Exhibiting reality: collaboration in practice

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ABSTRACT

In this paper we examine developments that fall outside traditional development processes with the intention of identifying emergent themes that we can generalise back to the wider computing sphere. The developments are all exhibit based, a a collaborative inquiry based robotic agent development with a group of young scientists, a long running collaboration with a photographer, an augmented exhibit that provides a cross over between virtual and real life and the computer based component in the development of a large scale tropical habitat development. These developments have in common an interactive basis. All are driven by computing that is non-trivial. In the finished form none involve a traditional screen-keyboard-mouse arrangement. We find a different role for functional requirements, differing measures of success, a complex role of interactivity that is closely intertwined with narrative and educational parameters. Perhaps the most important aspect is that of reality, not in terms of virtual reality (although this is discussed too) but in terms of the integration of real and not real in the forms of interface, story and engine. This element of faked aspects of development is perhaps unique to this area.

1. INTRODUCTION

Often the hardest questions are asked by those who don't know what they ask. In this paper we examine the challenges posed through collaborations with others, not just from outside our field, but from outside our traditional base of business database or scientific processing. We examine four developments, all from exhibitions, three from a museum setting and the other from an art exhibition. This article contains some theoretical and practical findings from this experience in creating technology-based exhibits, or as Walker (2001) puts it: "in trying to hide the computers while making exhibits come to life".

This 'trying to hide the computer' should resonate with most computer people, it is the direction in which much of computing is going: Walker's argument about computer-based exhibits "the computer ceases to be a stand-alone box, and becomes so well integrated into the gallery that, in effect, the exhibition is the computer, and the artefacts, information, and visitors are the data it processes" could easily be describing the invisible, ubiquitous or disappearing computer (Weiser 1991, Kaku 1997, Steitz and Nixon 2005). This development is more complex than a miniaturization of the technology, such a development is a perhaps indicative of a paradigm shift, as Weiser argued, the goal of "we are trying to conceive a new way of thinking about computers in the world, one that takes into account the natural human environment and allows the computers themselves to vanish into the background". In line with Shneiderman (2003), we examine aspects underlying each development with a view to moving towards a human centred view of computing.

2. DEVELOPMENTS

The developments discussed are a "Pengy", a collaborative inquiry based robotic agent development with a group of young scientists, a long running collaboration with a photographer (culminating in an international exhibition: "Timed Lapse"), an augmented exhibit that provides a cross over between virtual and real life ("Fish n'clicks"), and the computer based component in the development of a large scale tropical habitat development ("Metamorphamatic").

"Fish n'clicks" (Fox *et al.* 2004, Figure 1) was developed for an interactive exhibit for new aquariums at the Otago Museum's Discovery World. The goal of the project was to enhance the experience of visitors to the aquarium. Like most aquariums, the exhibit included a sign "Do

Figure 1: Fish n'clicks

Figure 2: Pengy

not tap on the glass", overcoming this limitation was the sole requirement for the project. In Fish n'clicks, visitors design their own fish, which are then "released" into the museum's real aquarium. Image capture software, real-time video, an augmented reality interface and simple AI are used to make it appear that the virtual fish is interacting with the real fish.

"Pengy" (Figure 2) was the result of a very different process, also for Otago Museum's Discovery World. Using participatory design, the interactive puppet was developed with the design ideas coming from a group of 10-13 year olds using very rapid physical prototyping (Phidgets: Greenberg and Fitchett 2001). Once a week, over a four week period, the children were taught the basics of programming using the equipment and brainstormed what they would like to see as a new exhibit in the science centre. We consolidated their ideas and rapidly built a penguin that could move its arms, talk, waddle (though stationary) and move its eyelids, it also had sensors and a microphone. The children then developed a sequence for the puppet: sleep, wake up, talk, ask name, respond, ask for food, offer to dance, dance, yawn, sleep.

"Timed Lapse" is the result of a collaboration with a photographer, Lloyd Godman (Figure 3). We have worked with Lloyd for six years, developing various exhibition pieces mostly involving plants and light controlled via a computer according to either the state of the plants or the visitors. For an international exhibition "Accelerating Sequence" (at MOCA, Atlanta Georgia), artists were challenged to explore time and aging. Timed Lapse is a combination of plants growing (and dying) while the images of visitors are collected and displayed in an ever increasing time lapse sequence.

Otago Museum is currently embarking on a major development, a tropical butterfly habitat. "Metamorphamatic" provides interactivity in this environment (Figure 4). Much like Fish n'clicks, in this exhibit, visitors design their own creature and then watch it interact. In this case their butterfly is released into a virtual butterfly habitat but before it can fly it has to progress through all the life stages over a period of several weeks. Visitors are given a card containing a unique ID which when swiped will tell them (always fortuitously of course!) that their creature is about to hatch/moult/pupate/emerge. A tree house at canopy height overlooks the real butterfly enclosure, a large screen on an otherwise blank wall contains the virtual habitat, buttons on the rail release virtual food to which some species will respond, and a remote control da Vinci style ornithopter (flapping wing plane) can be piloted around the virtual habitat.

These developments have in common an interactive basis. All are driven by computing that is non-trivial. In the finished form none involve a traditional screen-keyboard-mouse arrangement. All were developed to tight time frames for clients who, while perhaps having a model of what they wanted, were unable to clearly articulate these needs.

The aim of this paper is to examine these developments for emergent themes that we can

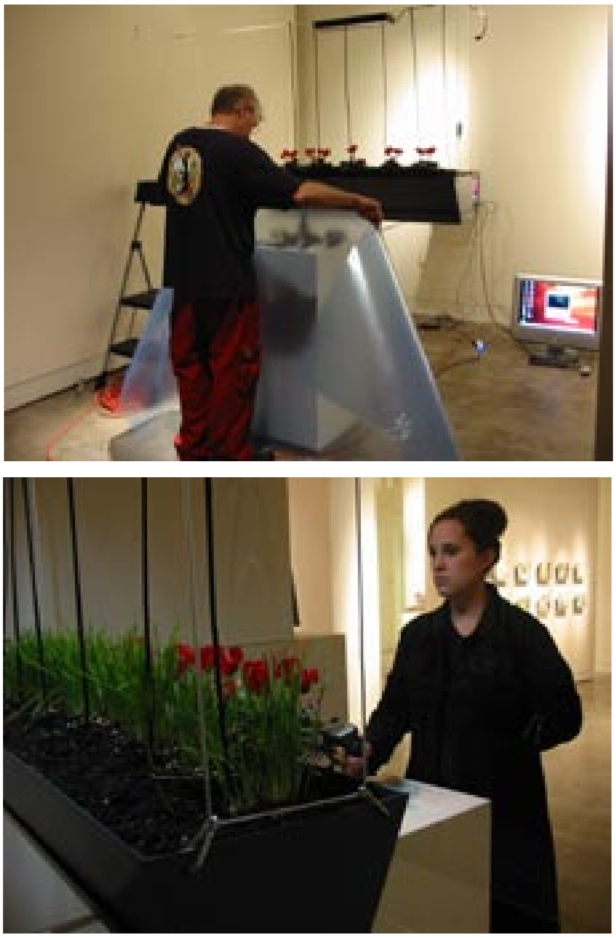

Figure 3: Godman's Timed Lapse

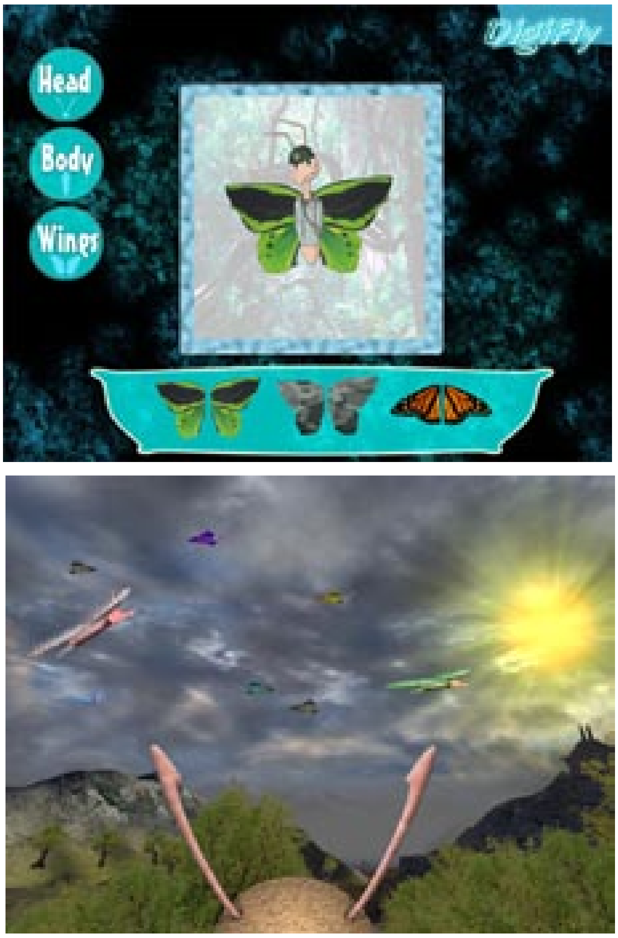

Figure 4: Metamorphamatic

generalise back to the wider computing sphere. This is not without precedent, Galani (2004) discusses the concept of the museum as a test bed for technological innovation, and Milekic (2002) argues that metrics developed for direct manipulation interfaces (icon based point and click or drag/drop) fail in real multimodal interaction. He argues that we need to "unlearn adopted conventions". Clearly though, this is itself an overstatement, 'normal' usability considerations will uncover the different needs of different visitor/user groups (kids under six can't read etc). In this paper we attempt to focus on areas that might fall outside traditional development processes.

3. EXPERIENCE

In much of computing, the development task concerns a specific business process, often the client has a pretty good idea of how that might transfer to a database and from there to computer screen. In all of our exhibit examples, the collaborators were not interested at all in the computer process, the closest we got to instruction in this regard was "do anything, just don't let anyone see the computer". Walker (2001) argues that "what counts is computing, not computers". Both museum and new media literature focus on ideas of the experience. This is only slowly becoming common in computing.

Preece *et al.* (2002) differentiate between usability goals and experience goals. While usability is widely accepted in system design (focusing on the improvement of efficiency and productivity), less clearly defined are criteria regarding the users' subjective feelings while interacting with systems. Experience goals deal with the following question from a user's perspective: Is the system and interaction with the system, emotionally fulfilling, entertaining, fun etc? Such experience goals though go beyond a simple "fun-o-meter" in design of software. Galani (2004) for example, examined how social interaction amongst visitors (remote and physical) mediates and shapes the personal experience.

Interactivity is considered critical in exhibit design, yet the relationship is somewhat uneasy.

Walker (2001) pointed out that "merely giving more control to visitors is not the answer…interface design, like exhibition design, involves balancing freedom and control".

Shedroff (1997) described three groups of similar metrics: Feedback (includes kinesics - gesturing, haptics -touch), Control (creativity, productivity and communication) and Adaptivity. Many museum exhibits are a long way towards Shedroff's (1994) goal of the holodeck being immersive conversational environments (Mann and McGregor 2003), but there is a paradox, an exhibit must hold a visitor's attention, but not for too long: Johnny's brother wants a turn too.

Durbin (2003) argues that a critical part of interactivity in an exhibit situation is the encouragement of a sense of involvement where the outcome is dependent on the opportunities individuals have to exercise their imagination and creativity. Again, this does not always mean more is better. An early version of Fish n'clicks allowed children to draw their own fish which were then digitally released. Early user testing, however, showed that children as old as ten were daunted by the blank page with instructions to draw a fish and didn't draw anything (or drew houses, trees and cars – anything but fish).

Barbieri (2001) is critical of exhibits where user interaction seems to be the goal, rather than the means to accomplish something: "users amuse themselves by interacting, but they are not trying to get any specific result out of their experience". In all of our developments, "interactivity" was the stated goal and we agree with Barbieri's observation, yet that was why our collaborators sought us out. Fish n'clicks was because visitors cannot interact with live fish, Metamorphamatic provided interactivity beyond the (admittedly powerful) dodging live butterflies.

Durbin (2003) discussed the importance of layering information in a museum. They identified eight audiences (schools, further and higher education, local visitors, independent learners, ethnic minority groups, specialists amateur and professional, families and visitors from abroad) and four learning styles (analytical, common sense, experiential and imaginative). They planned the galleries so that visitors in any of the audience categories or who favoured a particular learning style could come to the galleries and find material that appealed to them. This layering provides a better justification for our developments: the interactivity is providing more layers of information/experience.

Several researchers report a "surprisingly strong interest in streaming media, TV-like experiences…clearly favoured by our subjects over more interactive experiences such as chat rooms, information search systems, or user-curated tours" (Vergo 2001). This highlights a divergence in approaches between a documentary or database (Johnson 2003) and suggests somewhat of a return to more passive experiences. Murtaugh (1996) indeed asks why anyone would want to exert control over a well constructed story.

4. NARRATIVE

The story or narrative is a critical component of exhibits. It is the story that lifts the exhibit above interactivity for the sake of it. The story can be told in many forms: explicit documentary style, constructed by the visitor from links between artefacts (Johnson 2003), told by the visitors themselves (Springer 2004), or told by the interaction of present and remote visitors (Hoffman 2003). An important part of the story is the dramatic concept.

In Fish n'clicks, the approach for 'selling' the experience of the virtual fish interacting with the real fish is critical to the story. Rather than having a computer screen beside the aquarium (where the real fish are swimming obviously sans fake fish) the narrative approach taken involves virtual reality glasses in a suspended old-style dive helmet.

The story is important at several levels in Metamorphamatic but in some cases this took some quite subtle adjustments. The visitors make choices about their own butterfly and then take a card with their ID number to come back later to see their butterfly progress through the life stages. In user testing at this stage a common comment was "is that it?". This we traced to a discontinuity in the story, they had just designed an adult butterfly but then were expected to wait to see their creation in the first stage (egg). To address this we added a "Reverse transmorphication device", an overly elaborate Heath Robinson style device that showed their butterfly going quickly backwards through the life cycle ending in an egg taken by conveyor to the virtual habitat. By adding some narrative we got the story to the end of a chapter, teasing the visitor for more, rather than an abrupt end.

At the other end of the life cycle we grappled with the concept of butterfly death. Unlike another virtual fishtank (Nearlife 2002) where a rapid demise awaits the fish of most visitors, we wanted visitors to become attached to their creature (and come back over several weeks). Death is a component in the butterfly life cycle, but neither we nor our collaborators wished to have little Johnny come back to the museum, only to be told that his creation had just been eaten. To overcome this we introduced sacrificial caterpillars and butterflies to be carried off by predators. The only exception to this is if the return visit is very late, when visitors might reasonably expect their butterfly to have died, but to avoid disappointment, their virtual progeny are shown instead.

The narrative and interactivity are often seen to come together in a game environment and many authors have used this approach in exhibit design (Kaufman 2001, Sauer 2003). Some have used successfully used the 3D nature of games engine to produce an immersive experience (eg Calef's exploration of a Japanese temple 2001) but increasingly the game platform is being used to provide environments for communication and interaction (Galani 2004). Mann and Smith (2004) provided a "gameness model" that provided a vehicle for facilitating discussions about "how much game do you want?". This model was used in the exhibit developments. In every case here, our collaborators did not want a competitive element, hence the designer fish don't get eaten by superfish, and there are no rewards for particularly well designed butterflies. With the exception of the piloted flight stage of Metamorphamatic, there is no "twitchspeed" (cf Prensky 2001). Perhaps most important, however, is the use of the underlying game model, all of our developments rely on a game engine (ie an event loop with game states) as the underlying programming structure.

This piloted flight stage of Metamorphamatic posed a conceptual problem for us. It was not part of the original plan, rather it emerged as we experimented with the technology for the virtual habitat: "wouldn't it be cool to see this from the butterfly's point of view" quickly became adopted as the final stage including "Be your butterfly". While technically possible, even easy, this was dropped from the final exhibit as we felt it distracted from the story of the virtual habitat being a "real" virtual habitat: how could your butterfly be autonomous and a real creature if you could somehow be in its head as pilot? This disjuncture was brought to light by consideration of the control system – what does the inside of a butterfly head look like? It was the cockpit metaphor that prompted us to realize that we could get the same gameplay without disrupting the story by introducing here an ornithopter (fortuitously introducing educational areas involving flight systems).

In perhaps all of computing, a goal is to make systems as approachable as possible. In exhibit design this is taken to the extreme. Gammon (1999) pointed out that help buttons are little used and it is "impossible to get visitors to read printed text", or if they do, people read text after completing the task: a successful exhibit is one in which interaction can begin in two seconds – the "initial handshake". One solution is inbuilt instruction (Neal and van Wormer 2004), but as Gammon also points out, these too are hardly ever read or followed. For Pengy, there is no need for instruction, the puppet simply talks to the visitor and provokes them to "feed me", "sing to me", "dance with me". The participatory design process however required significant teaching of material so that the children could usefully contribute to the development. In Fish n'clicks and Metamorphamatic the creature design component is quite complex, both make use of a sequenced development where the selection of wing shape makes available the patterns, choosing these makes available the palettes. This approach might raise concerns in HCI about a loss of control but is a good example of revealing tasks.

These developments are in some contrast to Timed Lapse. In this artwork, instructions are not given. Cullum (2005) reviewed the work as

> *"elegant and complex, is so oblique in its juxtaposition of growing plants and digital photos gallery visitors take of themselves that*

it takes the viewer to figure out its relation to time and natural processes".

5. CONTENT KEY CONCERN

Durbin (2003) describes a continuum of approaches in exhibits ranging from the museum as expert to the visitor as expert. When translated to the computer based systems, these can be seen as database approaches (including 3D systems such as Garrett *et al.* 2002) through to sites where visitors add their own stories or sites that build collections of things of interest to visitors. Durbin described an archive of shoe fashion and a system where visitors are given props used in a famous photograph and are invited to make their own collection. Timed Lapse is clearly in this realm: while most visitors took simple pictures; many others contrived elaborate (and sometimes revealing) poses. The participatory design phase of Pengy takes this perhaps further than Durbin's model, the children were actively involved in the design of the exhibit.

It is harder to use Durbin's categorisation for the Fish n'clicks and Metamorphamatic. For these, a model described by Marable (2004) is more useful. Marable describes a model that positions layers (multiple views of content) along a format spectrum. At one end of the spectrum, the site takes the form of an entertaining, immersive, linear experience that is low on content but high on emotional engagement. At the other end of the spectrum, the site becomes a powerful research application, completely non-linear, structured by the visitor, and ever growing in its content. Fish n'clicks and Metamorphamatic can be considered as entertaining and to some extent immersive but are not linear in the way a documentary might be considered. They are game-like in their entertainment and immersive approach but non-linear, yet they do use emotional engagement (ie attachment to fish and butterflies) to help carry educational messages.

Unlike a content management system approach, where the content of a system is not an integral concern of the IT developers, in these cases the education content is critical to the design and success of the project. Unfortunately, this not an easy task. Schaller (2003) argued that critical to an educational role is that there is a clearly focused subject domain and that learning goals or outcomes can be explicitly articulated by the designers (even if only after the fact). Korteweg and Tofanenko (2002) take this further and argue the importance of sustained interactivity, whereby the exhibit is considered in terms of the whole pedagogical approach with links back to the classroom. For this reason, Metamorphamatic was developed with school curricula as an explicit driver.

Schaller (2003) also argues that constructivism underlies much educational practice in museums and indeed Pengy (in development phase), Fish n'clicks and Metamorphamatic fit this description with visitors.

5.1 Metaphors and tensions

An educational approach may mean that pedagogical devices such as metaphors are used in explanation but Gammon (1999) warns against being too clever in this approach: "visitors tend to take things very very literally". To some extent this naivety can be of use, Pengy can prompt conversations as if real. In Metamorphamatic the problem of story discontinuity described above solved with the "Reverse transmorphication device" could have been solved with a stork delivering the baby (egg) but we did not want to confuse learning with a metaphor that distracted from the learning outcomes involving life cycles. The clearly preposterous elaborate machine is so far removed from reality that it leaves the scientific message intact.

This can be seen as what Rounds (2002) described as the tension between mythic and scientific thinking (similarly Baird 2001 describes an "inherent delicacy"). It is argued that museum visitors often interpret science content in mythic terms; the factual content is not what interests them. It is the meaning they can make from the stories that is important, and they judge those stories by their affective authenticity, not by their factual accuracy.

This tension probably caused the most consternation our developments. Mythical aspects are used to tell the story and provide interactivity and engagement but these are often at the cost of scientific accuracy. However, Gammon (1999) advises to "cheat a little" and get an exhibit that visitors can use and understand. While such an approach may be an anathema to much of computing (imagine the notion of writing code that cheats in an eCommerce arena), showmanship can be traced to the very beginnings of computing. Babbage was in part inspired by a visit to the chess playing automaton, "The Turk" (Standage 2002).

5.2 Faking reality: inspired by science

There are many instances of cheating in our exhibition developments. The whole notion of the fake fish interacting with the real fish is of course a con but there are other tricks, perhaps more subtle. In Metamorphamatic, visitors design their own butterfly, and return to see it progress through the life cycle, but the egg, caterpillar and pupae stages are entirely faked (short loops of generic footage with multi-coloured creatures). This is helped by the science; there is no clear relationship between the patterns and palettes of the adult and the juvenile forms.

Schaller (2003) argues that the key is a scientifically credible mythic framework. Initially Metamorphamatic had cartoon-like characters (see Figure 4) but our collaborators did not like this, telling us to "lose the Disney, stay true to the science". This caused us some difficulty, how could we stay true to the science and give visitors the ability to create their own creature? We eventually settled on "inspired by science", this solution not saying that reality should be the rule, rather that design features should not be incongruent with the science. This was important to maintain the credibility, especially important in an educational environment.

The role of truth becomes more complex when we think of the projects in an educational context. Arseneault (2003) highlights teenagers' weak judgement of quality of information. Durbin (2003) questions the inaccuracy presented to exhibit visitors, and those mistakes made by them; "interaction and participation allow visitors to express opinions and even make wrong statements of fact… As 'seekers after truth' can they allow inaccuracies to appear?".

Testing of Fish n'clicks showed that some users invented relationships, selection of larger fins produced a more elegant fish but one that swam more slowly – a convenient simplification but one for which the science wouldn't hold (else the fastest approach would be miniscule fins). This was made worse by the larger fins all being, by chance, purple. One small child explained to a sibling that the purple fish swam slower because "purple was a warning colour so they didn't have to worry about being eaten".

In both Fish n'clicks and Metamorphamatic we had much debate about the behaviour of the creatures in the virtual habitats. While the original plan was to have entirely autonomous avatars we soon realised that some scripting of actions would be required. This was primarily induced by a need to have the creatures come to stage front so that their creator could actually see them. We decided that the creatures should enter from the back of the habitat and slowly drift toward the front, building the anticipation for the visitors. This was quickly dismissed by our Museum collaborators who pointed out that without a quick hit close encounter they would become disillusioned and leave. Once the decision was made to have scripting, the floodgates opened. For some time in development we had fish swimming in formation (ala Nemo) and butterflies skywriting. We also had the butterflies following instructions: "fly to that tree", "go to the lake". These ideas were eventually toned down. In the final version there is no synchronised swimming and butterflies are only controlled by attraction to feeding stations (operated by the user); otherwise the behaviour is autonomous and 'natural'.

5.3 Technical fidelity

The realism of the exhibits goes beyond measures such as reproduction fidelity as described on virtuality-reality continua (Milgram 1994). None of our exhibits aspire to photorealism yet the decisions were all based on not detracting from reality, even if we had to fake reality.

The balancing of reality and falsity also occurs behind the scenes. Some of the approaches used, inspired by science, and sometimes expediency, are not pretty in computing science terms. The approach taken to colouring the butterflies involved template wings containing patterns of cell structures bounded by veins to which colours were randomly allocated, thus from simple structures a very large degree of variation was possible. This process was one that by chance closely matched the genetic process but is mathematically inelegant and resulted in

40GB of wings. Pengy would have been far more elegant had an agentbot approach been used in programming, but the loop used only became apparent to anyone who stopped and listened for twenty minutes. The reviewer who described Timed Lapse as "elegant and complex" might not have described the time lapse code as elegant, anything over 500 images got discarded in the calculations.

5.4 Augmented experiences

Milgram and Kishino (1994) presented a virtuality-reality continuum, with augmented reality in the middle. In recent years, AR has been joined by tangible interfaces (Ullmer and 2000). Both of these concepts have found uses in exhibit design, sometimes together (Bannon 2005), either as immersive environments (Kaufman and Kline 2001) or to augment real experiences (eg DinoBuilder Sauer *et al.* 2004, or Telebuddy: Hoffman and Goebel 2003). Our developments have both. Fish n'clicks is clearly an interaction of real and virtual (indeed during development it was called "un/reality bytes" and the "unreel fishtank"). Freedman (2003) writes of the value of creating compelling narratives by juxtaposing objects from the permanent collection can that are not usually seen together. The next stage of Metamorphamatic now being developed is to have the visitors' butterflies "escape" the virtual habitat and explore the museum, trailed by their human friends, finding butterflies in unexpected places (Chinese vases, Japanese clothing, Egyptian crockery etc).

Kaufman and Kline (2001) stress the importance of not distracting from the interaction, for example "by requiring a user to move a mouse or press buttons in order to connect with a virtual object, the designer has only emphasized the seam between the real world and the virtual". For this reason we agonized over whether to include ID labels above butterflies and a "wake up" button was removed from Pengy. Kaufman and Kline (2001) go on to argue that in successful theme parks people leave their experiences wondering "how did they do that?!".

The corollary to this are notions of user control and feedback. Gammon (1999) argued that in mechanical displays you should expose the links between control and action. In a separate development, a large scale chessboard, we initially hid the control systems but later exposed them for this reason (Jordan and Mann 2004). In Pengy we made no attempt to disguise the robotic nature of the puppet, indeed the poor penguin was never given a skin, instead the exposed mechanical skeleton had the air of a piece of kinetic sculpture. In the installation of Timed Lapse, the artist Godman initially hid the computer infrastructure, making the time lapse images appear "as if through the eyes of the growing plants" but then decided that the inelegance of the cables added to the artistic statement about needing props for vision and memory as we age. Similarly, at a late stage the motion sensor to automatically take pictures was replaced with a joystick trigger (avoiding a looming ethical dilemma about capturing peoples' images without consent) but also returned some control to the visitor.

Working with collaborators from outside computing raises particular technical challenges. A requirement of exhibition work is that the systems, both software and hardware are bullet proof – they can demand zero maintenance. Timed Lapse fell over when it reached 50,000 images – a limitation we hadn't thought of, Metamorphamatic generated 40 GB of butterfly images, the motion capture module of Fish n'clicks was affected by lighting conditions (fortunately stable). A zero maintenance requirement also derailed a tangible approach to fish creation, our plans for a bucket of fish parts were scuppered when our collaborators pointed out how quickly such pieces would be distributed around the museum.

In all of our developments, the exhibitions quickly pushed to the edge of computing practice. We had to write a motion capture module for Fish n'Clicks, a complex process was needed for generating butterfly wings, and Pengy's ability to interact with music required a software driven music program.

6. CONCLUSION

In addition to the conceptual and technical issues regarding exhibit development, software engineering metrics perform poorly in this area. Although some measures are emerging (Arseneault 2003), there is little to describe the complexity of work in this area. We have found that while at first sight these developments might seem frivolous when compared to the traditional business application, they are every bit as complex and require a different set of rules and processes.

With increasing moves to ambient intelligence, the IT profession is going to have to become more comfortable working outside the square. Working with a range of collaborators has pushed us to work at the edge of 'normal' computing, but this, we argue, has enhanced our work in the traditional computing sphere.

Acknowledgements

These collaborative developments were carried out as part of capstone projects. We are indebited to the creative and skillful work of the following students (now graduates) - Ann-Marie Fox, Lilieta Takau, Cathy Yuan, Naz Taylor, Adrian van Leeuwen, Brendon Mills, Bojan Wang, Boudewyn Erkins, Daniel Himburg and Jade Thomlinson - and their clients - Brian Patrick, Lloyd Godman, Clare Wilson, Amos Mann, Mark Sharma and project mentors especially Patricia Haden and Mark Crook.

REFERENCES

Baird, J. and S. Borda (2001). The Importance of Integrity in Virtual Environments : A Discussion of New Approaches to the Web:"Our World-Our Way of Life" Website. Museums and the Web 01, Pittsburg, Archives & Museum Informatics. http://www.archimuse.com/mw2001/papers/

Bannon, L., S. Benford, J. Bowers and C. Heath (2005). “Hybrid design creates innovative museum experiences.” Communications of the ACM 48(3): 62-65.

Barbieri, T. (2001). Co-operation Metaphors for Virtual Museums. Musuems and the Web 01, Pittsburg, Archives & Museum Informatics http://www.archimuse.com/mw2001/papers/

Cullum, J. (2005). MOCA muses on realities, ironies of growing old. Atlanta Journal-Constitution. 03/06/2005 http://www.accessatlanta.com/arts/content/arts/0305/06mocaga.html

Durbin, G. (2003). Using the Web for Participation and Interactivity. Musuems and the Web 03, Archives & Museum Informatics http://www.archimuse.com/mw2003/papers/

Fox, A.-M., L. Takau, S. Yuan, P. Haden and S. Mann (2004). Fish n Clicks. Proceedings of the 17th NACCQ, Christchurch, NACCQ. p492

Galani, A. and M. Chambers (2004). Empowering the remote visitor: supporting social museum experiences among local and remote visitors. 2nd Intl. Conference of Museology, Mytiline, Greece.

GrGreenberg, S. and C. Fitchett (2001). Phidgets: Easy Development of Physical Interfaces through Physical Widgets. Proceedings of the ACM UIST 2001 Symposium on User Interface Software and Technology,, Orlando, Florida., ACM Press. www.cpsc.ucalgary.ca/grouplab/papers/ UIST (2001) Symposium on User Interface Software and Technology,, Orlando, Florida., ACM Press.

Hawkey, R. (2002). Systematically speaking: how do natural history museum websites represent science. Musuems and the Web 03, Archives & Museum Informatics http://www.archimuse.com/mw2002/papers/

Hoffmann, A. and S. Goebel (2003). Designing Collaborative Group Experience for Museums with Telebuddy. Musuems and the Web 03, Archives & Museum Informaticshttp://www.archimuse.com/mw2003/papers/

Jefsioutine, M., J. Arthur and M. Bawa (2004). Designing the User Experience: An Evolving Partnership for Collaborative Research and Development. Musuems and the Web 04, Toronto, Archives & Museum Informatics http://www.archimuse.com/mw2004/papers/jefsioutine/jefsioutine.html

Johnson, B. (2003). Disintermediation and the Museum Web Experience: Database or Documentary? Which Way Should We Go? Musuems and the Web 03, Archives & Museum Informatics http://www.archimuse.com/mw2003/papers/

Jordan, R. and S. Mann (2004). Knightsmove. Proceedings of the 17th NACCQ, Christchurch, NACCQ.293-296

Kaufman, H. and C. Kline (2001). Designing Immersive Public Entertainment Spaces. Game Developers Conference, San Jose http://www.gdconf.com/archives/proceedings/2001/game_papers.html

Korteweg, L. and B. Trofanenko (2002). Learning by design: teachers/musuems/technology. Musuems and the Web 02, Archives & Museum Informatics http://www.archimuse.com/mw2002/papers/

Kristof, R. and A. Satran (1995). Interactivity by design: creating and communicating with new media. Mountain View, CA, Adobe Press.131

Mann, S. and G. McGregor (2002). Conversation as a basis for interactivity. Proceedings of the 15th Annual Conference of the National Advisory Committee on Computing Qualifications, Hamilton, NZ, NACCQ. 281-288

Mann, S. and L. Smith (2004). ‘A serious thing, no fun’: : A Model for Gameness in Interactive Game Based Learning. NZ Games Developers Conference Fuse, University of Otago, NZ. 127-133

Milekic (2002). Towards Tangible Virtualities: Tangialities. Musuems and the Web 03, Archives & Museum Informatics http://www.archimuse.com/mw2002/papers/

Milgram, P. and F. Kishino (1994). "A taxonomy of mixed reality visual displays." IEICE Transactions on Information Systems Vol E77-D(No.12).

Milgram, P., H. Takemura, A. Utsumi and F. Kishino (1994). Augmented Reality: A class of displays on the reality-virtuality continuum. SPIE: Telemanipulator and Telepresence Technologies http://vered.rose.utoronto.ca/people/paul_dir/IEICE94/ieice.html

Murtaugh, M. (1996). The Automatist Storytelling System: Putting the Editor’s Knowledge in Software. MIT Media Lab, Masters Thesis,. http://ic.media.mit.

edu/Publications/Thesis/murtaughMS/HTML/
Nearlife (2002). Virtual Fishtank. www.VirtualFishtank.com
Preece, J., Y. Rogers and H. Sharp (2002). Interaction Design: Beyond Human-Computer Interaction. NY, John Wiley
Prensky, M. (2001). Digital Game based learning. New York, McGraw-Hill. 442
Sauer, S., K. Osswald, S. Göbel, A. Feix, R. Zumack and A. Hoffman (2004). Edutainment Environments. A Field Report on DinoHunter: Technologies, Methods and Evaluation Results. Musuems and the Web 04, Toronto, Archives & Museum Informatics http://www.archimuse.com/mw2004/papers/jefsioutine/jefsioutine.html
Shneiderman, B. (2003). Leonardo's Laptop: Human Needs and the New Computing Technologies, MIT Press.288
Standage, T. (2002). Monster in a Box. Wired. 10. http://www.wired.com/wired/archive/10.03/turk_pr.html
Streitz, N. and P. Nixon (2005). "Introduction." Commun. ACM 48(3): 32-35.
Ullmer, B. and H. Ishii (2000). "Emerging frameworks for tangible user interfaces." IBM Systems Journal 39(3/4): 915-926.
Walker, K. (2001). "The Museum as "Information Architecture"." Spectra: Journal of the Museum Computer Network, 2001.http://www.exhibitresearch.com/mcn.html