'Game Engines' And The Relationship Between Digital Creativity And Technological Innovation In Computer Games Development

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Introduction

There is an intuitive assumption that the combination of aesthetic, cultural, and affective features and digital technology encountered in computer games can drive the generation of innovation. We have, however, a limited empirical and theoretical understanding of how the realization of aesthetic, cultural, and affective features of computer games and technological innovation feed-off one another through computer games development processes. This paper seeks to address this knowledge gap by investigating the interplay between the design and development of the cultural and affective features of computer games and technological innovation in a computer games development context.

The study focuses on the involvement of the 'game engine' – the software that interacts with the hardware of the platform (e.g. console, PC) on which the game will be played – in the realization of novel game features, examining the co-creation of these features through the collaboration between highly specialized 'game engine' technical experts – both within and beyond the organizational boundaries of the studio – and developers involved in designing and building these features. [through this engagement building a computer game. The paper seeks to explore the key research question: how do digital creativity and technological innovation co-evolve in computer games development around a central technological artifact such as the 'game engine' and what new insights might be gained in relation to such an issue from new theoretical debates around the interplay between human and material agencies that are underpinning the growth of a broader sociomateriality research agenda in fields ranging from theoretical physics, organization studies, and information systems research, to science and technology studies (Barad 2007; Ciborra 2006; Latour 2005; Leonardi Forthcoming; Sassen 2006).

The paper draws from qualitative empirical data collected at three leading computer game development studios and one of the leading developers world-wide of the 'physics engine' component of 'game engines' and argues that the 'game engine' is a key locus at which digital creativity and technological innovation co-evolve and that by studying this co-creation and co-evolution, the analytical separation of technological innovation and aesthetic creativity is rendered problematic. The paper claims that it is through understanding such mechanisms of co-creation and co-evolution that a better insight into how the relationship between creativity and digital technological innovation assumed in computer games plays-out in practice and what implications this may have regarding the importance of a healthy computer games development sector to maintaining or achieving leadership in digital technologies.

By focusing on the collaboration involved in this aspect of the development of computer games, both between ‘game engine’ specialists and other developers working on a project and between ‘game engine’ specialists in-house and those of third-party suppliers beyond the boundaries of the development studio, the article also examines the implications to organizational boundaries and managerial practices of such a process of reflexive digital aesthetic creativity and technological co-production.

Literature Review and Theoretical Background

In the information systems literature it has often proved difficult to reconciling the technological and the human/social nature of digital systems, particularly in terms of how to investigate such settings in a comprehensive and coherent way that avoids conventional dualities between the technological (material) and the social/human and thus overcoming conceptual difficulties arising from the ways the technological and social are inextricably entangled in sociomaterial practices of digital systems development.

The notion of sociomateriality, debated in fields ranging from theoretical physics, organization studies, to science and technology studies, seeks to overcome these difficulties by proposing the viewing of things, technologies, people, and organizations not as having inherently determinate meanings, boundaries, or properties (Barad 2007), not as *a priori* self-contained entities that influence each other through impacts or interaction (Orlikowski and Scott 2008), but instead as constitutively entangled and separable only for analytical purposes. It is argued instead that in order to gain an understanding of the intimate tangle of digital systems and organizations - their co-emergence, co-production, and mediation - it has become necessary for the “conceptual bubble” of the social/material duality to be burst (Woolgar 2002).

Beyond the relevance to digital creativity and technological development, the concerns found in socimaterial perspectives regarding the temporal unfolding and reproduction of meanings, boundaries, and properties also address broader issues relating to the relationship of digital technology and organization in an environment characterized by the growth of sectors in which “a single optimal solution may not exist” (Okhuysen and Bechky 2009), progress towards the completion of tasks or an output may be difficult to plot and assess (e.g. software and interactive design) (Kellogg et al. 2006; Kraut and Streeter 1995), and boundaries of organisations and functions have become increasingly blurred (Hargadon et al. 2003; Scott 2004).

The increasing interest in sociomateriality in the information systems literature, therefore, also speaks to developments relating to issues such as the increasing participation of wider and more diverse specialisations in the design and development of digital systems and how organization can be achieved in such circumstance without recourse to costly and time-consuming approaches unsuitable to post-bureaucratic organisations involved in “high-pressure, project-based” work with unpredictable demands and in volatile conditions (Kellogg et al. 2006; Levina 2002; Sapsed and Salter 2004).

Leonardi (Forthcoming), for example, explores how in many contemporary organizations that “work with flexible routines and flexible technologies” employees who find that they are unable to achieve their goals in their current work arrangements decide whether they should “change the composition of their routines or the materiality of the technologies with which they work”. Taking a perspective informed by the broader research agenda of sociomateriality, Leonardi suggests that this depends on “how human and material agencies – the basic building blocks common to both routines and technologies – are imbricated” (Leonardi Forthcoming). Imbrication of human and material agencies through which infrastructures are produced in the form of routines and technologies that people use to carry out their work is put forward by Leonardi, drawing on the work of authors such as (Ciborra 2006) and (Sassen 2006), as an alternative to views of sociomaterial entanglements that refuse to give primacy to either human or material agency in the explanation of outcomes but rather see them as hybrid entities that contribute equally, not only by shaping one another, but by exchanging properties, for the building of further sociomaterial associations (Latour, 2005). Imbrication instead conveys the idea of an "interweaving" of separate human and material agencies, but arranged as "distinct elements in overlapping patterns so that they function interdependently" (Leonardi Forthcoming). Seen in this way, routines or technological infrastructures used at any given moment are then "a result of previous imbrications of human and material agencies" that either constrain people's ability to achieve their goals or afford the possibility of achieving new goals (Leonardi Forthcoming).

By focusing on the entanglement of things, technologies, people, and organizations in the co-development of both novel game features and digital technology innovations, the study aims to contribute to this emerging field of debate by investigating how the temporal meanings, boundaries, and properties of such entities are continually (re)produced (Pickering 1995; Pickering and Guzik 2008) and what this tells us about the questions and conceptualizations regarding the relations between human and material agency at the centre of the emerging information systems sociomateriality research agenda.

Research Setting and Approach

Research approach adopted in this study is interpretive (Walsham 1995), aiming to capture an in-depth understanding of the work practices involved in the development of new computer games titles, and a leading developer world-wide of 'physics engines' for computer games in order to develop a rich description of how the 'game engine' relates to novel and innovative features of a game being developed.

Data collection therefore involved a combination of in-depth interviews and observations at three leading UK-based computer games developer studios and one of the leading developers world-wide of the 'physics engine component of 'game engines'.

Over twenty-five interviews have been carried out to date with developers and managers at these companies. In addition to formal interviews informal interviews were also used for much more specific questions relating to key aspects of the development process that emerged during observations. The observational evidence was recorded primarily in note form continuously during the time at the studios, usually contemporaneously. Field notes were supplemented by sketches drawn by the developers as they explained something either to the researcher or to each other, printouts of key documents used in the development process, screen grabs of computer applications and displays.

Of particular interest in the assembling of the data was the chance afforded by the use of one of the development studios of the ‘physics engine’ of the supplier studied. This meant that it was possible to interview the ‘physics engine’ specialist at the development studio who was also responsible for liaising with the ‘physics engine’ supplier regarding the development of new and the maximizing of existing ‘physics engine’ functionalities as well as someone from the ‘physics engine’ side with a similar role on that side.

The first study site was GameCo1 (a pseudonym). Since its foundation in 1990 GameCo1 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 second site was GameCo2, a pseudonym for a leading 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.

The third case study was conducted at GameCo3 (a pseudonym). Since its establishment in 1992, GameCo3 has, through the acquisition of other UK studios, become one of the largest UK computer games developers; what has started to be referred to in the UK games development sector as a “superstudio”. The company produces games both under its own brand and for third-party clients and has enjoyed significant commercial success. It is now a multi-platform and multi-genre developer operating out of four different locations around the UK. In addition to its games business the company also has some print publishing activities.

Since its funding in 1998, EngineCo has become a leading provider of real-time collision detection and physical simulation middleware used in ‘game engines’ by computer games developers and by digital graphic animation studios world-wide. Its ‘physics engine' component is in over 250 launched computer game titles, with many more in development.

Empirical results

For a computer game to be realised, a whole set of digital objects – referred to as "assets" by games developers – need to be described, assembled (either from an existing stock or developed ex nihilo), and arranged together. "Assets", include digital artwork for the entities – both active and passive – found in the game, 3D models, digital artwork relating to the setting within which the game takes place, maps of levels and locations, animation sequences, artificial intelligence algorithms for entities not controlled by the player, visual textures, special effects, sounds, text and spoken dialogues, music, graphical user interfaces, and many more depending on the game, its genre, and its complexity.

The sequence of actions that takes "assets" from their source form (usually the output of whatever package the developers created them in) to the final data that can be burned on to a disc or cartridge to form part of the finished game, is what is referred to among the developers as the 'asset pipeline' (Arnaud 2010; Carter 2004). It is a central common preoccupation of computer game development to ensure that this "pipeline" is as smooth as possible and that assets are at the right place at the right time and in the right form, both in relation to the progression of the development process over time and the demands of the computer program at the centre of the game known as the 'game engine'.

The 'game engine' itself is a crucial part of a computer game, being the software that interacts with the hardware of the target platform (e.g. console, PC) on which the game will be played, translating the elements that make up the game from the specific formats they were developed in, into the code that can be run by the different hardware components of the platform. The functionality provided typically by a game engine includes: a rendering engine for 2D and/or 3D graphics that generates, by means of computer programs, images from a mathematical description of objects based on geometry, viewpoint, texture, lighting, and shading information; a physics engine dealing with collision detection and responses using algorithms that check for the intersection of two given mathematically represented solid objects simulating what happens once a collision is detected without which characters would go through walls and other obstacles; sound processing; scripting control for other software applications in the game; animation; artificial intelligence; networking; data streaming; memory management; threading; and scene graphs, that arrange the logical and spatial representation of a graphical scene (Arnaud 2010; Carter 2004). Due to the high cost of developing these functionalities from scratch, game development studios in large part reuse the game engine for a number of different games, altering its functionality or improving its performance incrementally, project by project. As such, the 'game engine' has important installed-base characteristics that can have an effect on what can and cannot be done in a new computer game being developed based on it.

At GameCo1 the studio had created its own development tools and 'game engine' with an internal technology division servicing the needs of both the internal development teams as well as external third-party users to which the company's tools and 'game engine' technology are licensed.

The 'game engine' team interfaced face-to-face with game development teams on a regular basis, usually with the senior managers of the engine side liaising with senior managers of the game development side to discuss high level issues and more long-term requests for features. "These meetings occur quite frequently at the start of projects as some game teams might need brand new features from the tools to add to their game and obviously the sooner the tools team know and schedule for this, the better", explained the director of development of the studio.

In addition to these more high-level interactions between 'game engine' specialists and game developers, there were also more general day-to-day interactions during the development of a game. "We have quite strict systems in place to capture communication and requests between tools and games", explained the director of development, pointing to the use by the studio of a combination of databases and forums for these purposes. The database in particular was used to capture everything from small changes needed and bug-fixing requests to the logging of larger features for further discussion and then directing specific requests for parts of the tools or engine functionalities to specific people in the ‘game engine’ division. The same system was also used for liaising with the external ‘game engine’ clients of the company.

At GameCo3, they also used their own proprietary ‘game engine’ technology. “The technology you use (…) is inherent to how good the game is and how easy it is to make”, explained an executive producer at the studio. “We have an engine we’ve coded pretty much from the ground up and is many years in the making”, he explained. “We haven’t bought in physics, for example; one of our lighting solutions comes from the requirements of the teams and of the company itself”, he continued. While there was a general view at the studio that their tools were “sufficiently mature” to provide most functionalities that might be required when developing a game, there was an acknowledgement there will be some part of a particular feature “within the script of the game or within the actual game itself – for example a particular artificial intelligence behavior or a particular tack” - that has to be made available and developed from scratch.

At GameCo3 this was particularly relevant to moves by the studio into new genres of games. “When we moved from traditionally a (…) shooter-oriented genre to a platforming genre, (…) all of a sudden, we had to do grappling and climbing walls or floating through air with a gigantic great big cape behind you – even double jumps were something brand new that had to be thrown in – and you rely on your team to code those in for you”, explained the company’s executive producer.

In order to minimize the cost of such ‘game engine’ improvements, GameCo3 would work through to a certain point of the game being developed on what they called “the main branch of the engine” that would be “picking-up” updates from all of the different projects going on at the company. The only additions that would be allowed to be made at that ‘shared’ stage of the ‘game engine’ would be “things that have gone through the head of programming, or the deputy, or a senior lead programmer who is allowed to add to the engine”, explained the GameCo3 producer. “Anything they create – in fact it’s part of their job description to be thinking about how that’s going to benefit other games”, he continued. “So, for example, if they write a particular animation blueprint system, it is not just for their own game, but they must write it with benefits for others in mind also", he concluded.

Once an individual game was into what was referred to as the "polish and fixing phase" and moving towards an "alpha" and "beta" version, the 'leads' on the project would have to make a decision as to when to "cut the game free" from the main branch. "Then, at that point, we plow our own furrow [in relation to 'game engine' modifications and improvements] and we won't accept any new features in from other games because they may break our game and they may cause unnecessary bugs", explained the executive producer.

During the research it was possible to see at first hand during observations at GameCo2, the importance to the game development process of the 'physics engine' and how what could and could not be done by that middleware component related to the creativity of the design team of the studio and the realization of new playing experiences and features in the game under development.

In order to "zoom in" to the level of interactions at which these issues played-out (Nicolini 2009), we focused our analytical attention on the development of certain particular features for which the capabilities of the 'physics engine' were at the centre of the attention of the development team being studied at GameCo2 and which involved significant collaboration between the 'physics engine' specialist of GameCo2 and his counterparties at EngineCo.

One key such episode related to the development of a location in the game that the team designing the game had envisioned as a proto-industrial region with a relevant look and feel. Because canals and barges were associated with the early days of the industrial revolution, the thinking of the design team was that it would be an evocative feature of the game in terms of its atmosphere if, while the gameplay was taking place there, barges could pass up and down the canal crossing through the region and the hero could both fight from them or on them or even leave that region on them to go to another location in the game.

When it came to start work on the region in question, one of the key issues became how to develop this "moving barges" functionality. This was very much an issue of the 'physics engine' and whether it could support this functionality, which at the 'physics engine' level was modeled as two platforms/surfaces that were solid and on which characters could stand without falling through. These platforms would also need to move in relation to each other but also in relation to all around them and in a way that the characters on them would also move in relation to them in exactly the same ways so that it appeared that they were standing on them (characters and platforms could not be the same entities, so both had to move in the same way together giving the impression that the characters were standing on the moving platforms).

This proved to be a much more complex problem than originally anticipated and one that required new functionalities from the 'physics engine'. The question was whether that would either require the 'physics engine' supplier EngineCo to liaise with the development studio in terms of enabling existing but previously unused features of the engine to make possible this complex modeling, or whether the feature would have to be abandoned until a new version of the 'physics engine' that supported such a model was developed. Furthermore, through the liaising with the EngineCo support team, it also became clear that apart form the issue of the functionality of the engine, even if the feature could be supported, there were many other issues relating to the performance of the related hardware and the usage of CPU power and memory and other computer resources that also had to be taken into account. It was thus possible to see at first hand the intricate interrelations between the creative vision of the designers on the development team and the technical features of the 'game engine' and how the two were mutually dependent but also mutually constitutive. Even if the feature had to be modified or abandoned, however, this did not mean that the story ended there. Through the interactions with the engine developers, the needs for new functionalities for the physics engine were surfaced. Through the interactions between the physics engine programmers at EngineCo and the hardware providers and vendors (of which on of the leading players world-wide in that market also owned EngineCo), the limitations and areas for future improvements for chipsets were also highlighted to them. So while a creative feature might have had to be sacrificed this time around, the technological advancements and innovations necessary to make such creative features possible in the future were also triggered, setting in motion changes in the future hardware of PCs and game consoles.

Discussion

Through the focus on the interplay between game design and 'game engine' development at the three research sites and the specific episode of the relationship between creativity and technology presented, we have tried to illustrate in greater detail a) the trade-offs between the desirability of new and innovative features for a game and the efforts needed in order to overcome the limitations of existing 'game engines'; and b) how such issues are dealt with in practice by the developers and 'game engine' specialists involved. While for the sake of economy of description we focus our detailed analysis on one characteristic episode (Ewenstein and Whyte 2007), this episode is treated as illustrative of practices observed across the three sites during the research in relation to such aspects of digital games development. Through this focus on the specific episode, the paper seeks to discuss in a more compelling way the core research question of how digital creativity and technological innovation co-evolve around a technological artifact and what implications this might have on the debates within the emerging sociomateriality research agenda in information systems regarding alternative views of the relationship between human and material agency (Introna and Hayes; Leonardi Forthcoming).

The paper has aimed to show how, through the challenging and stretching of the limits of what 'game engines' can do by the novel and innovative game features imagined and put forward by game developers, broader digital technological innovation and development at both the software and hardware levels is driven forward.

In the setting studied in this research, the clear distinction between human and material agency for which the notion of imbrication is preferred (Leonardi Forthcoming; Sassen 2006) is brought into question. The technological limitations encountered by the creativity of the developers are pushed and probed as ways of stretching what can be done are sought and every last drop of hardware resources is squeezed out of the existing technological configurations. While this may involve changing the routines and practices and “ways things are done” that the developers have utilized thus far, the technology itself is also changed.

While the extent of creativity was ultimately limited by the functionalities supported by the ‘physics engine’ and the capacities and capabilities of exiting platform hardware, over the long-run, the technology itself also changes, making possible in future games many of the innovative creative features that may have not been realizable in the past. This, in turn, raises an important question regarding the extent of the temporal frame adopted when examining and theorizing the interrelation of human and material agencies as is done by Leonardi and how much of the stability of entities presumed by the notion of imbrication can be presumed (Leonardi Forthcoming).

In our study, rather than clear boundaries between the material and the social and creativity and technological innovation we observed instead a continuous and dynamic co-evolving of entities and states where boundaries are not fixed but in a state of flux. The material could not be seen as separate from the social. The materiality of, for example, the ‘game engine’, is not a ‘given’ but *preformed* through intra-actions of complex networks of people and things as part of specific phenomena and their configurations and materialisations at a particular time (Barad 2003). It is therefore problematic to delimit and define the extent of the social and the material, as is presumed with the concept of imbrication. In the same way, the analytical separation of technologies from creative industries is also brought into question. The digital technologies that are seen as changing fundamentally the creative industries are not developed in separation from these creative industries. Apart from the argument that the development of the digital technologies themselves could also be seen as being within the remit of what we define as creative industries, as the study of the relationship between the creative features of computer games and the digital technologies that underpin these games presented in this paper has shown, creativity cannot be separated from the technologies that it relates to. Changes in one will always trigger changes in the other and vice versa and this is why they should be seen as mutually constitutive rather than one simply supporting the other.

Conclusion

By studying and presenting the reciprocal development of novel computer game features and innovative digital technologies, the article explored the relevance to this setting of ways of seeing and theorizing creativity and digital systems development from a sociomaterial perspective that gives prominence to understanding the composite nature of digital systems development and use and “the recursive intertwining of humans and technology in practice” (Orlikowski et al. 2008; Orlikowski 2007).

The paper has argued that the assumption of a separation between creativity on the one side and technological development on the other is challenged by the work of the computer games developers studied, whether concerning more the aesthetic and experiential features of a game or the technical functionalities of the ‘game engine’. Instead it is more fruitful to focus on the intimate tangle of digital systems, objects and people and their co-emergence, co-production, and the mediations that often subvert conventional disciplinary, organizational, and territorial boundaries. While the notion of imbrication predicated on the maintenance of a distinction between human and material agency provides one way of viewing this “intimate tangle”, in this empirical setting it was found to be too rigid to capture fully the ebb and flow and mutual transformations taking place between the human and material; creativity and technology.

The challenge then for researchers with an interest in the relationship between digital technology and creativity from the sociomateriality research agenda remains to find new concepts and ways of studying such interplays that are applicable to situations such as the one presented and in which the temporal meanings, boundaries, and properties of entities are continually (re)produced (Pickering 1995; Pickering et al. 2008) rather than presumed or assumed.

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