A Space for Innovation and Experimentation: University Museums as Test Beds for New Digital Technologies

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There is an irony in the perception of university museums today. Despite the fact that universities are places where innovation is paramount and new discoveries are made every day, university museums have a reputation of being traditional, object-focused and guardians not only of history, but of historic practices. University collections have been likened to "mausoleums" that function to protect the legacy of the institution itself, rather than as sources for new discovery.[1] Certainly, anyone entering the Petrie Museum of Egyptian Archaeology at University College of London (UCL) might feel this way. The museum was established in 1892 as a teaching resource for UCL's Department of Egyptian Archaeology and Philology. The large majority of the museum's 80,000 ancient artefacts were excavated by Sir Flinders Petrie, one of the world's greatest archaeologists. The collection is housed in a small space on UCL's campus in densely-packed display cases dating from the early 1950s. However, despite the look of the space, the Petrie Museum has always been connected with innovation. Flinders Petrie himself pioneered a range of archaeological techniques and UCL was the first UK university to offer Egyptian Archaeology as an academic discipline. More recently, the museum was one of the first to make its entire collection accessible through an online image catalogue. Following in this tradition, the Petrie has made great efforts to support new research into digital technologies that seek to change the way audiences engage with material culture and heritage. Over the past two years it has transformed itself into a digital test bed where new technologies being

developed by academics across UCL can be set up and pilot tested. This chapter looks at three digital projects developed at the Petrie Museum between 2010 and 2012. Each demonstrates how university museums have the potential to fill a gap in the technology development "supply chain" by bridging the divide between blue sky research and innovation that has social impact in the cultural sphere.

Project 1: Swipe I Like

UCL's Bartlett Faculty is world-renowned for its innovative work related to architecture and the built environment.[2] It offers an MSc degree in Adaptive Architecture and Computation, a programme that teaches students to see digital technologies not only as tools for designing new physical spaces but as mechanisms for enhancing built environments by making them more adaptable to the people who use them.[3] MSc students are required to undertake a project using iterative prototyping and design methods in the field or in a laboratory setting in order to complete their degree.

The Petrie Museum was approached by Bartlett MSc student Mortiz Behrens, who wanted to investigate the use of RFID technology in architecture. RFID technology, which uses radio waves to transmit data wirelessly, is commonly used for building access cards where the user swipes a reader to be admitted. His thought was to combine RFID technology with the Facebook *I Like* feature to enable people to easily communicate preferences about an event occurring in the physical world without having to log on to a computer. Users

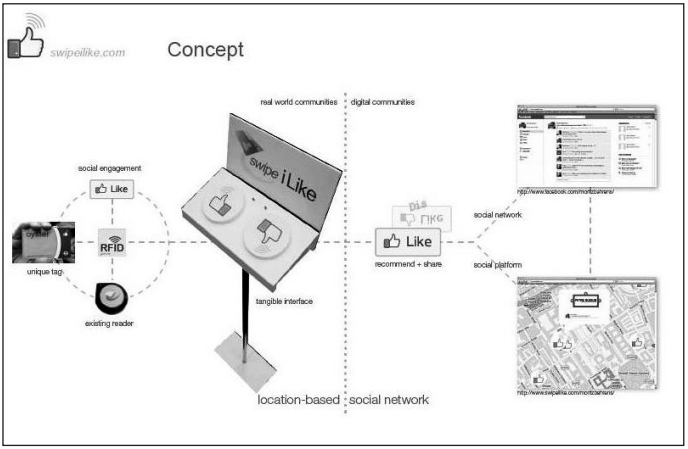

Figure 1: Schematic of the Swipe I Like system.

could simply swipe an RFID card (like a student ID or transport travel card) across a reader and instantaneously register their preference online in the virtual world.

Behrens initially approached the Petrie about installing RFID readers in order to allow visitors to express whether they *Liked* a particular museum event. However, the opportunity for using this technology to collect a broad range of visitor opinion data was instantly recognised by the Petrie team. Collecting visitor data is difficult for museums, especially for those that do not have ticketed admission. There is no way of recording demographic information on a routine basis, much less more nuanced opinion data. While supermarkets use loyalty cards to track consumer data, this method of data collection has never been used in a museum environment. *Swipe I Like* seemed to be a way for museums to enter this realm of continuous visitor data collection.

In order to develop the research idea, Behrens was invited to a Petrie staff meeting to discuss how the technology could be put to use. The team decided that the I Like feature would not be used to simply recommend a museum event, but to collect opinions about controversial aspects of museology. The team wanted to push the boundaries of typical commercial uses for such technologies and encourage visitors to think more deeply about issues such as the display of human remains, the use of 3D technologies to present objects, and the demand for repatriation by source communities. Not only would it give visitors the opportunity to express their views and thereby increase their connectedness with the collection, the results would provide the staff with useful information which could inform how future exhibitions are designed.

The field study was conducted over a three week period. RFID readers were mounted on stands and placed in relevant locations in the museum. Visitor services staff informed visitors about the study and how to participate as they arrived. The impact of the project was observed almost immediately. Participants looked at objects and displays longer in order to formulate their opinions. Even more interesting were the instances where families or groups came together but only one person had a card using RFID technology – an Italian family visiting on a holiday had quite an extensive debate about the issue of repatriation, children on one side and parents on the other. There were some things, however, that we immediately knew did not work. One question – *I Like the Petrie Museum displays generally* – was connected to a feature

Figure 2: Swipe I Like *card reader in the Petrie Museum galleries.*

that would instantaneously register and tweet the statement on the museum's Twitter account. It quickly became apparent that repeating this statement multiple times a day looked like automated spam rather than a personal recommendation. Behrens and the Petrie team jointly decided to stop this aspect of the study and consider the use of other social media platforms for instantaneous distribution of data.

A barrier to participation was explaining the technology to visitors. A particular issue with this project was explaining to visitors upfront that any personal information connected to their RFID card would not be accessible to the museum; the only identification information transmitted is the unique code associated with the card itself. An introductory leaflet was created to explain the technology, but key to the high participation rate were highly engaged visitor services personnel who could communicate the use of RFID cards and readers quickly and simply.

Overall, 859 visitors participated in the study and the results formed the basis of Behrens' dissertation. A discussion with Behrens' tutor, Lecturer Ava Fatah gen. Schieck, revealed that it was one of the most developed research projects submitted that year, not only because of the amount of research data collected, but because it was implemented in an actual museum where the dynamic factors experienced in a real world setting (outside a lab) could be observed.

Based on his work, Behrens was invited to become a research assistant at the Bartlett after graduation and has launched a start-up company that will develop *Swipe I like* software and devices for a more extensive roll out across the cultural sector.[4]

Project 2: 3D imaging

The Department of Civil, Environmental and Geomatic Engineering at UCL has a long history of research in the area of 3D imaging technology. For several years UCL Museums has

worked closely with Professor Stuart Robson, who leads a 3D scanning initiative to investigate the uses of 3D technologies across the heritage, medical, engineering and creative sectors.[5] Due to UCL's multidisciplinary approach to exploring this technology, the university has been able to work with a number of commercial and government organisations to explore a range of different types of 3D imaging mechanisms, techniques and applications.

Robson and other researchers in Geomatic Engineering have a keen interest in the Petrie Museum collection because it presents numerous new research challenges for 3D imaging technology – irregular shapes, complicated materials, and a diverse colour palette. In 2007, UCL entered into a partnership with the Canadian company Arius3D, a leader in the development of 3D laser scanners.[6] A large part of this partnership involves developing scanning technology to better capture heritage materials and to produce the world's first 3D image library for museums using the Petrie collection. While the partnership has yielded improvements in laser scanning technology which have resulted in the production of extremely high quality 3D images, end-user applications for 3D images had not been extensively explored until recently. In 2010, the Petrie won a grant from the Museums, Libraries and Archives Council (MLA) to develop an online exhibition design tool that would allow designers and members of the public to develop displays using 3D images of the Petrie collection. In addition, an opportunity arose to display 3D images as part of an exhibition at the British Library.[7] For this, a computer-based

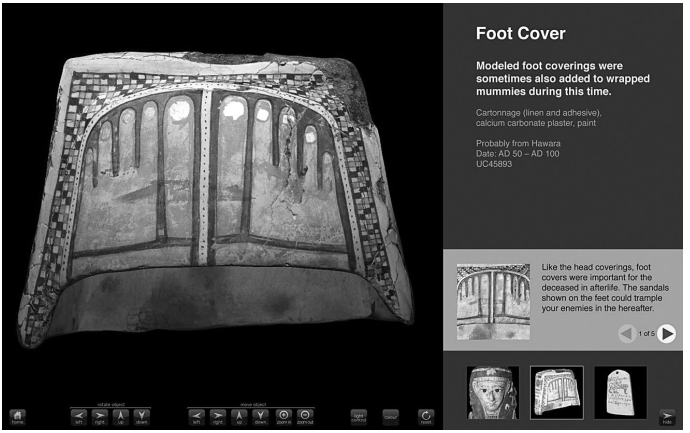

Figure 3: The computer-based 3D exhibition Crossing Over.

display called *Crossing Over* was designed by IET, an Ireland-based multimedia company which has been exploring the potential for using 3D images for large-scale international touring exhibitions.

Developing end-user applications using 3D images of the Petrie Museum collection brought into sharp view the challenges of moving from blue sky technical research to applied uses of 3D technology. The first, and maybe most important challenge, was cost and scalability. There is no way around the fact that scanning objects is time and labour intensive. Scanning ancient objects is not like scanning manufactured components. Objects must be reviewed for condition and proper handling before being scanned. The scanning process itself can take days if an object has an irregular shape, is made of multiple or troublesome materials, or has hard to capture colour or shine. However, some volume

of 3D models is necessary to make user applications interesting and commercially viable. Consequently, the museum found itself bumping up against production limitations in developing these end-user applications. Particularly in the case of the online exhibition design tool, where the objective is to give users the same access to the collection as the curator working in the museum, having as many objects available as 3D images is critically important.

A second challenge was quality. The research around 3D imaging has focused on improving colour, light and texture accuracy. However, the heavy data sets that result from the production of high quality 3D images cannot be used in web-based applications. In order to make them usable, the application developer has to "decimate", or reduce the amount of data contained in, the 3D image. This raises an important issue: should museums invest in high quality image capture if they are currently unlikely to be able to present that level of quality to the public? Because of the fragile nature of the Petrie collection and the need to limit the amount of handling, it was decided that capturing the highest quality data possible was prudent. This decision was based on the assumption that rapid advances in web-based technologies will likely yield 3D viewing tools capable of displaying the full quality of images in the near future. Still, it is important that the Petrie confronted this issue – first, because it will incentivise research and development in 3D viewing tools and second, because it allows advocates for use of 3D technologies in the heritage sector to prepare for potential arguments against such investment.

The third challenge was to understand whether audiences would see the value of 3D models as digital replicas. Most people visit museums because they want to see authentic original artefacts. Particularly at the Petrie Museum where some objects are 5000 years old, people come to be close to history. As a public university museum, the Petrie is well positioned to explore this issue. The museum conducted a series of user testing days that allowed visitors to engage with both applications and provide feedback in various forms, including one-on-one testing sessions, focus groups, and questionnaires. The findings indicated that 3D images are valuable resources that improve visitors' access to and engagement with museum collections, but cannot act as substitutes for actual objects. For example, the value of the computer-based display for the British Library was that visitors had the opportunity to see objects from perspectives not possible in traditional displays. The online exhibition design tool added value in the sense that for the first time audiences could be curators – they could select and group objects in order to articulate new meanings and share different perspectives. Later, the Petrie conducted a study aimed at understanding whether visitors learned more after using a range of digital tools (including the 3D applications). The results showed that there was not a substantial difference in knowledge acquisition between visitors using digitals tools and visitors using paper-based learning tools. This was a small informal study, but it served to remind those involved in 3D research that the technology itself is only as good as the user

applications that deploy it.[8]

The work that the Petrie has done in 3D has not only informed the direction of future research at UCL, it has provided valuable data for the museum sector. A number of the larger UK museums have been experimenting with 3D for many years, but no model for sector-wide adoption of the technology has been developed. Many of the large funders of heritage in the UK are prepared to invest in new digital technologies that help improve access and engagement, but are rightly hesitant to make the large-scale upfront investment necessary to establish 3D imaging programmes without evidence of the costs and limitations of the technology balanced against the potential benefits of 3D. Over the years, UCL has attempted to start answering these questions – an Arts and Humanities Research Council (AHRC) funded project called E-Curator looks at the potential of 3D technology from a number of different perspectives.[9] The Petrie's recent work with end-user applications takes this research one step further by introducing 3D to the general public and allowing the experience of developing end-user applications and visitor feedback shape the future research agenda.

Project 3: Tales of Things

The Centre for Advanced Spatial Analysis (CASA) at UCL is an interdisciplinary research centre dealing with digital technologies in geography, space and the built environment. As part of a collaboration with Brunel University, the University of Dundee, the Edinburgh College of Art and Salford University,

CASA is exploring new ways of preserving social history by providing a platform to allow "memories" to be attached to everyday objects via simple tagging mechanisms.[10] A major output of this research was *Tales of Things*, which uses QR codes to connect objects to an online database holding information or stories about objects.[11] Using any smart device, like an iPhone, iPad or Android phone, users can scan QR codes to access data about an object and, more importantly, add their own information about that object which will be accessible to all subsequent users.

Tales of Things was trialled with Oxfam in a project in which donated items were tagged so new owners could know their history.[12] Looking for other relevant uses for the technology, CASA approached UCL Museums. The connection between the objective of the project and the objective of museums was obvious – both are concerned with recording and preserving stories about material culture.

The Petrie started its work with CASA by creating a guided tour of its top ten artefacts moderated through *Tales of Things*. Each of the ten items selected was given a unique QR code that was placed where the object is displayed in the museum. A map identifying the location of the each object was created and given to interested visitors upon arrival along with an explanation of how to download the *Tales of Things* mobile application. The instant appeal of this technology for a small museum like the Petrie is that it obviates the need to purchase handheld devices like audio guides. Because of the capital expense, maintenance requirements and staff time required for

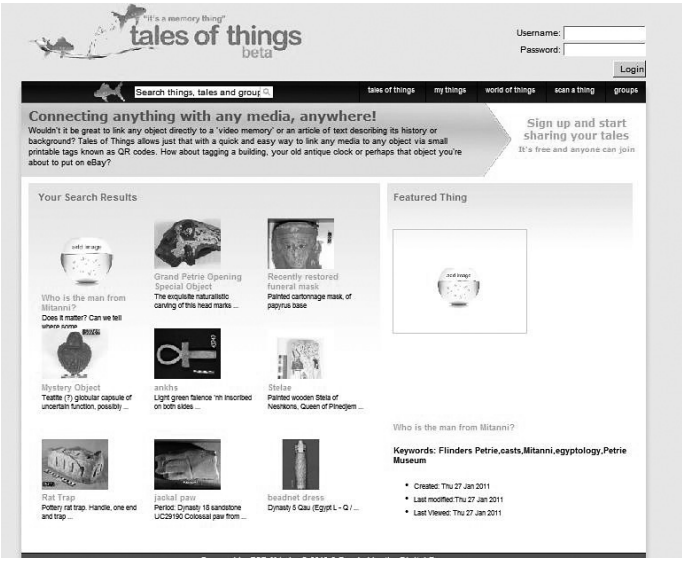

Figure 4: The Tales of Things *website.*

management, audio guides are only viable for large museums. What *Tales of Things* does is turn visitors' smart phones into audioguide equipment. All the museum has to do is populate the *Tales of Things* database with content, which can come in the form of text, audio recordings or videos. The added benefit is that this content can be accessed later, once the visitor has left the museum by logging into the *Tales of Things* website.

User testing of the *Tales of Things* provided great insight to the world of smart phone app development and user-generated content. While conceptually what CASA was offering was ideal for museums, it became clear that the application itself was not developed for museums. It was difficult to upload images of artefacts because the *Tales of Things* database had specifications

for photo size and format that were not compatible with the Petrie Museum's online catalogue images. A lot of cutting and reformatting of images had to be done before they could be uploaded into system. The interface also presented some problems – there were limitations in formatting that made viewing background information about the object and user comments on the same screen difficult. More challenging was deciding how to manage user-generated content. What if users added comments that were inappropriate or obscene? Conversely, what if users provided content that the museum felt was important to add to its internal catalogue? During the pilot, the Petrie decided to monitor but not moderate *Tales of Things* in order to see how visitors used the system. As it turned out, neither issue posed a problem, mainly because very few people were leaving comments of their own. It seemed the system was better for providing information than collecting it.

The work done at the Petrie related to *Tales of Things* informed CASA's future development in the area of user-generated content. In collaboration with the Centre for Digital Humanities at UCL (UCLDH), *Tales of Things* has since spawned a bespoke application for museums called QRator.[13] This iPad-based application works as an interactive object label. The opening screen of QRator presents information and a thought-provoking question about an object and then invites visitors to respond. Unlike in *Tales of Things*, the full history of user comments is easily accessible by simply scrolling down the screen. After some piloting at the Petrie, QRator was rolled out extensively in the Grant Museum of Zoology at UCL, to much

praise.[14] *Tales of Things* lives on, but the CASA team has built in customizable functions that allow different users to tailor the application to meet their needs.

Why university museums?

One might ask, did these projects necessarily have to take place in university museums? Did the Petrie Museum add value that public museums could not? Based on discussions with the researchers and academics involved in these projects, the answer is a resounding yes. Three main benefits come from working with university museums:

1. minimal bureaucracy which results in researchers being able to swiftly set up and conduct user testing sessions;
2. the opportunity to engage in iterative design and long-term research in which prototypes can developed, tested, analysed and refined numerous times;
3. and an openness to experimentation and innovation which means radical ideas can be developed and tested.

Minimal bureaucracy and ease of access: All the academics involved said that organising research projects with organizations outside the university can be difficult. The creator of *Swipe I Like* initially attempted to work with a public art gallery. However, he found that while his idea was met with enthusiasm initially, actual installation and testing never got off the ground due to the numerous levels of approvals and staff who had to be consulted before any activity could take place. Fatah gen. Schieck praised the Petrie Museum

for providing what she called unprecedented "plug-and-play" opportunities for students looking to conduct applied research. She went on to say that the success of the *Swipe I Like* project will ultimately motivate her research group to do more work with the Petrie in the future to test research ideas "in the wild". Fatah gen. Schieck also noted that academics are being asked to provide pilot results or preliminary evidence demonstrating the potential of proposed research as part of major grant applications. She thinks that university museums are ideal for this kind of foundational research because they provide instant access to audiences for small-scale testing.

Fatah gen. Schieck's comments relate to a larger movement taking place in UK universities. Increasingly universities are being asked to demonstrate the economic and social impact of their research[15] and to share the benefits of higher education teaching and research with the public[16] in order to obtain research funding. Consequently, there is potential for public university museums to play a broader role in universities' research agendas. Not only can their collections be used for teaching and research on specific topics, their facilities and ability to reach different audiences can and should be used to support impact and public engagement requirements. UCL's research strategy identifies impact and engagement as key aims and consequently UCL Museums actively encourage academics from across the university to use their spaces and expertise in working with the public to help shape and deliver funded research projects.[17]

Iterative design and long-term research: University museums

also provide a better platform for long-term research and iterative design. A PhD student who works on the 3D scanning project commented that working with external museums can be restrictive in that they want research to fit into pre-existing projects or very limited timeframes. At the Petrie Museum, problems with 3D colour capture, for example, are being identified and resolved through continuous upgrades to the 3D laser scanner provided by Arius3D. The Petrie is also conducting research into the 3D image production process itself, looking for efficiencies that can be made to reduce labour and time inputs by periodically adjusting aspects of the documentation, capture, modelling and review procedures necessary to create 3D images. It is only through this continuous refinement that a cost-effective and viable model for 3D image production will be established for other museums to adopt.

Furthermore, long-term research projects can lead to the development of a wide range of user applications for a given technology. After the Petrie developed the 3D exhibition design tool and the computer-based exhibition, a multitude of other applications were discovered and pursued, including the use of gesture recognition technology to allow 3D images of objects to be manoeuvred using motion tracking and augmented reality technology to allow 3D images to be imported into any physical environment using smart devices.

Openness to experimentation and innovation: The Petrie staff's openness to experimentation and innovation was also cited as a special characteristic of working with a university museum.

Claire Ross, a PhD student from UCL's Centre for Digital Humanities, who worked on creating the QRator application commented: "There is a willingness to be experimental, to try new things, and not be hesitant in breaking some of the traditional stereotypes around museum interpretation." The Director of CASA, Dr. Andy Hudson-Smith, repeatedly called UCL Museums staff "brave" for allowing mechanisms for unmediated user-generated content to be tested in their facilities. Researchers from the Bartlett Faculty also commented on the surprising openness Petrie Museum staff had to testing technologies that were far from commercially ready. Fatah gen. Schieck commented that the openness was not simply about allowing researchers to use the facility, but about engaging with researchers' ideas and helping them to align their ideas with the needs of the museum sector. This openness to experimentation comes from the stated UCL Museums department mission and values which filter into the ethos of the staff and the activities of the department generally.

This openness, however, does not come easily, as museum staff face the challenge of working with researchers from different academic disciplines who speak different academic languages. What some would call "architecture" others would call "built environment." What some might call "scanning" others might call "image capture." Understanding different terminologies is the key to collaboration. It is also important to be able to speak different academic languages when applying for research funding, as success can depend on whether expertise on the subject is demonstrated by use of the correct

terms of art and popular industry jargon.

Remaining open to new ideas and innovation also requires a certain mind set about university museum spaces. University museum leaders must accept that their spaces will sometimes look messy when they test new equipment or applications. If university museums hold themselves to the same standards of presentation as other public museums, they will likely also adopt the other characteristics that make those museums difficult to work with – high barriers to access and an inability to host long-term iterative research. In this regard, a key challenge to university museums that want to position themselves as test beds is to find ways of setting expectations for visitors. The Petrie positions itself as a visible store of objects used for academic research and thus differentiates itself from traditional public museums.

Benefit to university museums

These technology projects have benefited the Petrie Museum, UCL museums department and the museums sector generally. In the competitive museum market in which the Petrie Museum exists (only five minutes away from the British Museum, Wellcome Collection and a range of other highly esteemed small museums), offering visitors something different, in the form of being able to participate in cutting-edge technology research, is a draw. When several technology projects were running simultaneously at the Petrie, the museum offered a series of *demo days* that allowed visitors to test and give feedback on each. The appeal of new technologies

attracted audiences which would not have visited otherwise, thus expanding the museum's visitor base.

The Petrie Museum has also benefitted from new funding opportunities. Many funders in the area of humanities are seeing the benefits of new digital technologies for access and engagement and are looking for projects to fund. The range of technology research in which the Petrie has been involved means that it is prepared to respond to these new funding opportunities. The Petrie has received grants to develop e-learning applications using 3D images, government funding to develop the 3D exhibition design tool and financial support from the commercial sponsors of the laser scanning research to develop additional end-user applications for 3D images. Researchers from CASA and Bartlett noted that additional funding sources were opened to them based on their work with museums. However, all involved in museum technology projects noted that the sums available for development from humanities-oriented funders is often significantly lower than science-oriented funders, making high-risk or long-term technology development in museums more difficult.

As news of the technologies being tested by UCL Museums has circulated, a number of national museums approached the department about rolling out these applications more broadly in their galleries. Major funders have also approached UCL in order to learn about new technologies in order to prepare themselves to evaluate future funding requests for digital projects. Thus, not only have these projects help raise the internal profile of UCL Museums, they have helped to carve

out a new place for museums like the Petrie in the museums landscape. The museum is being seen as a source for new ideas that can be more fully developed and polished by larger institutions. In essence, the Petrie is becoming a digital test-bed for the cultural sector.

UCL Museums also receives increased support and recognition from the University. One of UCL's key research goals is promoting interdisciplinary collaboration. Consequently, as the department demonstrates its capability to successfully work across disciplines, it is invited to be involved in campus wide research initiatives. For example, the Petrie Museum's work in 3D scanning has led to its being involved in discussions to create one large 3D imaging centre that would see medical, architectural, industrial design and heritage research conducted collaboratively in a facility that would give the Petrie access to more expertise and equipment to support its project. To further support the development of these types of relationships, UCL has given the Petrie extra funding for high-tech equipment such as a 3D projection system.

Supporting technology research projects like those described also benefit the sector generally. First, university museums can act as educators for museum staff and visitors unfamiliar with new technologies. A key challenge in all the projects discussed was teaching visitors about the technologies so that they could effectively use them. Few people had heard about QR codes when the Petrie used them as part of *Tales of Things*. Now QR codes are everywhere and the Petrie hopes that it has played a small part in teaching museum professionals

and audiences how they can be used to access information about collections. Even more important may be the effect these projects have on researchers and technical developers. The Director of CASA said that working with UCL museums in conjunction with *Tales of Things* and QRator motivated the department to initiate a new area of work around museums and cultural organizations. Having more people thinking about how new technologies can be used to make material culture accessible and engaging will ensure museums stay relevant in tomorrow's world.

Conclusion

This chapter is ostensibly about the Petrie Museum's experience of acting as a test bed for new digital technologies being developed at UCL. However, it is just an example of the role university museums can play as innovators in the cultural sector. Not all university museums will have strong academic departments in digital technology research, but there is no reason that university museums cannot work with academics in economics departments to develop new funding models or environmental sciences to develop better sustainability models for museums. The main argument being put forward here is that university museums should embrace the opportunity they have to be experimental spaces that form a link between academia and the public. Not only may such activity make university museums more relevant to their institution's research agenda, it also holds the potential for cementing a place for university museums within the

cultural sector supply chain as key incubators of new ideas and approaches for increasing visitor access, engagement and overall sustainability.

NOTES

1 Graeme Were. "Re-engaging the University Museum: Knowledge, Collection and Communities at University College London." *Museum Management and Curatorship*. 24: 3 (September 2010).

2 Additional information and UCL's Bartlett Faculty can be found at: http://www.bartlett.ucl.ac.uk/

3 The MSc degree in Adaptive Architecture and Computation is offered as part of the Bartlett's School of Graduate Studies: http://www.bartlett.ucl.ac.uk/graduate/programmes/postgraduate/mscdiploma-adaptive-architecture-and-computation.

4 Information about the Moritz Behren's work can be found at: http://moritzbehrens.com/2011/swipeilike/. His start up company website is SwipeILike.com

5 Additional information about Professor Robson's work can be found at: http://www.cege.ucl.ac.uk/p?ID=683

6 Addition information about Arius3D can be found at http://www.arius3d.com/

7 The Petrie Museum produced a computer-based display for the British Library's exhibition called *Growing Knowledge*. http://pressandpolicy.bl.uk/Press-Releases/Growing-Knowledge-Exhibition-Enters-a-Second-Phase-4aa.aspx

8 This research was published as a blog on the Petrie Museum technology blog site: http://petriemuseum.com/blog/do-digital-tools-aid-information-retention-in-museums/

9 The aims, software and methods of dissemination of the E-Curator project can be found at http://www.ucl.ac.uk/museums/research/ecurator.

10 Background about CASA's collaborative project that led to the development of the *Tales of Things* project can be found at http://fields.eca.ac.uk/totem/?page_id=2

11 The *Tales of Things* application can be accessed from http://talesofthings.com/

12 Additional information about *Tales of Things* at Oxfam can be found at:

http://www.youtotem.com/

13 Background on the QRator project can be found at: http://www.qrator.org/about-the-project/

14 QRator was listed as one the emerging technologies that will have an impact on the museum sector in *The 2011 Horizon Report*.

15 The Research Council UK (RCUK) impact requirements can be found at: http://www.rcuk.ac.uk/documents/impacts/RCUKImpactFAQ.pdf

16 The National Co-ordinating Centre for Public Engagement provides useful information about the scope of public engagement activities university are expected to deliver http://www.publicengagement.ac.uk/what

17 UCL Museums department has formalised its offer of assistance in public engagement and impact activities. The offer can be found at http://www.ucl.ac.uk/museums/research/impact

References

Johnson, L., R. Smith, H. Willis, A. Levine, and K. Haywood. *The 2011 Horizon Report*. (Austin, Texas: The New Media Consortium 2011).

Petrie Museum. "Do Digital Tools Aid Information Retention in Museums?" *Future of the Ancient World* (blog). http://petriemuseum.com/blog/do-digital-tools-aid-information-retention-in-museums/

Research Council UK. "RCUK Impact Requirements." Accessed 13 April, 2012. http://www.rcuk.ac.uk/documents/impacts/RCUKImpactFAQ.pdf

Robson S., S. MacDonald, G. Were, M. Hess. "3D Recording and Museums" in *Digital Humanities in Practice*. ed. C. Warwick, M. Terras, & J. Nyhan (London: Facet Publishing, Forthcoming).

The National Co-ordinating Centre for Public Engagement. "What is Public Engagement?" Accessed 13 April, 2012. http://www.publicengagement.ac.uk/what

Were, G. "Re-engaging the University Museum: Knowledge, Collection and Communities at University College London." *Museum Management and Curatorship*. 24: 3 (September 2010): 291-304