team and organizational level, as well as on the "know-how" embedded in the practices of networks or communities of users (McDermott 2001, Prusak 2001). This approach recognizes that documented policies, flow charts and procedures alone cannot facilitate effective management of knowledge. Hence, it highlights the need to take into account the intellectual

and social capital which lies with individuals and groups, and which is tacit (Nonaka and Takeuchi 1995).

It is also recognized that, apart from a formal structure with policies and procedures, in every organization there are informal situations where people interact, build relationships and networks, and exchange and share knowledge (Lesser and Prusak 2002). This observation has renewed interest in the study of informal structures or communities and - combined with earlier studies on organizational learning by Argyris and Schon (1978), Bourdieu (1990) and Nonaka and Takeuchi (1995) - is used to improve our understanding of how communities are formed and evolve and, in doing so, how they produce, exchange and manage knowledge. More recently, the concept of "communities of practice", coined in the early 1990s by Lave and Wenger (1991), has gained ground and found application in a wide range of organizations in various sectors, including museums. CoP are ubiquitous and range from more formally structured ones, found within organizations, to quite informal ones. According to Wenger (1998), the distinctive characteristics of a CoP are its members' commitment to a *domain* of knowledge, the relationships developed between the members of the *community*, and the advancement of their *practice* through the development of a shared repertoire of resources. In the museum context, CoP theory has been used by museum professionals and researchers in order to set up projects and/or study how – on- and off-line - communities related to museums operate (Semper 2002, Fasoli 2002, Koepfler, McLain & Sala 2010). Studies that have used CoP as a framework for conceptualizing and studying collaborative exhibition design are few and far between (Lee 2007).

The study presented in this paper has used CoP theory because it approaches learning as a fundamentally social phenomenon, deeply embedded into the context of our experience of participation in the world. CoP take into account the social nature of knowledge production and learning that takes place in the exhibition development process, and acknowledge the active role participants play in the practices of exhibition production-related communities and how their identities are intertwined with their membership in those communities. It also allows for different levels of participation in different communities. Hence, we considered CoP to be at the centre of collaboration, and that, even though not all collaboratives may neatly fit with Wenger's (1998) strict definition of a CoP, they would probably have CoP-like characteristics.

Computer-supported Collaborative Exhibition Development
Morris (2002), in reviewing the trends emerging from survey studies, has pointed out the role existing technology such as software for project management, communication tools and networked-systems play in the management of exhibitions. Indeed, used appropriately, technology can make a considerable contribution in supporting both teams and CoP in their effort to manage knowledge in a more efficient way and at a much lower cost. Furthermore, in the current environment, where there is a lack of in-house exhibition development staff - especially in small museums (Dillenberg, Friman and Sims 2001) - and high turn-over due to an increasingly large percentage of museums going through organizational change (Morris 2002), technology can provide the space where museums store their 'organizational memory'. Existing technology can help, up to a point. For example, the TEAMS consortium used electronic mail, listservs, and a website to support their collaboration. The New York Hall of Science used the ASTC listserv to invite members to contribute to a brainstorming session for the Connections: An Exhibition about Networks project over the Internet. The Liberty Science Center's Experiences Services is involving a range of people in the development of a new exhibition on cooking (http://cookingexhibitchefs.ning.com/). STEPS

used a project management wiki via Basecamp, Webex for video and voice conference calls, as well as desktop sharing and email in order to assist a multi-institution collaborative network (Koepfler, McLain & Sala 2010). Basecamp became the preferred on-line project collaboration tool for members of the NISE Net collaborative, after trying a number of off-the-shelf tools such as an intranet system, a listserv and the public website of the project. The advantage of Basecamp over the other options was familiarity - a large number of NISE Net members had used it before and had set up their own Basecamps for the NISE project – and ease of use – individual Basecamps could be easily linked to the project's Basecamp working group. Basecamp is also used by the IOA students working on their projects with the Geffrye Museum. Morris (2002), reporting on technologies used by the Smithsonian National Museum of American History and its collaborators, refers to the use of web-based technologies used for planning and scheduling. YMEC use phone conference calls and email in between the face-to-face meetings they have three times a year. They often circulate materials electronically, while they use FTP sites to post large documents for discussion at these meetings. Hence, technology is used to sustain communication and exchange resources in between meetings, but most of the work is done during those meetings.

As the above presentation demonstrates, off-the-shelf tools can support some aspects of the work involved in exhibition development, namely the management and communication aspect of the project. However, none of the existing generic tools used by large collaboratives cater for the diversity of tasks exhibition teams have to perform "under one roof". In order to fully support cross-organizational collaborative exhibition development, we developed an on-line knowledge management system, known as Mirror. Mirror offers a particular solution to computer-supported collaborative work specifically created for exhibition development. Mirror [3] is predicated upon the principles of Etienne Wenger's model of CoP. According to this model (Wenger et al 2002), to function effectively and grow CoP need a 'shared workplace' or 'conversation space' where they can define and reinforce their domain; and tools that can facilitate the exchange of knowledge the CoP shares, and the development of relationships among its members. Mirror involved museums of natural history [4] as a model to explore the concept of CoP. It aimed to develop a methodology for the study of a museum-related CoP that could be adapted and applied in CoP operating in other settings; and to develop Internet-based tools (the Mirror Knowledge Management System) that can support knowledge production and exchange within CoP members.

Exhibition developers were chosen for a number of reasons. Firstly, they seemed to fit well with Wenger's definition of CoP. Exhibition production is a core activity that brings together a full range of museum personnel but, at the same time, team members still participate in the particular community of practice within their specialization. Due to the interdisciplinary nature of exhibition teams, this covers diverse fields ranging from project management and design to curatorship and interpretation. Clearly, they also form a network or a community of individuals who have close working relationships with each other, and their practice concerns the planning, development and production of (three dimensional) exhibitions. Thus, a study of exhibition-focused CoP can provide insights into a wider cross-section of CoP diversity found in natural history museums [5] and beyond. Indeed, exhibition work transcends museum types and subject matters: exhibition development projects share the same phases, while exhibition development teams have similar responsibilities and tasks whatever the museum type [6]. Hence, focusing on exhibition teams would make it easier to roll the MKMS out to different museums. Also, due to the nature of their work, we hypothesized that members of exhibition teams are more likely to have developed formal and informal relationships with a wider range of internal and external communities related to natural

sciences and/or exhibition development than any other group of museum professionals. We expected that exploring these relationships could better illuminate the complex net of interactions and the different levels of participation existing within a single CoP. In fact, these networks are very important for at least two reasons: communities tend to build on pre-existing networks, since the already-established relationships support their evolution more effectively; and they provide a forum for a dialog between internal and external perspectives, which can facilitate innovation.

The MKMS is a tool that provides the required 'space' and a means for having 'conversations' to support CoP of geographically distributed exhibition development teams. It combines and adapts existing software for project and content management, and employs three-dimensional digital visualization technologies over the Internet. By doing that, it caters for all aspects of collaborative exhibition development and helps teams manage both explicit and tacit knowledge produced at the different phases of their work. It can also offer a 'shared workspace' where organizational wisdom and expertise can be stored and retrieved. MKMS can further be used as a virtual meeting place where specialist organizational knowledge can be maintained and where internal processes can be automatically documented and reconstructed for review by internal and external team members [7].

MKMS Development and main Features
The conceptualization and design of the MKMS was based on basic [8] and applied research studies to ensure that it 'mirrors' the practices of the exhibition development teams and that CoP evolve around them. To this end, development, design and research were seen as a continuous iterative process: an initial set of user requirements was produced based on the basic research findings. In turn, user requirements were used to develop alternative-use case scenarios, which were subsequently presented to a number of users in the form of illustrative vignettes. Finally, a subset of the original requirements and usage scenarios was chosen that would be of primary benefit to exhibition developers and could be implemented within the time frame of the project. The members of the Mirror consortium were also geographically distributed across different European countries and, thus, had to find ways of working collaboratively and iterating through the cyclic design processes. Hence, development and evaluation proceeded in parallel using an interactive version of the MKMS available on-line and maintained by the technology partners. Progress was monitored via a so-called *issue tracker* and user feedback was collected at different stages of the development: 1) preliminary evaluation of the low fidelity mock-up; 2) evaluation of the high fidelity mock-up; 3) pilot evaluation of the prototype at the Mirror Workshop; and 4) final evaluation of the prototype from remote locations.

Ten European museums with natural history-rich collections, and of different sizes and type (small, medium, large; national, independent, university, regional and local authority), participated in the Mirror project. These included: the Institut Royal des Sciences Naturelles de Belgique (Royal Belgian Institute of Natural Sciences) in Brussels, Belgium; the Muséum national d'Histoire naturelle in Paris, France; the Riksmuseet (Natural History Museum) in Stockholm, Sweden; the Goulandris Natural History Museum in Athens, Greece; the Geological Museum of the University of Copenhagen; the Natural History Museum in Århus, Denmark; the Museo Civico di Storia Naturale di Verona (Natural History Museum of Verona), Italy; the National Museums and Galleries of Wales in Cardiff, UK; and the New Walk Museum of the Leicester City Museums, Leicester, UK. In addition, through the Institut Royal des Sciences Naturelles de Belgique, the Mirror project gained access to a European Commission-funded natural history museum network, CASTEX.

The prototype of the MKMS includes four main features: a 3D design studio; project management; content management (offering multilingual content); and forum and conference communication. All of the features are integrated and can be used in conjunction with existing software. Further, the MKMS can be used for training new members of staff, allowing for different routes through it; it can adapt to different approaches to exhibition development; and it has built-in the potential for evolving together with the "Mirror community". The following paragraphs describe the MKMS prototype features.

The 3D exhibition design studio (3DEDS) is a multi-user environment that assists collaborative visualization and exchange of 3D scenes and models as well as exchange of exhibit ideas and comments (Fig. 1). The 3DEDS can be used in conjunction with existing software such as Microsoft Project, AutoCAD, Photoshop and QuarkXPRESS. It can be used both by designers for developing and commenting on exhibition layouts and exhibits, and by other members of the team for viewing default images of the exhibition design.
"place Fig. 1 about here"

In the project management feature users can create an area for a new project; create team lists with different roles and responsibilities; create the exhibition development phases - as defined by each museum – with milestones, tasks and deliverables; create and manage the budget; create reports; and document the whole process from concept development to post-opening and project review (Fig. 2). Again the project management can be used in conjunction with existing software such as Microsoft Project.
"place Fig. 2 about here"

The library is the area where users can create, manage and exchange content (both generic and specific) related to the exhibition (Fig. 3). There is a public and a personal library area that provide different access rights to users. Among other things, the Library contains a database of contacts, organizations and suppliers, as well as content related to different topics such as interpretation and communication, exhibition technology and exhibition evaluation. Multilingual content can be uploaded and saved in different forms: text, image and film.
"place Fig. 3 about here"

Finally, the forum and chat communication features enable users to communicate with colleagues in the same museum as well as in other organizations (Fig. 4). A conference server enables simultaneous collaboration using visualization and text.
"place screenshot 4 about here"

Developing and testing an Exhibition Collaborative through the MKMS
As mentioned above, the development of the MKMS was based on basic research and evaluation in order to develop and test the concept of the Mirror community, the members of which came from different exhibition teams and were located in different institutions across Europe. This section will present key findings from our basic and applied research to show how they shaped the development of the MKMS and to demonstrate its key benefits in the co-development of exhibitions. The basic research – a mini-ethnographic study – helped us delve into the interworking of exhibition teams and CoP-related communities which are made up of people who have a wide range of backgrounds, knowledge, skills and expertise; play different roles within the exhibition team; and participate in CoP-related communities on different levels. The mock-up and prototype testing of the MKMS was embedded in a series of workshops, where the Mirror community came together to develop and work on an

exhibition scenario. Communication was facilitated through the Mirror forum and the chat feature (Fig. 3 above), as well as by having mini face-to-face meetings.

CoP versus Teams: fuzzy Boundaries
First of all, we found that the boundaries between the exhibition development teams in the ten museums studied and the operation of an informal CoP appeared to be blurred. This came in contrast to the CoP literature (Wenger et al 2002) which tends to make clear distinctions between goal-focused teams and CoP. What seemed to happen in our case is that, when individuals from different backgrounds and museum departments came together to form an exhibition team, they brought with them their own specialist areas of knowledge. Yet they may, because of their shared understanding of the museum and changing positions within it, also act in CoP-like fashion at some level. Further, while individuals working within exhibition development teams share fields of interest and may form a definable social community with shared knowledge (which may feed into exhibition development processes), the core of the exhibition-building activity – interaction between team members – is not centred around a single CoP. Hence, there is good reason to believe that exhibition relationships act both as a (relatively weak) CoP and as (stronger, though not necessarily cohesive) teams of individuals who each belong to other CoP. The fact that individual exhibition team members rely upon their own CoP to improve and develop practice, suggests that both teams and CoP share knowledge that covers the same topics. This does not come as a surprise since both of them are dedicated to developing the same domain of knowledge. For exhibition teams to meet their goals, they need to cover all topics related to the concept, design and management of an exhibition. This knowledge may be used again by the same team or by different teams when building another exhibition, via their membership to similar CoP.

From the above finding we concluded that, for the MKMS to be useful, it would need to cater for both teams and CoP-related communities; and, consequently, it would need to cater for all aspects of exhibition development (project and content management as well as design and communication), as well as for the more informal knowledge exchanges that take place between members of the same CoP.

Training and continuing Professional Development
The research identified the need for organization, developmental information and training – particularly in areas of museum communication. This indicated that the MKMS should create a knowledge-sharing environment, along the lines of a CoP. The content of, and ability to communicate through, the MKMS (Fig. 4 above) appeared to be the aspect of the system which added value to individuals, groups and organizations.

Another point raised by the Mirror members when testing the MKMS was that it could be used as a means to structure the exhibition development process, and also as a training tool to demonstrate the process to new staff members or those not familiar with exhibition development. Although users felt that training is needed in order to use the Mirror system, they thought that three or four hours of training would be enough, provided that there is a manual.

Research versus Interpretation
The research also identified tensions between collections-based research and interpretation, particularly in large national museums. A dominant source of tension seemed to be that between members of exhibition teams who mainly conducted research but were also asked to

work on exhibitions related to their research areas, and interpretation and communication staff. These different perspectives seemed to run in parallel with the two main functions a museum is perceived to have: academic research and a social/educational function. However, it was often acknowledged that finding new ways of using and presenting the results of collections research is what produces innovative exhibitions. Research-heavy institutions are perceived as conservative in the modern museum context, often because researchers can be inflexible about the need to communicate scientific detail. On the other hand, there is clearly a tendency to see the isolated collection researchers as simply self-indulgent, which can be a misrepresentation of their work.

The above finding suggested that there is certainly scope for a resource – like the MKMS - capable of mediating between research, the interpretation of scientific evidence, and audience and communication studies. Further, such a resource would need to cater for participation for those individuals who remain at the periphery of the CoP until such time as they need specific information and tools to facilitate exhibition activity. This is particularly important for members of the extended exhibition development team who are involved in the periphery of exhibition work or in specific projects only (such as research staff). The MKMS could also provide a platform on which these differences can more easily be connected and illustrated. Since exhibition developers do not form homogenous communities, they may benefit from common, supportive software which makes the similarities and differences more transparent, and which thereby could ease the learning processes. Our expectation that such a support system would facilitate the resolution of conflict would have to be further investigated in the future. Given the short-life span of this project, we currently do not have any evidence to support it.

Exhibition Collaborative: an evolving Process/Entity
Developing collaborative exhibitions with other museums or cultural institutions, as well as working more closely (and from an early point in exhibition development) with fabricators and external design firms, seemed to be a priority for all museums in this study. Some of them had already pursued such partnerships on a number of projects, while others had not accomplished that yet. All in all, collaborative exhibition development was high on the agenda of all museums participating in this research. Although the MKMS was initially perceived as a collaborative tool, this finding indicated that the MKMS (or any such system, for that matter) should also be able to evolve with the changing needs of its users.

MKMS's added Value
Based on the findings of the mock-up and prototype evaluation, a number of key elements of the MKMS were reported to add value to the system. This included the following interrelated elements: collaboration, communication, managing the development process, content and technology. The collaborative element of the Mirror community seemed to be what would provide value to individuals, teams and organizations. The 3D design studio was particularly referred to here as it enabled the designers to co-design exhibits in real time and allowed the other team members to visualize the exhibits. What participants stressed was the fact that this visualization tool sits within a comprehensive solution that covers all aspects of exhibition development. The ability to communicate with other museums and other colleagues – who may or may not work on the same project – and work on collaborative projects was mentioned as the main motivation for using this system. All museums were already involved or planning to be involved in collaborative projects. People's ability to communicate in English as a common language and the size of the Mirror community would be instrumental in making a decision on whether to join or not. Further, the fact that Mirror can help

museums formalize the exhibition development process and, hence, make it more transparent at a time of increased pressure for accountability, seemed to be important for users in deciding whether to join. This finding should not come as a surprise since formalizing exhibition development appears to be a trend amongst the AAM-NAME members, as documented by a 2002 survey conducted by Rounds and Hulshof (2002) where 108 institutions participated. Furthermore, using common exhibition development-related terminology in a consistent way was seen as part of the 'formalization' process and as key to effective communication. Indeed, lack of shared vocabulary can often lead to conflict within exhibition teams (Cohen-Strayner 2010). It was also felt that the nature and type of content gathered, as well as the ability to add content in different formats and languages, would add immense value to the system.

Information and Communication technology-related Issues

Both the basic and applied research studies showed that the familiarity and ease of use of information and communication technology (ICT) play a key role in the acceptance of the MKMS. This is supported by informal feedback we received from members of other exhibition collaboratives mentioned above. Mirror team members reported to have used the most informal and direct methods to locate solutions to exhibition development problems (face-to-face visits, the telephone, email). Museum appreciation of technology among participating museums also varied a lot. Large institutions with considerable resources to maintain such technologies were more inclined to use them. However, the MKMS could act as a forum to develop reliable museum applications and installations.

Although people thought that they would not need considerable training on how to use the MKMS (they were all very experienced ICT users) they felt that the Mirror community and system would need continuous support and development, some of which should be provided by the community. However, they thought that Mirror would need its "champions" within each participating organization. Further, Mirror members commented on the value of having a mixture of face-to-face meetings and tools like Mirror for helping them to create a sense of shared identity as a community, exchange knowledge and start improving practices. They felt that, although technology is an important factor in community building and sustaining, it is not enough [9]. People would need on-going support and some form of social, face-to-face contact as well. They would need the support their community members and "champions" can give them as well as technical support. The importance of face-to-face meetings is also underlined by all the other networks presented in this paper.

Overall Experience of the Participants

Mirror members made a number of positive and negative comments about their experience with the MKMS during the exhibition development workshop. Since we only tested the prototype of the system, there were quite a few bugs, error messages and issues with navigation in some areas of the system. Of course all of those issues would need to be addressed and fixed to simplify it and make it more intuitive. However, what we will present here is overall experience with the system and key areas that met or failed to meet the Mirror members' needs. As these refer to areas of exhibition development common to all such projects they go beyond the case study presented in this paper. They are chosen because they highlight issues of common concern among exhibition developers across different institutions.

All Mirror members were able to follow and successfully complete all tasks either on their own or with some help from the facilitators. One of the most important issues raised was that

the MKMS (and any such system for that matter) should be able to be used in conjunction with existing software. Another commonly reported issue was the terminology used to describe different elements of the exhibition development process. This was partly due to the fact that different museums in different countries would use slightly different terms to refer to the same element of the process, and partly because the prototype had not always used standard terminology. For example, Mirror members asked for standard project management terms (like "milestones") to be used in the project management section. Furthermore, all terms would have to be explained in the MKMS glossary. An important comment for other potential uses of the MKMS was that it could provide excellent links with the marketing and public relations side of exhibition work.

Mirror members also commented on their experience with different areas within the system. Specifically, they found the 3-D studio and the on-line communication facilities (conference and forum) particularly useful. Mirror members reported that being able to look at the same designs or documents, and to discuss, comment or change them as a group had the possibility to transform the way they develop exhibitions. However, they found it problematic that no dimensions or reference scale was provided. Another area of the system that attracted a lot of attention was project management. Mirror members expressed the wish to have a flexible project management tool to fit the needs of the different museums and projects. For example, they wanted to be able to specify how tasks were going to be assigned and timetabled: some tasks need to be shared between more than one person or department and run across more than one phase of a project, while other tasks may need to be added later during the process, as the need arises. A common request was for the system to send updates whenever changes were made so that team members could see how new development might affect their work. Furthermore, they all expressed the view that all team members needed to have access (but not necessarily editing) rights to all areas of project management, such as the budget, lists of deliverables and tasks, with their description and information related to who has been assigned to them, the deadline, and where it should be saved once completed.

Although a number of elements are identified and presented in isolation above, the 'value-addedness' of Mirror as a collaborative, knowledge management and communication tool was its ability to combine all these functions in the same environment. Furthermore, what would make it even more attractive would be making it compatible with existing software.

The next section will draw together some of the key issues presented above and discuss their implications for museums.

Conclusion and Future Work
A key aim of this paper is to show how the use of on-line collaboration tools can facilitate long-distance collaboration and advance exhibition development practice. The review of relevant literature showed that, by using a knowledge management system, exhibition development and coordination could become more transparent and help ease tensions. Furthermore, the development and management of exhibitions – especially collaborative exhibitions where a large number of individuals from different backgrounds and different institutions are involved - is a considerable undertaking and should not be underestimated.

With more and more museums choosing to form partnerships, there is a clear opportunity for technology to support internal processes. As mentioned above, several museums have already started experimenting with off-the-shelf technology. The software currently used to support exhibition development provides support with project management and communication and is

a generic tool that can be used for any type of project. In contrast, the MKMS can perform "under one roof" and cater for all aspects of exhibition development and the needs of the CoP of exhibition developers. The research showed that the MKMS's added value lies in its ability to combine and support collaboration, communication, the management of the development process, content development and exchange, and technology. A focal area of collaboration seemed to be the 3D design studio that enabled designers to co-design exhibits as well as allowing other team members to visualize those exhibits in a 3D environment. Although the design studio (crude as it might be) was referred to by all Mirror community members, its added value lies in the fact that it sits within a comprehensive solution that covers all aspects of exhibition development and, also, facilitates different levels of communication within and across exhibition-related communities.

Although technology is a key enabler in facilitating and sustaining communication, face-to-face meetings play a key role in forming and sustaining exhibition collaboratives. This paper does not question the importance of face-to-face meetings, which are considered to be irreplaceable. It argues that, by carefully developing an approach to the management of knowledge as the basis for the incorporation of ICT tools in the exhibition development process, they can offer significant benefits. In particular, the research conducted within the Mirror project has demonstrated the need to explore the specific needs and practices of particular CoP. The literature on CoP can be particularly helpful at providing the concepts and language needed to talk about issues so 'obvious' and part of everyday life as CoP. It is also useful for framing issues and identifying questions that must be asked. However, we argue that it cannot replace research in the case at hand which is necessary to understand its particular characteristics. In this study, this was demonstrated by the fact that in exhibition development there is a great amount of overlap between teams and CoP.

Hence, instead of focusing on what distinguishes CoP from other groups, we need to embrace the diversity and complex nature of museum-related communities, where the boundaries between groups and CoP are not clear-cut (Hoeg Hansen & Moussouri 2002). Furthermore, we suggest that groups, networks and CoP are on a continuum, with museum professionals being – core or peripheral - members of multiple groups and CoP, as defined by Wenger (1998). Membership to both formal and informal groups and CoP involves the exchange of knowledge related to a domain of knowledge (defined by the exhibition topic) and the practice of exhibition development. As they do that, their members develop relationships with each other. This relationship between exhibition development-related CoP and groups was evident in all the museums that took part in this study. The nature and size of the museums did not seem to be a determining factor. Owning to the ubiquitous nature of CoP, we can hypothesize that our findings can be applied in different types of museums. However, this is something that needs to be researched further as the museum content (*domain*) might have an impact on findings.

One of the most commonly cited goals of the exhibition collaboratives reviewed in this paper was staff training and continuous professional development. Indeed, the research showed that the MKMS can support professional development and on-the-job training. However, individuals and organizations would need on-going support if they are to become able to use the MKMS effectively. Mirror "champions" within each organization could play that role. This is an important finding since there is a constant need to train new staff - who may have considerable expertise in the subject matter/collections but no exhibition development experience – and staff in small museums, as documented in the literature (Siskel 2002, Jennings 2002, Cheney and McSweeney 2005). Using the MKMS with its on- and off-line

social support and networking system can speed up the training process and make it more effective.

The evaluation has also demonstrated that, in developing a knowledge management system, one needs to consider and solve a number of practical issues. For example, one of the open questions is how knowledge management systems such as the MKMS might be used in the long run: whether they can become a tool used and incorporated into the normal working lives of their users; which practices they can enhance; and what benefits they can offer to the individuals and organizations involved. Based on the research conducted for the Mirror project, it is expected that the adoption of such systems depends on at least four factors. Of primary importance seems to be the range and the quality of the content developed and held on the system. Although the Mirror consortium did, in consultation with the users, develop a considerable content collection we found that content needs to be continuously updated, developed and used by community members. Also, it appears that a 'critical mass' of museums interested in joining a community such as Mirror is required to make it valuable enough, since having access to a significant network of professionals seemed to be a high priority among users.

Another important issue to consider is whether a system like that is able to enhance existing practices. We understand that the use of technology can only succeed if it complements existing practices. A good example is the pivotal role of face-to-face meetings. As mentioned above, the MKMS was seen as another component in fostering communities and improving collaboration. It is only one component of a solution and can only provide assistance in an environment that promotes communication and the sharing of knowledge. Hence, users can only benefit to the degree they contribute to the common body of knowledge. Finally, overcoming the problems associated with the deployment of another new technology will be a noteworthy determining factor. Familiarity with the system did not seem to be a particular concern. Based on our research, participants' training needs were reportedly quite modest. While only a long-term cost benefit analysis could determine the viability of systems such as the MKMS, our work has shown that there are distinct benefits for exhibition development teams who employ this system.

this area of practice, which remains largely under-researched. A big thank you goes to: Kate Vogel, Tricia O'Connor, Christine Farris, Maria Mortati, Jenny Sayre Ramberg, Edward Rodley, Eric Siegel, Gail Ringel, Eugene Dillenburg, Catherine McCarthy, Kirsten Ellenbogen, David Goudy, Victoria Coats and Frances Benton. Finally, I would like to thank George Rousos for his advice and helpful comments on earlier versions of this paper and Catherine Charles for her thorough editing and proofreading of the final version of this paper.

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Figures captions
Fig.1. The MKMS 3D exhibition design studio enables collaborative visualization through the exchange of spatial models.

Fig. 2. Project management for collaborative exhibition development under the MKMS.

Fig. 3. Content management using the MKMS highlighting the document preview feature.

Fig. 4. Forum management under the MKMS highlighting the Gannt chart feature.

Table 1. The key themes of Community, Practice and Domain in the Wenger model (Wenger et al 2002) together with ideas from Kim (2000) and McDermott (2002) were adapted and used as a basis to design the interview and observation tools as well as to guide field note-taking (See footnote 8).

Endnotes
[1] For more information about TEAMS visit: http://informalscience.org/research/show/3207 and http://www.inverness-research.org/reports/2005-04-teams/2005-04-Rpt-Teams-summative_eval.pdf (12/10/2011).
[2] For more information on the British Museum's national collaborations see: http://www.britishmuseum.org/the_museum/museum_in_the_uk.aspx, while information about its international collaborations can be found at: http://www.britishmuseum.org/the_museum/museum_in_the_world.aspx
[3] Mirror is a 2 million Euros (around $2 million) project funded through the European Commission Information Technology Society (IST-2001-32504) 5th Framework Programme. The project consortium consists of IT companies (Syntax Information Technology, Inc., Greece; uma, information technology, AG, Austria), universities (Museum Studies Department at Leicester University, UK; The Manchester Visualisation Centre, University of Manchester, UK; and University of Athens, Greece), and user representatives (Institut Royal des Sciences Naturelles de Belgique, Brussels, Belgium).
[4] Natural history museums were chosen as test sites because of their membership to an existing exhibition collaborative, CASTEX. A large number of the participating museums were already CASTEX members, while the others had close links with one or more CASTEX member museums. Our assumption was that they would meet at least some of the key CoP characteristics (focus on a particular domain, i.e. natural history and exhibition development, community relationships and practice) through their CASTEX membership or their existing links with CASTEX members.
[5] For a discussion of CoP diversity found in exhibition teams see Hoeg Hansen and Moussouri (2004).
[6] Museums that use the team process and have formalized exhibition development seem to go through similar project management phases that characterize interpretative projects. For a discussion see the 2000 and 2002 spring issues of *Exhibitionist* (Formalizing Exhibition Development & Rethinking the Exhibit Team). Similar approaches are used by the London-based Science Museum and Victoria & Albert Museum.
[7] Morris (2002) reported that 91% of the museums surveyed were undergoing organizational change. Further, referring to performance measures she commented that only a small number of museums 'are looking at the internal processes and attempting to take lessons learnt from their experiences' (Morris 2002: 9).

[8] A mini-ethnographic study was designed using semi-structured interviews, field notes, participant observation and secondary recourse. The main aim was to explore the exhibition developers' perspectives on how their community operates and how they create knowledge or engage in knowledge exchange at a local, national and European level. Approximately five members of staff from each museum were involved, representing different development-related roles (such as management, research and curatorship, exhibit design, interpretation) and departments. The key themes of Community, Practice and Domain in the Wenger model (Wenger et al 2002) were used as a basis to design the interview and observation tools as well as to guide field note-taking (See table in appendix A).

[9] This point was made by a recent article by Kevin Desouza (2003) who argues that ICT is not a 'silver bullet'. Knowledge management can only succeed if it moves the motivational barrier by getting people to interact and 'share their know-how'. Desouza goes so far as to say that only face-to-face interaction can facilitate tacit knowledge exchange.