

Knowledge Integration and Innovation in Computer Games Design and Development

Abstract

This paper investigates the processes through which knowledge is continuously elaborated and innovation is generated and sustained in computer games development. By drawing on two case studies of computer games development, it provides an empirical account of how game developers devise objects and strategies that span boundaries of skills and expertise and draw on these in their collaboration. The paper argues that knowledge should be seen as dynamic and linked to practice and not as a fixed object that can be integrated through organizational form or communication channels alone.

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Introduction

This paper begins from a recognition that knowledge integration can be viewed from several different levels of analysis. For theorists of strategic management, for example, knowledge integration has been identified as the *raison d'être* of the firm itself (Grant 1996), both in terms of enabling purposive coordinated action across a distributed system of knowledge (Cohen and Levinthal 1990; Tsoukas, 1996) and as the cornerstone of dynamic capabilities (Eisenhardt and Martin, 2000). Writers on innovation, however, have generally been more concerned with the way in which the knowledge of individuals and groups can be combined to produce new knowledge within the innovation process (Nonaka, 1994; Alavi & Tiwana, 2002). This has led to a concern with the *mechanisms* of knowledge integration. The latter have been variously identified in terms of the development of shared perspectives through social interaction (Huang et.al, 2001; Boland and Tenkasi 1995); the role of networks in enabling access to specialized bodies of expertise (Coombs, Harvey et al. 2003); and the use of 'boundary objects' to overcome the disciplinary boundaries between groups (Carlile, 2002).

In this paper, however, we draw on a study of collaboration amongst the developers of innovative computer games to re-frame our view of knowledge integration. Hitherto the problem of knowledge integration has been viewed in terms of enabling some degree of interaction (ranging from coordinating links through to full-blown transformation) amongst pre-existing and relatively fixed bodies of knowledge. This view is reflected in work both at the level of strategy, and in innovation studies more concerned with the mechanisms of integration. The insights developed through our empirical study, however, challenge this view in two ways. First, we question the objectified view of knowledge that suggests it can be integrated through organizational form or communication channels alone. Rather, in our study knowledge is seen as closely intertwined with social practices – as something which resists efforts to transfer and combine it (Pickering 1992; Gherardi and Nicolini 2000). Second, our work challenges the assumption that the pre-existing knowledges, which underpin the innovation process are relatively fixed and determinate. As described below, by focussing on practices our study suggests that the different forms

of specialized expertise involved in games development are both highly emergent and continuously inter-penetrating. This is in marked contrast to the more monolithic images of disciplines and expertise seen in other studies. In short, by focusing on the material practices of computer games development and the interactions among people and between people and objects involved in those practices, the paper seeks to highlight the processes of the networking of people and things through which knowledge is continuously elaborated and put into circulation in the design and development of computer games.

The remainder of this paper is structured as follows. The next section describes the research approach used, explaining its focus on the boundaries and objects encountered in the design and development of computer games, the use of case studies, and the collection of the empirical evidence involved. This is then followed by a more detailed description of the two computer game development studios studied and how the research at each one proceeded in practice. The following section presents in some detail the empirical findings that were found to relate to issues raised in the literature on knowledge integration and the role of the firm. The two important areas identified relate to boundaries and specialisation and the role of objects. In the subsequent section the discussion centres on the way the notion of knowledge integration does not really chime with the practical work done by the computer games developers studied and how the concept of 'circulation' proposed by Gherardi and Nicolini (Gherardi and Nicolini 2000) appears to offer a much more fruitful avenue in terms of capturing the much more dynamic and exploratory way that the practices of the games developers deal with issues of knowledge and knowing.

Research Approach

In order to access the work practices of game developers and the objects they interact with and elaborate during the development of these games, an interpretive case study research approach was chosen (Walsham 1993). This case study research was carried out at two leading UK computer games studios.

The research design was aimed at acquiring an in-depth understanding of the way in which the developers studied interact, both with one another but also with things and objects in their work, and through this to account for how meanings and knowledge

are built (Ngwenyama and Lee 1997). The aim has been to develop “thick descriptions” of the research setting through engaged field experience that capture its distinctive complexity (Geertz 1973).

Formal interviews were recorded and transcribed, while observations and informal conversations – intended primarily as a way of accessing in greater depth and detail the understandings garnered during the interviews – were recorded in note form after the encounters. Data collection also encompassed material entities, activities, schedules, hierarchies, routines and variations, significant events, participants’ meanings, and social rules (Altheide and Johnson 1994). The case analysis focused on the interfaces of expertise encountered in the two case study settings and the processes involved in the creating, leveraging, and altering of objects in the realisation of an innovation outcome such as a computer game.

Research Setting

The first case study is based on interviews and observations conducted at GamesDevCo, a pseudonym for a UK-based games development company. Since its foundation in 1990 GamesDevCo has grown into a leading independent multi-platform developer employing around 250 people and comprising of five distinct divisions: family games; mature titles; serious games; downloadable games; and games technology. The company develops games under both its own brands as well as on behalf of external publishers and intellectual property rights holders.

The researchers made a number of visits to the company’s studios and headquarters between September and December 2008. During these visits a tour of the five divisions was undertaken. The various teams that comprise each division were encountered and informal and unstructured conversations with team members relating to their work, their interactions with other teams, the way they work within the team, and the importance of objects to this work took place. An in-depth formal interview with the company’s director of development was also conducted and there were also a number of more informal discussions and interactions with the company’s director of business development.

A range of artefacts involved in the design and development of past games titles also

formed an important part of the evidential basis for the fieldwork. Finally, a significant amount of documentation generated from a part publicly funded joint commercial and academic international research project relating to the development of reusable multimedia objects was also accessed. This helped provide an in-depth view of the paths the company was exploring in order to dismantle some of the disciplinary boundaries identified as being a hindrance to the games development process and enabling those from a more creative background without expertise in computer technology and programming to interact directly with the technical components of the game and input graphic elements and animations without the intervention of the technical experts.

The second case study is based on interviews and observations conducted at PetName, a pseudonym for a leading UK-based games development company that since its formation in 1997 has developed a series of commercially successful, critically-acclaimed and award-winning strategy, action role-playing, and simulation games.

A number of visits were made to the company's studios between March and May 2008. Following an initial formal and extensive interview with one of the company's executive producers and a development manager, extensive participant observation of the work of one of the development teams working on a particular action role-play title was undertaken over a period of two weeks. In addition to participation in a number of project-related meetings, this also involved many informal and unstructured discussions with team members relating to their work, their interactions with other teams, the way they work within the team, and the importance of objects to this work also took place.

Again, a range of objects involved in the design and development of the game being built, usually in the form of printouts and screen shots, also formed an important part of the evidential basis for the fieldwork. Other useful evidence included photographs taken by the researchers and video diaries about the development of the previous title by the team being observed and made available by the company itself.

When processing the evidence collected, particular attention was given to identifying similarities between the two cases and establishing points of comparability as well as

differences between the two settings. Furthermore, it was also possible to pursue points of interest identified in the first case and the extensive in-depth interviews conducted at the start of the second case study in the participant observation stage of the second case study.

Empirical findings

Two areas of interest relating to the topic of knowledge integration were encountered during the collecting of the empirical evidence for this research. One related to the difficulties found in identifying clear and stable boundaries between disciplines and bodies of specialist knowledge. The other, to observing at close quarters mechanisms and practices involved in the exchange, generation, and importation of knowledge during the design and development of computer games and seeing the importance of objects in such processes. Both contribute to important debates regarding what knowledge is, whether it can be integrated, and what implications this might have for firms and their abilities to innovate.

Boundaries, disciplines, and specialisation

Specialisation and the existence of disciplinary boundaries relating to established bodies of formal knowledge are at the centre of much of the discourse on the importance of knowledge integration and the role of the firm. Grant, drawing attention to how the cognitive limits of the human brain result in increases in depth of knowledge being at the expense of breadth of knowledge but also how production requires the combination of wide array of different kinds of specialist knowledge, concludes that “the primary role of the firm is the integration of knowledge” (Grant 1996). For Grant, “integration of specialist knowledge to perform a discrete productive task is the essence of organizational capability” (Grant 1996).

In computer games development, three key disciplines are usually identified as being ‘art’, ‘design’, and ‘programming’. In the studios studied, a certain fluidity in these disciplinary boundaries was observed in practice, even though the existence of these categories that implied the possession of a particular body of more or less formal knowledge and skills on the side of the individuals that comprised them was acknowledged in the formal organisational structures of the companies. In other words, while these disciplines had a formal status within the organization in terms of

the management of people and careers, and the broad division of labour within the firm, the actual practices of games development were much more transdisciplinary in nature. Thus, the actual day-to-day work of the individuals that comprised these categories, routinely transgressed these implied boundaries. Such transgressions involved not only a level of ‘redundancy’ of knowledge (Nonaka and Takeuchi, 1995) – i.e. overlapping domains of expertise – but also task flexibility. Thus, those from the art side would, as a matter of routine, have to engage in quite technical processes and tasks involving quite sophisticated computer technology, an understanding of the computational core of the game being developed, and even occasionally entering into the code itself. Individuals from the programming side would make suggestions to those on the art side regarding how the drawing of a particular visual asset could be done in order to make its incorporation into the game easier, more efficient, or make possible some new functionality. There would be individuals located organisationally within these disciplines and coming from a relevant background, but who would be almost entirely concerned with the management of the workflow as it related to their particular disciplines and ensuring, as much as possible, that necessary coordination took place. Furthermore, even within a particular discipline, there would be individuals with skills and knowledge that were much closer to those of one of the other disciplinary teams rather their own.

For example, the ‘level builders’ who are considered part of the design discipline need to have both considerable programming and art skills. The head of the design team at PetName explained in some detail how the work of the level designers can overlap with that of the people from the art side and how “sometimes there can be some friction there” because although “some of them only ‘white box’ things in the level in a minimal way ... others can put in quite a bit of detail”. In the same interview he also talked more generally about how while the idea of disciplines was reinforced by the formal organisational structure of the company and “to a certain degree by a certain culture”, in the actual work of designing and developing games, the boundaries were becoming increasingly blurred, pointing-out that even within his own team, there were almost “no two people who did the same thing”. It was difficult, therefore, to point to one and say: “he is a designer; he is an artist; he is a programmer”. “While people had certain things they were primarily responsible for, it would be impossible for a game to be developed if everyone stuck only to the thing they knew and were expected to

do”, he stressed.

Another observation relating to boundaries and specialisations in this setting was the introduction of new specialisations where it was increasingly difficult to see clearly within which existing group or discipline these new roles would fit.

At GamesDevCo new specialisations related to the ‘rigging’ of characters and 3D art, with the company now not only having specialist environment artists and character artists, but even “people ... just dealing with lighting”. In general, at GamesDevCo disciplines were described as “getting more and more specialised”, with the example given of the introduction of “special effects-only artists”.

This development has important implications with regard to the skills and knowledge embodied in the developers and how these were brought into play in the development process. While there was definitely a movement towards greater concentration of specific skills and knowledge within particular individuals, this was accompanied by a concomitant move towards these individuals having a broader but also more in-depth understanding and awareness of the needs and requirements of both the other specialisations participating in the development of computer games, but also of the objects, machines, and technologies involved.

As the development director of GamesDevCo put it, everyone needed to have “extra knowledge on top” and it was necessary to “marry-up two different people” in one role creating what were referred to as “*technical artists*” who know a lot about hardware, about software, about good visualisation techniques but also have a very intuitive and inquisitive mind in terms of experimenting with new and unusual ways of doing things. Such individuals were described as doing “research stuff that instead of going down the normal route ... could go in a completely opposite way ... figuring out that there may be a really cool alternative way of doing something”.

In both cases it was found that from the very early stages of the conceptualisation of a game, this ability to take into account the requirements and needs of other entities involved – whether these were people or things – was central in the development process. Designers but also senior technical people and senior art people were

involved in games origination from an early stage because “any change within an art specification could change the technical specification and the design specification also changes in terms of how many characters one can have on screen or how big the levels are”. It was frequently mentioned how all those things “feed into each other” and it was this interdependence and an awareness of its importance on the side of both senior and more junior developers that meant that any deepening of embodied knowledge and skills involved in specialisation could not be entirely divorced from a certain concomitant broadening also.

Throughout the research a number of occurrences of this interdependence were encountered and it was through these, but also through the ways that the developers managed them, that new knowledge and innovative outcomes that pushed the capabilities of both the game and the studio forward were achieved.

Another set of key boundaries with important knowledge flows across them identified in the research concern those between the games development companies and external partners. Skills, knowledge, and expertise not only flowed among team members within the company, but also between the development team members and their counterparts on the side of the clients or the vendors through which the games would reach the end-users. For GamesDevCo, with a significant part of its business being the development of games titles for third parties, an important element in this respect was that of previous relations with clients. The existence of these relations meant that clients knew what GamesDevCo was capable of and what not, what the company was good at, and what would fit strategically with GamesDevCo’s own portfolio of skills and future directions. While clients were involved at every level of the design and development process and from early on, their knowledge contributions were particularly important and pronounced in relation to marketing and market intelligence because they knew “what the market is doing in terms of genres and competition, so it is very important to know what they want” in terms of features or in terms of pushing forward in certain areas, but also in terms of what level of funding could realistically be supported by the market and hence what kind of manpower to put on a project.

Flows of knowledge and expertise were found to be much more tenuous in situations

of outsourcing in both cases. Interactions with contractors tended to be rigid, very prescriptive, and based on specification rather than collaboration with the outsourcers. “There is no collaboration. It is very much sending off stuff. ... It is very much a black box. It goes in, they do it to the specification we need, and – depending on how well we specify it – it depends how good it comes back,” explained the development director at GamesDevCo. The situation with regard to interactions with external contractors was no different at PetName, where special software tools had to be deployed in order to manage these interactions. This was not just due to the scale of the outsourcing used but also due to the extensive and prescriptive documentation and briefs involved, as the following extract from an interview illustrates:

DEVELOPMENT MANAGER: Outsourcers are in not in the building. They don't know [the game title]. They can't understand. They are not part of the team. They can't quite get it the way that we get it, so any possible room for error we have to try to nail that one shut.

INTERVIEWER: Is it a very prescriptive process?

EXECUTIVE PRODUCER: Yes.

INTERVIEWER: You have to define absolutely...

EXECUTIVE PRODUCER: [It is] totally different. An internal resource is much more about communication. Projects with an outsource or any external partner you are asking for a piece of work and you really have to know what your piece of work is. We do all the unit pieces in-house, and if we want variations on a piece that's what we have to do because it's so very clear what ... it's not such a creative endeavour.

DEVELOPMENT MANAGER: Yes, we'll do the clever creation stuff; anything that's unique, difficult, or risky we'll do in-house. Anything that's like cookie-cutter stuff [we can outsource]. [If, for example,] we want three buckets, we'll do the first bucket, we'll show them a screen shot of it and give them the grammar, with four buckets, one in silver, one in gold, one in ... Any possible way they could screw it up, it will happen, so you have to be very clear. The documentation is a hedge.

Not all relationships with outside contractors are so completely one-way, however. The chief of design production for the team studied at PetName pointed to valuable

inputs from the external developers of full motion videos (FMVs) that are used to link various levels of the game through film-quality animated videos. Having used storyboards together with the internal company style guides to make sure that the external FMV developers “would develop an animated video that fitted in well with the look, feel, and logic of the game” and despite the difficulties involved in coordinating such issues, the collaboration had “turned out well as [the FMV developers] could work much faster – not having to worry about the playable part of the game – and thus send back finished videos ahead of the scenes in the game being finished, [influencing] in a beneficial way the way the game was developed with some good new ideas”.

What the examples of the fluidity in specialisations and disciplinary boundaries and the differences in interactions across the external boundaries of the firm encountered in these studies illustrate is the dynamic and unexpected ways skills and expertise that are either embodied within individuals or exist outside the firm in other organisations are brought into play during the development of computer games. Attempting to integrate these in some fixed and unwieldy structure inevitably requires a certain amount of crystal-ball gazing regarding how the future will unfold in terms of the advent of new specialisations involving different combinations of skills and expertise. Instead, it may be more effective to focus attention on the mechanisms and practices through which skills, expertise, and knowledge are exchanged and circulate during production, with the individuals, organisations, and entities involved both contributing and gaining something in the process.

Objects

Adopting a dynamic view of knowledge as something changing, shifting, and circulating rather than simply residing in individuals and organisations that somehow have to be connected up in order for this knowledge to become productive and effective does not imply a total lack of stabilisation. However, this stabilisation – when it occurs – is an achievement rather than permanent state.

Organisational rules and routines (Spender 1996), “commonly-understood roles and interactions established through training and constant repetition” and signals (Grant 1996) are all mentioned as ways through which boundaries and

organisational stability are established in firms. As Grant points out, however, “detailed study of the operation of organizational routines is limited” (Grant 1996).

Through its focus on the material practices involved in the development of computer games and the interactions, not only among people, but also between the people and objects involved in those practices, this research has also sought to investigate how objects can play an important role in terms of both facilitating, but also giving a shape to, the dynamic and fluid process of circulation discussed previously.

Under the title of *intermediaries*, ‘things’ that define relationships between actors as they pass between them are seen as being of central importance by Callon, who points to examples such as scientific articles, computer software, disciplined human bodies, technical artefacts, instruments, contracts, and money in order to illustrate this point (Callon 1991). For Callon, “actors define one another in interaction – in the intermediaries that they put into circulation” (Callon 1991). Intermediaries play a crucial role by “giving shape, existence, and consistency to social links” and “the social can be read in the inscriptions that mark the intermediaries” (Callon 1991).

It is not only in science and technology studies and actor-network approaches that ‘things’ are important. Kopytoff points out the long tradition of ‘things’ as tools in ethnographic fieldwork, where, for example, “when an anthropologist is in search of inheritance rules, he may compare the ideal statement of the rules with the actual movement of a particular object, such as a plot of land, through the genealogical diagram, noting concretely how it passes from hand to hand” (Kopytoff 1986). Such ‘things’, therefore, provide answers as to where they come from, who and why came up with them, what is their purpose, what have their trajectories been so far, what changes have they undergone during this time and how have their uses changed, and what happens to them when they reach the end of their usefulness (Kopytoff 1986).

An important material nexus for the early-stage interdisciplinary work and exchange and accumulation of knowledge among internal and external participants

in the development process as a computer game move from conceptualisation to actualization was what was often referred to by the GameDevCo developers as the “*concept book*”.

A number of samples of concept books from past games were studied. They were very professionally produced and aesthetically engaging documents, styled in accordance with the theme of the proposed game. For example, one for a very successful science fiction film series had covers made out of shiny metal that was shaped and indented in such a way that it looked like one of the very characteristic spaceship doors in the film. Another for some medieval adventure had the look of an old and musty book. The documents included primarily text that described to the reader the game and its features and the thinking behind it and visual representations of the main characters of the game accompanied by what can only be described as imaginary biographies for them outlining their roles in the game and what they could do. The documents often – though not always – also included outline budgets and cost projections for the proposed game. It was explained that the production of these documents was undertaken by a specialist “pre-development” team that included individuals from business development and marketing as well as individuals with skills in business analysis, project planning, desktop publishing, and writing and editing text. This core team would then draw from the expertise of the different developers involved in the project from the three formal disciplines acknowledged by the company of art, design, and programming.

A similar approach was taken at PetName, the only real difference being that they used the term *concept document* rather than *concept book*. Again, it included visual representations and varied descriptions of the story and plots and who the main characters are with biographies of who these people are and what they look like. As was explained, “it covers all aspects of the game, and is usually a 70 to 80 page document which encapsulates what the game is going to be – what we intend it to be, anyway – and tries to cover all the risks, all the areas we are going to have to look at, the story, the core technologies and so on”. As with the GamesDevCo case, it would have a budget section at the end, a staff plan, end and start dates, and the phases and markers in between. “It tries to – at a high level – encapsulate the whole game, how long it’s going to take, and what it’s going to be”, explained the

PetName development manager. “We say we have this concept document that says it’s going to have this many levels and this story and [be] this long and will have this many events and scripts, and we have to work out if we can afford that, given the time and people we have”, he continued.

For GamesDevCo, once a more formal agreement to proceed with the development of the title has been reached, whether this is with an external publisher or in relation to internal approval procedures, a number of new objects that are crucial to the interdisciplinary collaboration involved are assembled.

At the beginning of the development phase of every project what were referred to as the “game design document” the “art design document” and the “technical design document” would be instigated. The game design document contains everything that is in the game. It will classify all the characters, all their moves, all the mechanics, all the animations needed, all the pickups, all the weapons, all the locations, all the mechanics. That will grow to at least a couple of hundred pages for just that during the development phase. The game design document was also described as “crucial to the relationship with the client”, as well as in terms of the “visibility” it provides for the internal collaboration. The same with the art and technology design documents and what they deal with. “Everything is documented in terms of meeting notes. Everything visual is designed and we obviously design everything digitally or scan it in or drawn digitally. So we keep a record of that,” explained GamesDevCo’s director of development.

The importance of these documents was also stressed at PetName, where the executive producer commented about the importance of the technical design documents because they include “very careful thinking about the structure and masks and architecture of [the] features [of the game] and other detailed programming points” while the game design documents were a key reference point with regards to the stories and dialogues being written out. The importance of these objects became even more explicit during the participant observation phase of the research at PetName. The sections of the game design document relating to a particular quest or level in the game would form the centrepiece of the interactions between, for example, the design team and the art team in terms of the assets the

design team wanted the art team to develop for them, why they wanted them like that, how they should look, where they would have to be placed in the level and so on. The documents themselves, would include a list of characters and entities that would be in that level, the purpose of the level in terms of the overall structure of the game, its topology as a space, maps and plans of the levels and of specific venues and locations in it, as well as concept art and external visual and other references through which the desired look and feel and experience of the level could be grasped. It is worth noting that as a particular level took shape, initial ideas were modified or dropped, new ones introduced, and problems encountered, different versions of that section of the game design document would be spawned with all being retained within the overall game design document.

The central importance of the technical design document also quickly became obvious during the participant observation at PetName. During a crucial milestone review meeting when a number of initial ideas about the game were questioned or had to be significantly reassessed, whenever such a new feature for a quest or level were discussed, people would turn and look at the head of the programming team and ask: “do we have the budget for that”? Initially it seemed that they were referring either to the financial or time constraints, but it then became obvious they were talking about CPU and memory use. Talking with the head of programming about these ‘budgets’, he explained how, when conceptualising the game, the technical team would assemble a *‘technical design document’* that, among other information would also specify budgets for memory use and CPU use for a range of different kind of scenes, specifying the number of polygons that can be used, the number of characters that can be displayed at any one time, what these characters can do, and so on. He explained how, for example in lush outside settings with much environmental content there was much less memory and CPU budget for other things compared to a scene inside a cave where there was much less computing power taken-up by such features. He then went on to explain how the way this tended to play out in practice was that the technical team would set out these kind of limits in the *technical design document*, then the other disciplines would tend to see how far they could stretch those limits, and that at some point the technical team would have to “rein them in”, while still trying to find ways, even as the game developed, to optimise the performance of the technical elements in order

to “squeeze out as much extra capacity and functionality as possible”. He also explained how things had been more complicated with the previous title in the series because this had been accompanied by “a major engine rebuild” that had left the technical team “in a way guestimating the technical budgets and relying on their own instincts and gut feelings regarding the performance improvements that would result [from the games engine rebuild], based on their own feelings regarding where previous code had been bloated and inefficiently written and how the improvements made to these would translate into improved performance in the game”.

The games design document is not only a repository of all the elements that need to be assembled during the development of a game. Because the milestones agreed for the delivery of different parts of the game are also included, much of the scheduling of the tasks for a project and included in a “milestone schedule” will also for part of it.

An important feature of the games design document of relevance to the issue of knowledge integration is that it is not just a static high-level brief. It evolves and grows together with the games project, with minutes, drawings, and other relevant resources and assets added throughout the development process.

Drawings, within the context of both the concept book and the games design document but also more generally in the games development process as a whole were found to have a crucial role in terms of knowledge that relates to the sensory experience of the game and aesthetic considerations. Drawings – but also visual representations in general – were very much linked to one of the central preoccupations for a games development company: how to capture and communicate, both internally and externally, the “vision” for a game.

But it was not just the drawings that were so important in terms of the circulation of the vision for the game. Within both studios there was a wide-spread use of all sorts of sizes and types of models in the development process ranging from miniature mock-ups of landscapes made from the kind of modelling materials used by model railways enthusiasts, to small sculpted figures or portraits of characters.

Throughout the GamesDevCo studio, props and objects from various well-known film and television titles could be seen on the desks of individuals and in areas occupied by different teams, but also all around the office space, giving a visually intense feel to the place.

More importantly, in both cases, external visual resources were extensively utilised in order to convey to the individuals involved in the development process the elusive vision for the game. Such resources could be a movie, a book, or in some cases, another game and in which something similar has been done or something diametrically opposite and from which everyone involved in the project can understand what is not really wanted. Things such as movies were found to be particularly important in terms of conveying among the teams an understanding of what was meant about the emotion of the game or the visual style of the game.

The development of computer games at both studios also depended on a number of tools and development methodologies that have knowledge, skills, expertise, and ways of viewing and knowing the processes involved in games development built into them.

These include computer programmes for the digital manipulation of artwork, for creating high-end 3D assets, development platforms for writing computer code, and project management applications. Of particular interest in relation to knowledges and understandings of collaboration built into such tools is provided in the case study by the decision of GamesDevCo to abandon Microsoft Project in favour of a programme called Hansoft, which has been developed by a number of games developers who built a specialist project management application having become fed-up with having to use MS Project.

Also of interest was the way tools for collaboration and managing and coordinating the development process at PetName tended to be developed in-house by the production team using where possible easily available and widely used commercial software packages such as MS Excel. “We work with something called the ‘*work breakdown structure*’ that we have as an internal tool”, explained the PetName development manager. “It’s Excel, but it’s a custom macro within Excel,” he

continues, explaining that the reason for that and not using MS Project or some other traditional project management tools, was that “it’s hard to use them”. The executive producer then intervenes: “We worked out a way to very clearly communicate with our creatives how their ideas were not feasible in the time we had. That is something that creates a big tension here because we all try to build the best possible game in the time we’ve got, but we do have a budget and have to get to the business, so using a tool like this was vital in showing how big those ideas are”. “We use these for projects”, continued the development manager, “but for this very specific purpose, because we have to hand this to pretty much everyone”. “The major thing here is we have to get buy-ins from the rest of the teams”, he continues. “This is very much a design led company, so the designers say: ‘I’ve got this wonderful design’. So, okay, we now have to make it fit. We have to have everyone in that team and the programmers, all buy into this thing and agree that it fits and is appropriate. The tool ... spans almost all the people involved. [We] said one day that we need a visual representation of this project. ... We want to show on the wall for the exact... We spent quite a lot of time with the current plan in that time building this. It was great and exactly what we wanted. Now what you see here is fully automated. So now what we do is we dial in the resources of people; who they are working for; where they are on the project, and on a separate sheet, we put in all those things we know about big chunks of tasks; assign people to it; determine how long it’s going to take and how much we want it; and how all this will be done and press a big red button—and it is a big read button now—and it just goes ‘thunk’ and goes up here in about five minutes. This allows us to wave this under the noses of the artists or the programmers, and because it’s in Excel we can all use it! It’s very friendly. It’s non-threatening!” It’s very visual,” intercedes the company’s executive producer. “This is in chunks of work, which, if you were at my level or above, you are not really interested in the day to day but are looking at the overall. You want to spot the trends and you want to see where it’s going. This is a very useful tool, and we use it within the project. I will see who is responsible for making sure it fits within the time we’ve got. The [tool provides] a way of managing that tension between creative ambition and the reality. It’s all reality cantered.”

Discussion

Through digital electronic technology, the world can be represented in computer code.

Through the performance of this code on computers and other associated electronic digital devices views of the world can be re-presented. Games developers take these techniques and use them to present fictitious, but highly interactive and increasingly experiential, worlds within which the game play unfolds.

What is interesting in the work of the games developers is that they are looking to develop techniques to represent or recreate not only the physical or spatial aspects of these worlds, but also the emotions and affections that accompany them. They are seeking to develop techniques of mastering the affective that go beyond the verbal and written.

As can be seen from the accounts of the two case studies presented, during the design and development process, the interactions that take place among the games developers are not just conducted through word-based communications and on a functional basis, but also take place through the use of external aesthetic references, the co-construction of storylines and narratives, and experimental orchestrations of sensory stimuli that bypass the cognitive.

Even during the repetitions of stable organisational routines, a great deal of experimentation – even self experimentation – were observed taking place. Through the confrontation between the limitations of the technology and the financial and time constraints of the project on the one hand and the infinite possibilities open to the creative ambitions of the developers, difficult to articulate intuitions about the experiences and emotions the end-users might feel when playing the game were rendered explicit as collective choices regarding what action to take and which of the many options to pursue had to be made. There were occasions when the developers would turn their own techniques and tools for engineering the experiential on themselves as part of their quest to render explicit many of these more intuitive aspects of their knowledge. Through the reconfigurations attempted during such self experimentation, both how the developers see themselves and the object of their work changes and new folds and features of the game as an object are put to the test of explicitness.

In practical terms this means that in order to be successful, the games company and

the people and things that perform it must co-evolve with the games they produce. Practices that have gained stability over time might help to give form to “a world in continuous meltdown” that is incessantly “bubbling-up new hybrids”, but the games developers studied show us how it is important to remain open to opportunities of capturing the many entities that enter and inhabit our worlds and of which “we can only name – or even imagine – just a few” (Thrift 2007). As the executive producer at PetName commented in relation to the development of one of the collaborative tools used by the company, developing computer games is all about managing “that tension between creative ambition and the reality” within which the project has to exist. It is not about removing this tension in favour of some fixed and unresponsive integration, but about managing this tension and learning from resolving the associated difficulties. In the process many of the intuitions and tacit understanding of the developers are rendered explicit.

Rather than knowledge integration, what was observed at these two studios was much closer to the notion of ‘circulation’ proposed by Gherardi and Nicolini (Gherardi and Nicolini 2000). Knowledge was not fixed and stable but changing and morphing (Gherardi and Nicolini 2000). Rather than integrating separate pools of existing knowledge, whether in the minds of individuals or other organisations, the emphasis was instead on facilitating and even encouraging the circulation of ideas and processes of experimentation and even self-experimentation. Research attention, therefore, should focus on understanding better the mechanisms and practices through which such circulation takes place.

If organisational knowledge “cannot be conceived as a mental substance residing in members’ heads”, it has to be viewed instead as “a form of distributed social expertise” (Gherardi and Nicolini 2000). As such, it is:

- Situated in a system of ongoing practices
- Relational and mediated by artefacts
- Always rooted in interaction
- Reproduced and negotiated
- Always dynamic and provisional

Taking such a view it then becomes important to study how knowledge is produced through process of abstraction that involve symbols, technologies and relations and how these different forms of knowledge then travel in space and time, how they are transformed in the process, what forms this circulation takes, what entities are involved, and how are practices impacted by such a formalisation of knowledge (Gherardi and Nicolini 2000).

Conclusion

Drawing from the setting presented and that is characterised by continuous new product development and collaboration between individuals from diverse backgrounds such as art, design, and computer programming and with widely differing ranges of embodied skills and expertise, the paper argues that dynamic processes of knowing and networking involving people and things rather than a focus on static network structures (Alter and Hage 1992; Conway 1995) provide a better account of how innovation is generated and sustained in computer games development.

Rather than seeing networks mainly in structural terms as communication channels, conduits, or 'pipelines', for knowledge transfer (Rogers and Kincaid 1981; Rogers 1995; Owen-Smith and Powell 2004), this paper argues that it is through the progressive bringing together of the skills and expertise of developers, clients, suppliers, intellectual property holders, hardware vendors and end-users with a range of objects and things that new computer games titles are actualised. In particular, the paper provides a rich empirical account of how game developers devise objects and strategies that span boundaries of skills and expertise and draw on these in their collaboration.

Furthermore, with sensory user experience and aesthetic considerations of primary importance in computer games development, insights into processes that bring together tacit as well as explicit knowledge and aesthetic as well as technical forms of expertise are also provided that challenge theorisations of innovation as information processing involving simply new ways of conveying and distributing knowledge, information, and physical artefacts.

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