

HART FOUGHT MATERIALITY IN COMPUTER GAMES DEVELOPMENT – ON THE DYNAMICS OF ENTANGLEMENT AND DISENTANGLEMENT

INTRODUCTION

As Information Systems development (ISD) is subject to conditions of ever greater change and uncertainty, there has been a growing dissatisfaction amongst researchers with conventional theories that assume stable entities and relational boundaries within that process (Girard and Stark 2003; Kellogg et al. 2006). To address the dynamic and emergent aspects of ISD, writers have critiqued existing theories predicated on stability, and have offered new conceptualizations more attuned to emergence and change. For example, studies of ISD in highly pressurised settings have suggested that the knowledge boundaries between different specialist groups are more ‘fuzzy’ and dynamic than previously asserted, and that the forms of collaboration involved are less dependent on the exchange of stable objects and representations across boundaries than on dynamic and unpredictable interactions which ‘transcend’ such boundaries (Majchrzak, More, & Faraj, 2011). In another study of knowledge integration, Majchrzak et al. (2011) found that members of cross-functional teams integrated their diverse forms of expertise by ‘cocreating a scaffold’ (p. 9) , i.e. an evolving ‘visual or verbal representation that encompasses many fragmentary contributions. As opposed to the concrete and stable boundary objects highlighted in previous studies, the scaffold ‘kept changing and was never interpreted in the same way by team members’ (p. 14).

These studies bring to the fore, but do not resolve, the question of how we theorize fluidity and emergence in ISD. The emergent phenomena they describe are important but their emer-

gence is itself dependent on the way organizations achieve some stability of entities. Thus, the knowledge-intensive work in projects is fast-moving and uncertain (Kanawattanachai & Yoo, 2007), but still depends on ways of defining and dividing tasks. Even though the boundaries between groups may become ‘fuzzier’, they retain a value for coordination and integration that must be accounted for and managed (Black, Carlile, & Nelson, 2004; Girard & Stark, 2003).

These observations suggest that our growing attention towards theories of change and emergence in ISD should be tempered by an equal need to develop theories that address change and stability as interdependent rather than discrete phenomena. One perspective which has the potential to do so is work based on the emerging notion of sociomateriality which is currently informing debates in diverse fields of study. This perspective offers important insights into reconciling observations of emergence, immanence, and flux with the conventional orientation of organisations and ISD towards closure and the achievement of stability (Barad, 2003; Barad, 2007; Brown & Duguid, 2001; Knorr Cetina, 2004; Thrift & Dewsbury, 2000; Tsoukas & Chia, 2002; Tsoukas & Langley, 2010).

A key concept in the sociomateriality perspective is that of ‘entanglement’. This term seeks to convey the meshes of relations, or ‘intra-actions’, between many indeterminate entities in flux that gives shape and substance, albeit temporary and local, to them (Barad, 2003; Barad, 2007). In this paper, we argue that this concept can contribute to our ability to theorize change and stability as related and not opposing concepts. Entanglement is particularly relevant in this respect because it affords new theoretical insights not only into the way in which phenomena become locally stabilized and determinate, but also into how they can ‘intra-act’ with, move across, and materialize differently in other contexts (Barad, 2003; Orlikowski & Scott, 2008).

We aim to develop this theory contribution in two ways. First, we address the question of how entanglement relates to the movement of phenomena across contexts. This area is currently underexplored theoretically, so as a means of deepening our understanding we draw on cognate work in the field of social studies of science to address the implications of what can be termed (dis)entanglement. In addressing the spread of phenomena such as scientific knowledge or economic calculations, studies in this field have had to address the question not only of their localized embeddedness, but also of their movement. Such movement presumes individual objects that can be materially and conceptually (dis)entangled from one context and entangled anew in another without the need to sustain some broader social connection (Slater, 2002). The focus on movement developed in this article can add to the current literature on sociomateriality as it elaborates, rather than focusing on the relationship between the social and the material (Jones, 2011), on how the movement of phenomena between contexts better helps to reveal the entanglements of sociomaterial practices within contexts (cf. Sandberg and Tsoukas 2011).

Second, in order to advance our theorizing strategy, we draw on the analysis of an empirical study of computer games development. The theoretical motivation for such a study derives from our concern to understand the role of entanglement in the movement of phenomena across contexts. As yet, there are few accounts which address the entanglements found in empirical settings – that is, the way in which specific indeterminate entities gain shape and substance within a particular context. Even less attention has been paid to the movement around such entanglements and how this is accomplished in practice.

The research setting of computer games development is of particular relevance here because it is an arena in which both change and stability are highly visible. In particular, the design dynamics in computer game development encompass the multiple forms of expertise involved in developing a cultural product, as well as the challenge of representing and integrat-

ing knowledge on the intangible aspects of design (cp. Orlikowski, 2007). Development in such settings thus involves a movement from initial amorphous ideas through to the production of the game as a digital artefact.

As we will explore in our empirical account, games development is thus played out through the stabilization, cross-context movement and re-location of multiple objects. Key moments in that process, as presented below, have to do with the importance of achieving ‘closure’ around particular objects, which enables them to move and be relocated (in a different materialization) across contexts (Austin & Darso, 2009; Bijker & Pinch, 1987; Ewenstein & Whyte, 2009; Kline & Pinch, 1996). As we discuss in more detail below, it is the stability obtained through ‘closure’ – albeit temporary and local – that enables the movement of such objects by supporting (dis)entanglement from one context and new entanglements in another. Motivated by these challenges, this article aims to address the following research questions. First, how do entanglements of sociomaterial practice evolve as objects move across contexts during the development process for a computer game? Second, what are the theoretical implications for our observations of such movements for our wider understanding of entanglement and the development of the sociomateriality perspective?

CONCEPTUALIZING ENTANGLEMENTS

The notion of sociomateriality, as proposed by authors such as Barad (2007) and Orlikowski et al. (Orlikowski & Scott, 2008; Orlikowski, 2010), asserts the inseparability of the social and the material by denying them the stance of independent or even interdependent entities with distinct and inherent characteristics. It suggests that things, technologies, people, and organizations have no inherently determinate meanings, boundaries, or properties (Barad, 2007). They are not, in other words, *a priori* self-contained entities that influence each other through impacts or interaction (Orlikowski & Scott, 2008; Scott & Orlikowski, 2009;

Suchman, 2007). This perspective has important implications for the field of Information Systems. Technology is viewed as an intrinsic part of everyday organizational practices, and as such as being constitutively entangled with and in organizations, distinguishable for analytical purposes only (Woolgar, 2002).

The sociomaterially entangled perspective is based on a relational ontology (Slife, 2004), in which we are in the world (Heidegger & Stambaugh, 1996) rather than being subjects entering into relation with objects separate from us (e.g. employees using a technology). Instead, things, people, and practices come into being only through their relationality with others. To illustrate this point, Sandberg and Tsoukas (2011) draw on the example of the hammer that becomes a hammer only within the specific network of sociomaterial practices of, for instance, a car repairer. An important ontological implication of these considerations is that phenomena, rather than things, are constitutive of reality. More specifically, reality is made of “things-in-phenomena” and not “things-behind-phenomena” (Barad, 2007: 140). In such a view, phenomena are defined as “differential patterns of mattering”, which means that through ongoing intra-actions and developing entanglements, “phenomena come to matter” (Barad, 2007: 140), gain specificity, materiality and thus the capacity to “hold together” and to resist (Callon & Muniesa, 2005).

Sociomaterial entanglement (Orlikowski, 2007) implies that we move from an idea of interactions of separate entities “with inherent boundaries and properties” to one where there is an “ontological indeterminacy”, that is, an inseparability of agentially intra-acting ‘objects’ and ‘agencies’ (Barad, 2003). While the notion of interaction presumes pre-formed substances of entities that enter into relations, intra-actions per-form relations such that “the boundaries and properties of the ‘components’ of phenomena become determinate” (Barad, 2003). Objects (such as a hammer) emerge from the intra-actions and do not precede or cause them. The meshes of “intra-actions” between many indeterminate entities in flux give shape and sub-

stance to them (even as we shall see only temporarily and locally), and perform relations that provide distinctions, and as such orientation (Sandberg & Tsoukas, 2011).

This shift from a notion of socio-materially intertwined, interacting, but discrete entities to one of sociomaterial entanglements understood as ‘intra-actions’ of non-determined, fluid phenomena, has important theoretical implications. For one, it withholds primacy from human or material agency in the explanation of organizational developments. Rather, agencies are viewed as hybrid, contributing equally in the form of indistinguishable, fluid meshes. In this respect, they shape one another, forming not only distinctions, properties and relations, but also exchanging properties and building further sociomaterial associations (Latour, 2005).

While the notion of entanglement resonates with other concepts such as “entwinement” (Sandberg and Tsoukas 2011) and that of the “mangle” (Pickering, 1995), it is clearly distinct from these and similar approaches in its treatment of material-human agency. Thus, Leonardi’s notion of ‘imbrication’ (2011), for example, accepts material as well as human agency, but draws a distinction between them : “people have agency and technologies have agency, but ultimately, people decide how they will respond to a technology” (Leonardi, 2011). From a perspective of sociomaterial entanglements and intra-actions, however, no primacy is given to either human or material agency in the explanation of organizational developments. Rather, agencies are hybrid, contributing equally in the form of indistinguishable, fluid meshes. Agencies, instead, gain specificity and directionality only through their developing relationality, their performed relations. Barad (2007: 140-141) comments with regard to this, that it is “this ongoing flow of agency through which (...) causal structures are stabilized and destabilized. (...) Relations of exteriority, connectivity, and exclusion are re-configured. (..) Agency is not an attribute but the ongoing reconfiguring of the world.” Agency, boundaries, properties, and meanings become differentiated “through the intra-activity of

matter. (..) Differentiating is not about othering or separating but on the contrary about making connections” (p. 392).

The Dynamics of Entanglements in Trans-local Intra-actions

i) Entanglements and Closure

Stabilization is a core concern of organizations as it allows for reducing ambiguity and equivocality, directing agency, and thus making organizational action possible (Tsoukas & Chia, 2002; Weick, Sutcliffe, & Obstfeld, 2005). In fact, “organization is the attempt to order the intrinsic flux of (...) action, to channel it towards certain ends by generalizing and institutionalizing particular (...) representations” (Tsoukas & Chia, 2002) p.567). Achieving closure has also been a central issue in science and technology studies and design studies, in particular in relation to the stabilisation of technological artefacts (Akrich, 1992; Austin & Darso, 2009; Bijker & Pinch, 1987; Ewenstein & Whyte, 2009; Kline & Pinch, 1996). In these contexts, closure is understood as the situation in which the details of a technological artefact no longer need to be specified because they have become taken for granted as “essential ‘ingredients’” for it (Bijker & Pinch, 1987).

In science and technology studies, a prime mechanism that helps bring about ‘closure’ is related to ‘relevant social groups’ (Bijker et al. 1987; Kline et al. 1996; Wilson and Howcroft 2005). ‘Relevant social groups’ are defined as those groups that share a set of meanings in relation to a specific artefact (Kline et al. 1996). ‘Relevant social groups’ are seen as crucial in the definitions of functions and resolution of controversies as change and development take place ahead of stabilisation being reached through ‘settlements’ in which the interests of a large enough group of relevant users are reconciled. p.44). In other words, closure is a result of the relationships between and within the various social groups and the object of concern.

In this view, however, relationality remains subject-object oriented, inasmuch as it addresses a given (albeit evolving) set of objects and subjects. In a sociomaterial perspective, changes in the closure and openness of objects need to be identified rather in the changing relationality of sociomaterial practices that involve both human and non-human actors. It is thus through recursive, relational dynamics of intra-action that material objects emerge. Their increasing materiality contributes itself to setting boundaries and performing what Barad terms “agential cuts” (Barad 2007) between sociomaterial practices. This ultimately leads to a stabilization of the objects themselves. Our argument here, therefore, is thus that materiality needs to be accounted for as a relational concept, not between given subjects and objects, but as evolving entanglements that gain determinacy over time.

Entanglements, however, do not perform determinacy through a linear development from indeterminate flows to closure and stability, on the contrary. Pickering (1995), for example, showed that because of the “tentative fixing of goals” and the stabilization of objects, processes of resistance and accommodation emerge and bring about “temporally emergent contingencies”, “unpredictable transformations”, and “emergently intertwined delineation[s] of machine captures” (p. 209). From such insights, authors have questioned the idea that objects can ever become fully stabilised (Kline & Pinch, 1996; Laet & Mol, 2000; Law & Mol, 1995; Mol & Law, 1994). Rather, closure can only be achieved temporarily and locally and movements of interrelating always bring about also reconfigurings and reopenings of the world. Such openings have been discussed, for example, under the term “interpretative flexibility” (Bijker & Pinch, 1987; Collins, 1981; Orlikowski, 1992; Pinch, 2008). Thus, even if entanglements can be stabilized, more stable materializations developed, and boundaries around phenomena and specific objects, subjects and activities delineated, “materialization needs to be understood in terms of the dynamics of intra-activity” (Barad, 2007: 208). Matter is at the same time “a stabilizing and destabilizing process of iterative inter-activity”, it is “not a thing,

but a doing” (p.210) and is reconfigured through each intra-action (p. ix), such that “boundaries do not sit still” (p.171). As Barad argues, it is the “iterative enfolding of specific materializing phenomena into practices of materialization [which] matters to the specifics of the materialization it produces” (Barad, 2007, p. 180).

Seen in this way, the dynamics of continuous stabilizing and destabilizing developments can be observed when locally stabilized phenomena and their ‘components’ ‘intra-act’ with and move across contexts to find themselves materializing differently. In fact, a major methodological challenge, when studying entanglements, is that they are only poorly visible and difficult to analyse as they are partly indeterminate and always in continuous development. Whilst Barad (2007: 158) suggested that breakdowns, “when things stop working”, are occasions for entanglements to surface, we propose that another way to study the developments of entanglements is to focus on the occasions when specific entanglements become, what we call, disentangled in order for new entanglements to take place. With disentanglement, we do not mean that a phenomena becomes discontinuous or cut into separate, independent parts (Barad, 2007: 348). Rather, disentanglements arise when locally determined phenomena move, for example, from one organizational context to another, such as to a different organizational unit (e.g. team or set of experts), or to another formally defined phase in a process. Through the intra-acting with other locally stabilized phenomena (which may move across contexts to find themselves differently materializing) subsequent iterations of particular practices result in the production of new phenomena. Callon specifies that in this trans-local movement, not only more entanglements are produced, but also attachments (e.g. in markets between goods and consumers), and whilst the first accounts for the shifting of boundaries, the second does for their stabilization (Barry & Slater, 2002a). In this way, taken together, entanglement and disentanglement can “describe the dynamics involved in reconfiguring entities and networks of entities” in a more precise and more dynamic way (Barry & Slater, 2002a).

ii) Entanglement and trans-local movements

Trans-local movements and their incurring entanglements and disentanglements in local displacements have been studied primarily with regards to how a particular management approach, innovation, object or practice is translated from one organizational context, industry, or geographical location to another (Birkinshaw, Hamel, & Mol, 2008; Czarniawska & Sevón, 2005; Gherardi & Nicolini, 2000; Scarbrough & Swan, 2001).

In social studies of science and technology, for example, the idea of “immutable mobiles” suggested that an entity can be geographically mobile, but materially stable, that is its elements and the relationships between them are not changed (Latour, 1987). This idea has been partially contested and/or refined and more elaborate views on what changes and what remains stable have emerged since. Czarniawska et al. (2005) have shown, for example, occasions of both isonymism, in which the name travelled with a relative stability whilst work practices denoted by the name changed, and of isopraxis, in which the work practices remained relatively stable, but were renamed differently. Of particular interest from a sociomaterial perspective is the study by Mol and Law (1994), in which they examined how anaemia changed when transported from Europe to Africa. Anaemia did not resemble an “immutable mobile”, but behaved like a fluid that was capable of transforming “itself from one arrangement into another without discontinuity” such that anaemia in Europe is not anaemia in Africa. In other words, the entanglements of anaemia with specific laboratory equipments, machines, clinical practices and medical skills, did not perform solid boundaries, but allowed for “variation without boundaries” (Mol and Law, p.658).

A key concern of the sociomaterial position then has to be to develop a more precise and empirical understanding of how entanglements develop and perform in the moves from a state of indeterminacy to a determinate phenomenon with boundaries, specific agencies and objects.

More specifically, in extending the sociomateriality agenda to information systems research there are important issues raised regarding the showing of how the “apparatuses” of “boundary-drawing practices” (Barad, 2007: 140) work, and to develop a *relational* account of mattering, that is, to show how relations perform determinacy in terms of closure (and re-openings) of technical objects.

Motivated by these concerns the key theoretical question which we focus on in our empirical investigation is how the materiality of entities can be reconciled with a view of the world in continuous flux and change. With the notion of intra-action being central there is an emphasis in our investigation on observing the performed relations “through which the boundaries and properties of the ‘components’ of phenomena become determinate” (Barad, 2003). In that context we focus on ‘entanglement’ as a description of the often messy and difficult to describe meshes of “intra-actions” between many entities in the setting studied that are in various degrees of flux and that give shape and substance to each other – even if only temporarily and locally. We study the developments of entanglements and the ways they perform stabilization (but also further openings) within the context of computer games development. This empirical setting allows us to focus on the multiple objects that are developed, signed off, changed and newly arranged during the game development process.

EMPIRICAL SETTING AND RESEARCH DESIGN

The research setting of computer games development was seen as of particular interest in relation to this because of its orientation towards both stabilised entities but also emergence and change. By tracing the stabilisation of entities in the form of key objects that are part of the development process of computer games and the entanglements - but also disentanglements - involved in the ‘closure’ of these objects, the analysis that will be presented shows how both

change and stability can be accounted for through the notion of entanglement and the detachments and attachments – or forming and removing of relations – involved.

To this end a broadly interpretive research approach (Orlikowski & Baroudi, 1991; Walsham, 1995) was taken that focused on the in-depth work practices of game developers in their context.

Data collection and analysis

In order to accommodate the relational ontology of sociomateriality in which primacy is not given to human agency and intentionality, but also as a way of acknowledging the limitations of the reliance of interpretive research on interviews (Orlikowski & Baroudi, 1991), data collection focused not only on interviews but also observations and the collection or studying in situ of key objects that are part of the development process.

The empirical study of computer games development on which this analysis draws on was conducted between September 2008 and January 2010. Data collection involved fifteen separate visits to three games development companies in this period to investigate their computer games development processes. Twenty five interviews were conducted along with 60 hours of observations at three leading UK-based computer games design and development studios. Most of the interviews were conducted in the formal settings of managerial offices however others were conducted less formally, with informants in the games development workspace. Interviews were selected to provide a cross-sectional view of the groups involved in the games development process. Interviewees' roles ranged across different levels of management (Development managers, commissioners, heads of design and programming), different functional groups (games engine, weapons and so on) and different levels of technical expertise (team leaders and team members). During each visit attention was also given to collecting and studying the key objects involved in the coordination of the development of the computer games at the three studios.

The observational material was recorded primarily in note form during the time at the studios, usually contemporaneously (or very soon after a certain event or encounter of interest). Field notes were supplemented by other materials including: sketches; print-outs of key documents used in the development process; screen grabs of computer applications and displays; and photographs taken at one of the studios.

The analysis of the empirical material assembled during the fieldwork for this study initially focused on: a) identifying patterns of events and interactions among developers (e.g. signing off, milestone review meetings); and b) associated key objects involved in these (e.g. concept book, game design documents) across all three of the sites studied. This was followed by more detailed analysis of the games development processes and the material entities involved. In order to aid this analysis, interview transcripts and observation notes were imported into nVivo – the computer-aided qualitative data analysis software. The software was used primarily as a tool for organizing and structuring the data.

From the entities, roles, and processes thus identified a narrative account of how computer games are developed and how objects are involved in this process was developed (Langley, 1999). As Langley points out, studying processes presents particular difficulties as it involves “events” which are conceptual entities that are difficult to capture and present, multiple units of analysis with ambiguous boundaries, varying “temporal embeddedness”, and an eclectic drawing on phenomena (Langley, 1999). One way of dealing with these difficulties is through the assembling of a narrative using a variety of data or searching for “similarities in the patterns of event sequences across cases” (Langley, 1999). While such an overview is necessarily an abstraction from the actual messiness and complexity of work practices observed, it does help in this case to trace the transitioning of objects within the process as a whole and their ‘closure’ and why that is important to the developers. At the same time, the high level of commonality found across all three sites in the structuring of the work process,

the groups or individuals involved, and the objects in play, highlights the exploratory value of this approach to presenting and analysing the empirical material assembled.

Within this overall account, analytical attention focused on particular moments of ‘closure’ and movement across contexts of objects and the associated entanglements and disentanglements observed. In the research setting of computer games development this is very much associated with ‘signing off’ procedures. We thus traced the stabilisation of entities in the form of key objects that are part of the development process of computer games and the entanglements - but also disentanglements - involved in the ‘closure’ of these objects, the analysis presented shows how both change and stability can be accounted for through the notion of entanglement and the detachments and attachments – or cutting and forming of relations – involved. Findings are presented in relation to the stabilisation and cross-context movement of entities and objects in the process of computer games development as a whole.

Empirical context

The studios in which the empirical study was carried out have been named (using pseudonyms to preserve company confidentiality): GameDevCo, PetName and Dredd. GameDevCo is a leading independent multi-platform games developer. Founded in 1990, the company develops games under its own brands, as well as on behalf of external publishers and intellectual property rights holders. PetName is highly successful company develops its own titles, almost exclusively for the Xbox console. Founded in 1997, the company has developed a series of commercially successful and award-winning strategy, action role-playing, and simulation games. Dredd is a multi-platform and multi-genre developer. Founded in 1992, the company produces games both under its own brand and for third-party clients, and has enjoyed significant commercial success.

‘ENTANGLEMENT’ AND ‘DISENTANGLEMENT’ IN COMPUTER GAMES DEVELOPMENT

A big part of the computer game development process involves the conceptualisation, production, and assembling together of digital “assets” that will make up the game. “Assets” that are assembled include 3D models and digital artwork animation sequences, artificial intelligence (AI) algorithms that control entities not controlled by the player, visual textures, special effects, sounds, text and spoken dialogues, music and many more depending on genre and sophistication of the game. These “assets” get passed between the developers for different inputs as they are produced and move along what the developers referred to as the “asset pipeline” through a number of format transformations that will make it possible for them to be associated with the “game engine”. The game engine is the software that must translate the elements that make up the game into the code that can be run by the different hardware components of the platform. Good collaboration and coordination are vital because “assets” have to be at the right place at the right time and in the right form, both in relation to each other, and the “game engine” but also in relationship to the progression of the development process. In the collaboration involved in both conceptualising and building a game, a number of key objects play a central role.

The presentation of the empirical material that follows will focus primarily on the entanglements and disentanglements involved in the transitioning between the conceptualisation and specification of the game and two such objects involved in this: the “concept book” and the “game design document”. Attention is given to how the ‘closure’ and movement across contexts of objects takes place as the game developers seek to materialise the highly fluid and indeterminate ‘idea’ for a game.

Fluid Entanglements Materialising the Idea of the Game

In the beginning of the game development process, a short (few pages of A4) word-based narrative description of the proposed game and its key features is written, usually by the lead designer of a studio. It establishes a provisional set of relations between characters, characters and locations, and the temporal unfolding of the game through a written narrative. This initial materialisation is illustrated in Fig. 1, the first of four figures through which the evolution of entanglements will be shown.

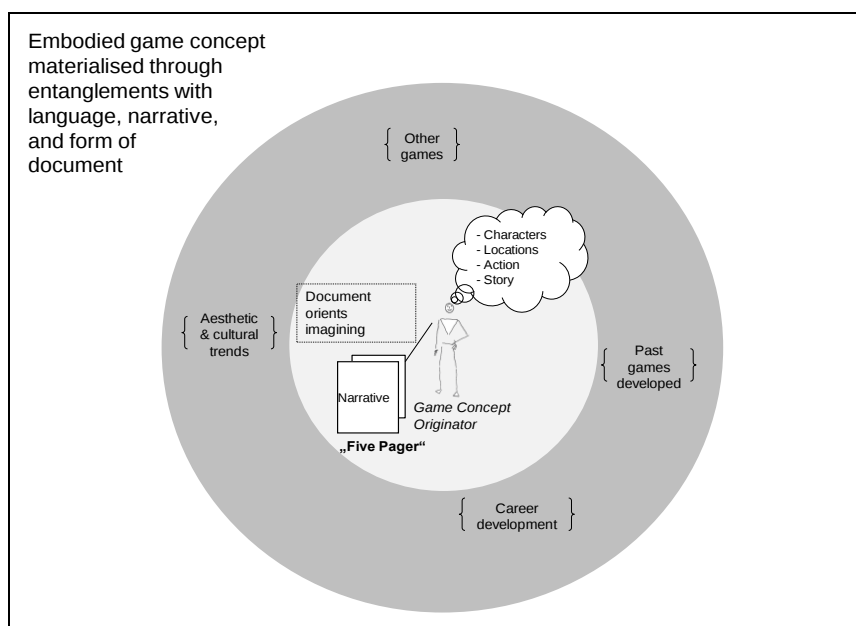


Figure 1: The first materialisation of the game concept through what was usually referred to colloquially by the developers as a “five-pager”

Entanglements in these illustrations do not only refer to the direct relations of the object with the author and between the entities that make-up the object, but also much more difficult to represent broader relations between the immediate context in which this document is being composed and wider meshes of relations that the materialisation is part of. These are shown in brackets around the outside of the development process in order to depict their indeterminacy and the bracketing of relations that their naming and depicting inevitably entails. They

are related both among themselves and with the context of the conceptualisation of a computer game through intricate and often overlapping meshes of relations.

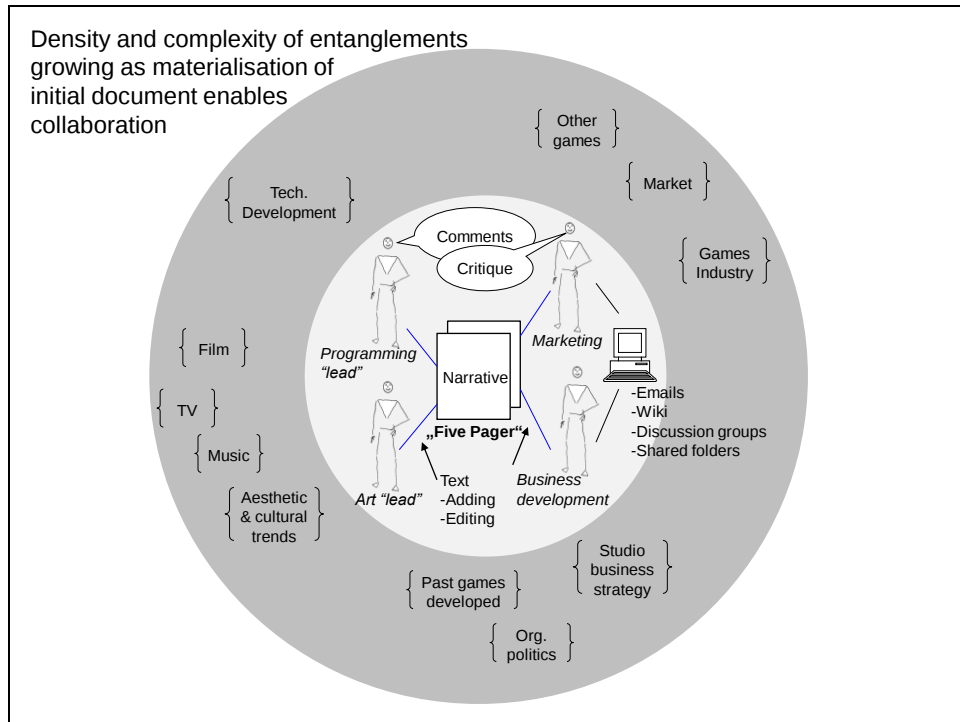


Figure 2: Growing entanglements as collaboration towards developing the “concept book” takes place

This initial written text gradually becomes entangled in more relations as others with different forms of expertise comment on, and make contributions to, the text as work on producing a “concept book” for the game gets underway (Fig. 2). The senior producer at Dredd, while drawing a diagram of the early version of the document and how it becomes transformed into a “concept book”, explained how this initial document would “boil the game down into five pages” and how the “five-pager, then via [these people] becomes 60 to 300 pages; whatever is required.” He pointed to concept artists who come up with visualisations of the game world, the characters and entities that will inhabit it and so on, business development managers who comment on the proposed idea and possibly propose changes in terms of how it fits with the way the studio wants to position itself in the marketplace both in the present but also

the future, and the “leads” of the art and programming teams who will comment on and propose contributions to the initial concept in terms of the inputs from their teams in the form of art styles or technological features and development tools.

These complex entanglements and how they go beyond the immediate vicinity of the interpersonal interactions between those working on the “concept book” are captured well in the following quote from the director of development at GameDevCo describing the inputs of various specialists to the conceptualisation of the game and the production of the “concept book”. The quote is number coded for the purpose of linking the illustration it provides to the analysis of entanglements that follows.

“[The work of the business developers] involves very much talking to clients and their contacts within industry (1a) and finding out what they require for a particular slot for the next few years. They may already own a movie (2) or TV (3) licence and want a game. (..) But we have to be careful, because quite a lot of people come to us with licences, but unless it fits with our studio profile (1b) we will not take the work. (..) The marketing department also has a big say about what they want [and] how they are going to sell it. They know what the market (4) is doing in terms of genres and competition (5), so it is very important to know that they want these kind of features or to push forward in certain areas. It is important to listen to also [in terms of] what funds are available and the manpower to put on. (..) We also follow the creative side (6) and involve our designers at the studio on this, but also involve our senior technical guys and senior art guys with regard to this, because the industry is so tied together (..). The technical guys must look at that and say ‘is that possible, how is it possible how much would it cost if we did do it’. (..) [They] will all sit together and go, ‘right how can we push this forward this design in a way that will make the brand (7) better; how can we push the tech’? All those things feed into each other. (..) The technology guy will say: ‘we have never done that before, we don’t know what it will take, we don’t know even if some of these effects are possible or how we go about them’ (8). Ultimately the project director will look at that from a costing (9) and from a scheduling (10) point of view and say ‘we have x amount of time to do this in and these resources we can bring. What are the major risks we need to be focusing on’? But in the end we get to the point where we create a high-end (..) document that looks great, (..) with all sorts of madcap stuff.”

What we see in the transitioning from the initial few page outline of the game idea to the “concept book” is that the very initial stabilisation of the first short document achieved through the structure of the text, the characteristics of a document (beginning and end, page length, title, date, authors/contributors), the use of language and its syntax and semantics, and the establishment of relations through the narrative between characters, characters and locations, and the temporal unfolding of the action is needed for the original and highly elliptical and fluid idea of the game to be rendered both more stable and ‘detachable’ from the person(s) with the initial concept. In order to disentangle the ‘idea’ of the relations between characters, characters and locations, and the temporal unfolding of the action from the author(s) and make it ‘attachable’ to others that need to contribute to it, new entanglements have to be established. A first materialisation of the initial game concept is therefore achieved with the stabilisation of relations between the components of the original idea (characters, locations, temporal unfolding of the action) through the entanglements described above.

It is through all these ‘entanglements’ between entities (components of the game idea) and configurations of entities that are both social (interactions of developers) and material (document structure, rules of syntax), that the original idea attains form and can then move without the presence of the originator(s) to become part of many more sociomaterial configurations encompassing a much bigger and more diverse group of developers.

Furthermore, as is illustrated in the quote from the director of development at GameDevCo, these entanglements go much further than the entities to be arranged and those working directly on incorporating them into the “concept book”. This is because those involved in the drawing-up of the “concept book” will be, through their own entanglements, linking the “concept book” to markets (4), other games on the market (5), past experiences of developing games (8), wider aesthetic and cultural trends both in gaming (6) and beyond (e.g. films (2),

television (3)), technological developments (8), the business strategy of the studio (1b, 7), organisational politics, in relation to competitors (1a), and so on. The detailed quote from GameDevCo shows that these ‘entanglements’ shape and give form to the game concept and thus increase its materiality. Through ‘entanglements’, ‘disentanglement’ and further ‘entanglements’ then become possible. Without these, the original idea would remain an embodied idea, unable to move and circulate beyond the presence of its originator(s)/author(s).

The new entanglements are given form and shape through the addition and editing of text, the combination of the text with concept art, timelines, and outline budgets, the application of sophisticated desktop publishing techniques, and the fitting to business and technology development strategies and market conditions. According to our informers, this takes place through complex and changing entanglements through both the work on the draft ‘concept book’ itself but also in meetings and through electronic communications.

Adding Entanglements and Performing Closure through the “Concept Book”

The aim of the concept book itself is to describe the game idea and its features, the thinking behind it as well as visual representations of the main characters and locations in the game accompanied by what can be described as imaginary biographies for the characters outlining their roles in the game and what they could do. It is an aesthetically engaging artefact, 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 in such a way as to look like one of the very characteristic spaceship doors in the film. Another for some medieval adventure had the look and feel –even smell (obtained from wetting the book and leaving it in a basement store room for some time) – of an old and musty book.

Describing a typical PetName concept document, a development manager explained:

“It has pictures and varied descriptions of the story and plots and who the main characters are, biographies of who these people are, what they look like; it covers all aspects of the game. It 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, ... even a budget section at the end, the staff plan, with the end date, the start date and the phases and all the markers in between. It tries, at a high level, [to] encapsulate the whole game.”

By studying the samples viewed it was possible to see how the concept book, as the first *named* and *objectified* physical materialisation of the idea for the game, is at the centre of a multitude of relations and intra-actions. It provides a first, high-level outline of the main entities in the game that will be realised as ‘assets’ and of their relational ordering. It also associates in a heuristic way that ordering to project time and resources. The document also made it possible for members of the development team with their multiple areas of expertise to bring together, in a common space, their interpretations of the vision, concept, and ideas of the proposed game. For this, they used textual narratives, textures, materials, drawings, photographs, tables, and spreadsheets, which have been made combinable into one object and accessible to all those involved in the games development process and from different areas of expertise with different representational techniques.

One more important function of the ‘concept book’ related to “sign-offs and green lighting procedures” for the commissioning and production of a computer game. These are required in order to trigger the transition from the conceptualisation to the production phase of the game with the signing of agreements, and the commitment of resources and funds. In this way, the concept book provides a first stabilization not only of the entanglements between the various aspects and parts of the game, but also between the various specialists, teams and groups in-

volved in its production, as well as their various entanglements with the objects of the game, that are still fluid and under development.

Achieving the ‘closure’ of an object such as the concept book was crucial in relation to the development of the game. The ‘concept book’ must be finalised so that it can be signed off and become the basis of the more formal specification of the game in terms of the game, art, and technology design documents. Its materiality (i.e. its resistance to change) (Callon & Muniesa, 2005) is important because it needs to ‘resist’ in order to provide the foundations for the project for all those who will have to produce the game.

Next to the concept book’s materiality, that is the entanglements it objectified, also its physicality and sensible qualities are important in terms of conveying to those commissioning or specifying the game many of the more difficult to represent aesthetic and affective features of the game. This was done through the use of styling, textures, materials, colours, and concept art. It is this physicality of the concept book (i.e. its sensible qualities) that also brings with it seeds of new openings and entanglements. In fact, these difficult to represent and hence under-determined aesthetic and affective features are nonetheless seen as important to the success of the game (Roberto & Carioggia, 2003; Tschang, 2007) and hence built in to the concept document and brought about much of the emergence in the game development process. In this way, the physicality through which the entanglements are held down, changed and rearranged the materiality of the concept book itself.

As can be seen in Figure 3, once the “concept book is assembled, a complex mesh of relations is put in place between increasingly well-defined entities in the form of a textual narrative, characters, concept drawings, textures, budgets, resources, timelines, tables and figures of market statistics, and technical characteristics, linked together, not just through the interactions of the developers but the inscriptions and circumscriptions of the physicality of the document.

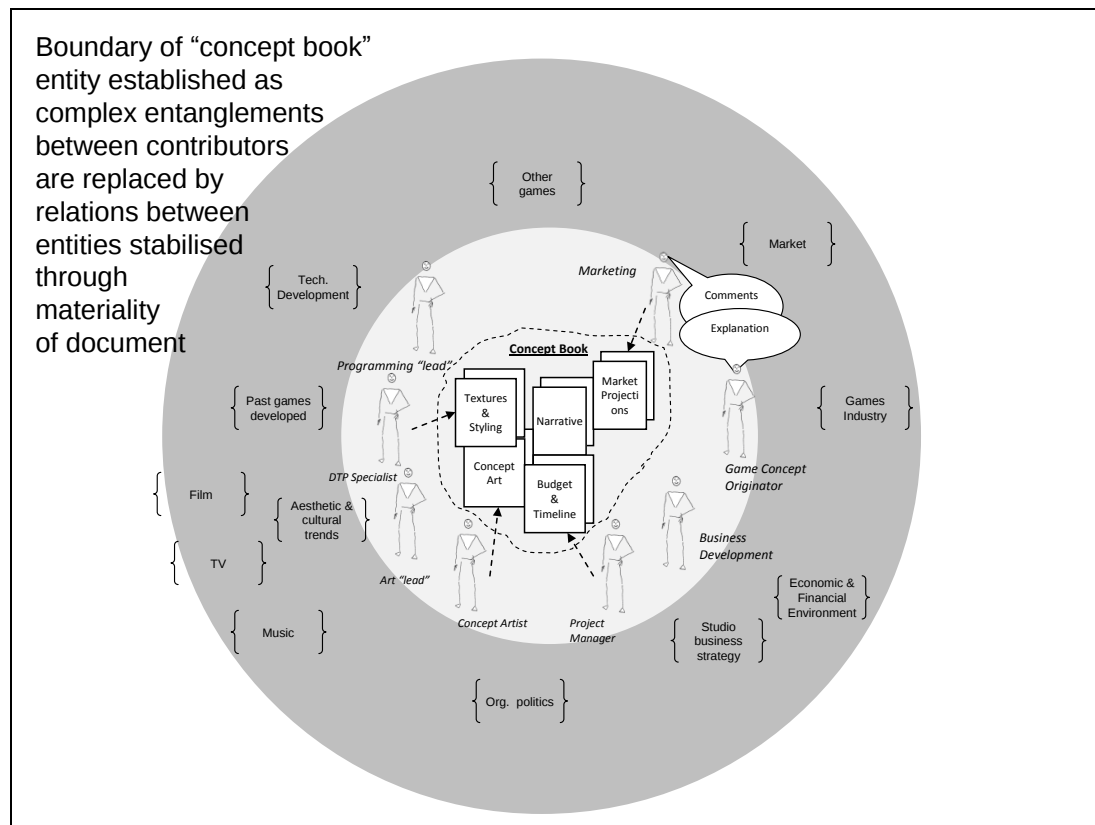


Figure 3: Disentanglement of the “Concept book” from the developers as inputs get committed in the form of well-defined entities (e.g. textual narrative, concept art drawings, budget, timeline, market projections, styling) related in a particular way

As the developers commit increasingly well-defined entities to the document they are disentangling them from themselves by entangling them with other entities in the document and with the document itself, giving further determinacy and hence materiality to the original idea for the game.

Trans-local Movements: Signing-off and the moving from the Concept Book to the Game Design Document

For the ‘concept book’ to move from the process of its production and become instead part of the commissioning and production of a game, there had to be a disentanglement from these

complex and localised interpersonal entanglements involved in its production so as to make possible the detachment of the “concept book” as an object. The definitive moment of ‘closure’ comes with a “signing off”, as illustrated in figure 4.

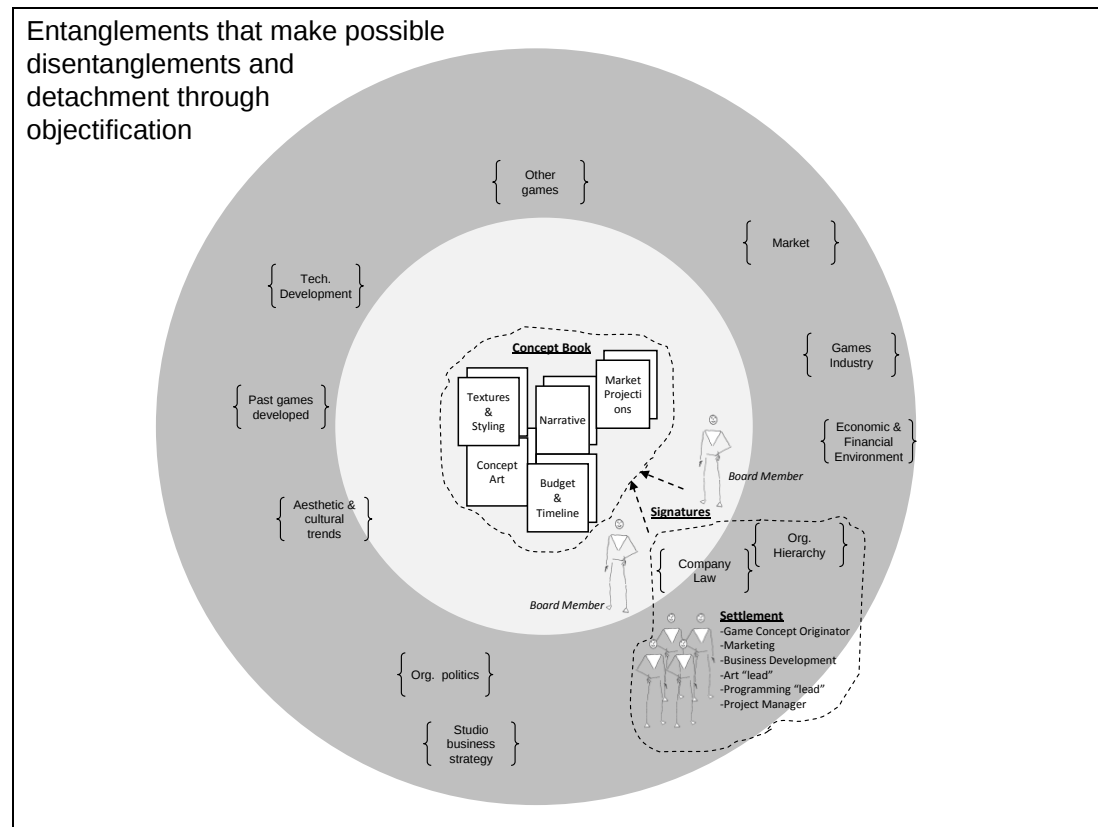


Figure 4: Detachment and mobilisation through the entanglements and disentanglements involved in the ‘closure’ of “signing-off”

Those involved in the production of the “concept book” are able to disentangle themselves and their discourses and interactions from the document through the signature(s) on the document of those empowered to do so organisationally and institutionally. At PetName, for example, this would be two board members of the company in consultation with the US parent company, while at GameDevCo that develops a significant number of games for external clients a more complex procedure was described where signatures of both the board of the studio and of the clients would lead to the start of negotiations on a formal separate project contract setting out deliverables, development advances and so. Through institutional, organisa-

tional, and legal entanglements, the “concept book” thus attains the status of a ‘closed’ determinate organisational document, but is also disentangled from the developers producing it, detached from the process and apparatus of its production and able to move to the commissioning and production process.

The physical qualities of the concept book also contributed to its trans-local movement, making it possible for the team involved in the next phase in the game development process to take away and consider this first structured materialization of the game, taking it into meetings, presenting it, and working on and through it.

Once a project has been agreed and approved and the concept book “signed off”, the entities and relations between entities outlined in the concept book go on to form the basis for the compilation of another key object referred to by the developers as the Game Design Document (GDD).

The GDDs specify the features of the game to be developed such as the levels the game will have; what these levels will be like; the script – including dialogues and decision paths – of the game and how that relates the different levels to each other; who the characters are; what their role in the game is; where they can appear; how they can encounter each other; what the mechanics of their interactions are going to be; how they are going to move; what ‘things’ they can interact with or manipulate; and so on. The GDD is composed of many sub-documents and is stored on – and available from – the shared servers of the development teams. It is also frequently materialised in the form of physical print-outs – usually of only certain of its constituent sub-documents at a time – for use in meetings. The following quote from the GameDevCo study provides a good illustration of this role of the GDD:

“The aim at the beginning of each project ... is to create a ‘game design document’ an ‘art design document’ and a ‘technical design document’. The game design document will contain 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. ... [The game design document] is also crucial to the relationship with the client [as well as in terms of] visibility for the collaboration.”

The content and structure of the GDD will depend on the genre of game being developed. It is usually accompanied by an Art Design Document and a Technical Design Document. In the former, art-related assets are specified in much more detail, style sheets are developed for even the most mundane and trivial entities, and so on. In the latter, detailed technical specifications for all the elements specified in the GDD (levels, tasks, characters, environments etc) are defined.

Whether an individual participating in the development process is a coder, an animator, a 3D artist, or a special effects or artificial intelligence specialist, during the development of the game the GDD and its component subdocuments will continuously cross backwards and forwards between individuals and groups of individuals with a particular expertise and way of working and interacting.

The importance of this group of objects became even more explicit during the participant observation phase of the research at PetName where the sections of the GDD 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. It is worth noting that as a particular level took shape, initial ideas might be modified or dropped, new ones introduced, and unforeseen problems encountered. This would result in different versions of that section of the GDD, all of which would be retained, however, within the overall GDD.

Closure is a Precarious and Temporary Achievement

What can be seen examining the transitioning from the “concept book” to the GDD and accompanying technical and art design documents is that while the “sign off” of the “concept book” appeared to signal a definitive ‘closure’ in terms of entities, boundaries, and relations among entities, this was not the case.

The settlement of relations captured in the “concept book” becomes open to contestation as soon as it becomes part of the production of the game. For example, a character in the game is not a determinate entity. Through its entanglement with the textual narrative, concept drawings, textures, budgets, and timelines of the concept book, it can move and be attached to the world of the art “lead” (who develops style sheets for the character) or to the world of the programming “lead” (who works out CPU and memory budgets and polygon counts relating to the character). The entity is quickly part of new and different entanglements relating to the detailed specification of the game needed for its production through the game, art, and technical design documents. While the entity of a particular character remains, the settlements relating to this entity as captured in the “concept book” are no longer sufficient to determine it and new entanglements need to provide the necessary closure.

These kinds of detachments and attachments and organisational movements through entanglements and disentanglements were not only found in relation to the objects associated with the collaboration involved in building a game such as the “concept book” and GDD. Also the objects that made up the game, the ‘assets’, will pass between developers who will alter and refine them. As they are signed off from a “milestone schedule” and articulated successfully with other ‘assets’ already in the “build version” of the game, they attain ‘closure’. As more and more ‘assets’ are incorporated into the ‘build version’ and more and more of the game and budget and time limitations get tighter, it becomes ever more costly and difficult to un-

dertake changes. In other words, when the object becomes more ‘entangled’, its ‘closure’ and stabilisation as an entity starts to take place.

Even then, however, closure is a precarious achievement. As the last ‘assets’ are incorporated, ‘bugs’ that were not previously encountered or noticed are surfaced. It is at this stage that the importance of the notion of sociomateriality is revealed and the mutual constitution of both the social and the material is highlighted. The materiality of the game under development proves to be greatest at the point when its physicality is at its lowest level and developers provide extra care not to “break the build” version of the game at this difficult to repair stage. It is because of the precariousness of this materiality and the importance of ‘detaching’ the game from the apparatus of the development studio and to make it possible for the game to cross via a retail channel into the world of the end user.

Step-by-step, relation-by-relation, the degree of change open to the game is reduced at great effort as the developers seek to transform it into a product by progressively disentangling it from the development process and configuring it in such a way that it can be detached from the development studio and enter the world, first of commerce and then of the buyer.

DISCUSSION

What our analysis of the empirical setting has brought to the fore is that rather than the permanent immutability of ‘closure’, the notion of ‘entanglement’ and ‘disentanglement’ allows for a more dynamic and emergent conceptualisation of stability and materiality. Our analysis suggests a precarious if hard fought-for settlement of what is to be held steady and what is open to interpretation or contestation in the development process of computer games. And while the achievement of stability through ‘entanglements’ is crucial to the ‘disentanglements’ needed for the detachment and movement of these entities across contexts, it is always

a temporary stability. Closure makes new ‘entanglements’ and different sociomaterial configurations possible and thus brings it them seeds of new openings.

The tracing of the entanglements and disentanglements involved in the development of computer games illustrates that despite the big efforts directed towards the achievement of ‘closures’ through the use of objects, this led to new ‘openings’ through new materialisations as objects and entities crossed from conceptualisation to development and production.

Mol and Law have argued that objects are never truly ‘closed’ because they are never the same from one setting to the other or from one set of interrelations to the other, even in the same setting (Law & Mol, 1995). Instead, they should be seen as participating in different joint heterogeneous performances and the particular networks of relations they draw on and build each time (Law & Mol, 1995; Mol & Law, 1994).

Our study shows that objects are only provisionally ‘closed’ or ‘settled’ (Girard & Stark, 2003) because of the relations they perform. Materiality is thus not as a ‘given’, but a precarious achievement preformed through intra-actions as part of specific phenomena and their materialisations (Barad, 2003). It goes on to show, however, how such “provisional settlement” (Girard & Stark, 2003) can be theorised and studied empirically through the concepts of ‘entanglement’ and ‘disentanglement’. Furthermore, by focusing not only on separate materialisations but on the transitioning between them, our analysis has shown why the achievement of this ‘closure’ or ‘settlement’ is important in terms of the detachment, attachment, and hence movement of entities across settings.

So, while we show how stability, rather than being the rule for organisations is a costly and hard fought-for achievement that is precarious and must be recursively attained (Tsoukas & Chia, 2002) and “things are the stability-patterns of variable processes” (Rescher, 2007: 149), we can also make some indications for why so much effort is directed towards these ends. Our analysis suggests that one reason for this has to do with how the pragmatic concerns of

organisations and the development of digital systems that require the achievement of stable states and well-defined entities can be reconciled with a world of change, flux, and indeterminism. This is because, in this reconciliation, entanglement and disentanglement and the accompanying organisational attachments and detachments are crucial. As was shown in the disentanglements involved in the assembling and “signing off” of the “concept book”, that is how materially stabilizing entanglements through physical and institutional inscriptions make trans-local movements of entities possible. Furthermore, we also see how these movements bring about new entanglements and reopenings and how, thus, emergence builds on closure and vice versa.

Seen in this light, the ‘closure’ of the objects studied, even if evasive and fleeting, is important in terms of how entities are formatted and given shape in order to be articulated with what Latour refers to as the “narrow channels of the social” (Latour, 2005). ‘Closure’ through the production and use of objects, therefore, relates to this process of attempting to articulate parts of the unformatted world of flux and immanence to the formalisms on which social life largely depends on because that is how “a privileged trajectory is built, out of an infinite number of possibilities” (Akrich, 1992). As Chia and Tsoukas point out, in order to manage “sensible reality” it is necessary to “abstract it, to harness its fluidity and concreteness in our conceptual systems to act systematically on it” (Tsoukas & Chia, 2002). Change has to be “channelled, guided, led-in” (Tsoukas & Chia, 2002).

It may appear that ‘closure’ is the norm in the object-oriented work of the game developers. It can be seen to underpin both a temporal and relational manageability in an often very uncertain, under-determined and high-pressure development process where loss of control in terms of scheduling and budget overruns can be catastrophic for a studio. Understood as part of the channelling of change referred to by Tsoukas et al. (2002), the ‘closure’ of objects is important because it offers the *possibility* of a settlement of what is to be held steady and what

can left ‘outside’ a particular materialisation of a digital system being realised. However, we have shown, that these are only permanent settlements as, in a paradoxical way, the ‘closed’ objects in the computer games development process can more readily pass and circulate between contexts and networks of relations, and let re-enter, what has been left out, in new and unpredictable ways (Callon, 1998).

This suggests that closure, determinate entities, and materiality are not ‘opposites’ of emergence, change, flux and immanence. There is no ontological inconsistency or confusion at the heart of certain sociomaterial views of the world (Jones, 2011). We have tried to show in this article why and how ‘the material’ cannot be separated from ‘the social’. This is why the notion of ‘entanglement’, seen in conjunction with that of ‘disentanglement’, is ontologically and epistemologically important in the sociomaterial view. The concepts provide a way of accounting for both stability and flux through a view of movement of entities between contexts that allows for alternative materialisations of those entities according to the relations which they are a part of. In other words, “matter is a stabilizing and destabilizing process of iterative intra-activity” (Barad, 2007). It is because of the provisionality of ‘closure’, but also as we have shown, of the movement this ‘closure’ makes possible, that entities are never fully stabilised and determined. Entities change as they move and flow, but also change what they become related to or ‘entangled’ with in the process of this movement.

Summarising, our sociomaterially informed analysis of the development of computer games has, therefore, allowed us to contribute to theory in a number of ways. Firstly, we add to the discourse on fluidity, emergence, and organizational and technological becoming (Orlikowski & Barley, 2001; Tsoukas & Chia, 2002; Tsoukas & Langley, 2010) by outlining the intricate ways how flows are not contradicted by, but depend on, closure and objectification. Whilst others have argued that movements rely on processes of objectification and detachment in the context of markets and the movements of goods (Barry & Slater, 2002b, 2002a; Callon &

Muniesa, 2005; Millo, Muniesa, Panourgias, & Scott, 2005; Slater, 2002), we can show that through objectification and closure, objects can also be opened up again and new attachments developed in settings relating to the collaboration involved in the development of digital technologies and systems.

Secondly, despite the taking into account in past studies of materiality to explain organizational and technological phenomena through concepts such as the “affordances” of objects (Hutchby, 2001; Jones & Karsten, 2008; Leonardi, 2011; Nandhakumar, Rossi, & Talvinen, 2005; Orlikowski & Barley, 2001), we show how the sociomaterial perspective makes possible a relational account of materiality and to show how it is the object in relation to the organizational texture that provides closure and subsequent openings. For example, it is not merely the “concept book” by itself which provides closure, but that it is being prepared for the signing off procedure. Agency thus lies not only in the object, in the organization as an authority system, and in the people and organizational entities (e.g. teams) it involves, but in the relationality between them. Furthermore, our analysis underlines, in particular, the performativity of relations with regards to closure and openings. We suggest this does not aim to dematerialise or de-sensualise the explanandum. On the contrary, we have shown how the physical aspect of the objectification of entanglements (e.g. the highly evocative cover of a “concept book”) acts on the materiality of the entanglements themselves.

Finally, there is a methodological contribution in relation to how entanglements can be shown and studied and which has been a point of criticism of the notion (Jones, 2011). Barad proposes that entanglements can best be studied in situations of breakdown, as for example when the body “breaks down” in the case of a disability and the entangled nature of the phenomenon emerges because the apparatus necessary for a particular materialisation is then noticed (Barad, 2007). Our study demonstrates how by considering entanglements in conjunction with disentanglements it is also possible to surface entanglements when looking at intra-

organizational movements without being limited to situations of break down, which would restrict the usefulness of the concept in the fields of information systems research and organizational studies.

CONCLUSION

So what does studying such a setting from the perspective of entanglement and disentanglement tell us about stability and emergence? What we have seen is that materiality is not a given, but a difficult and costly, but at the same time important and necessary achievement that needs to be performed by combinations of human and non-human entities in varying states and degrees of flux and change. In turn, these difficult to achieve performed materializations also give shape and form to the relations they are part of. This is why the notion of entanglements is important. It does not presume a clear set of existing and fixed bonds, but a changing and dynamic mesh or system of relations, with some entities and relations persisting longer and others being more ephemeral.

Objects and artefacts are crucial in this performance; both to the bringing about of stability and durability out of flows and change and vice versa. The closure, detachment, and movement of objects we focused on analytically in this article is not permanent and hermetic, but a precarious achievement that brings with it a whole world of new openings and entanglements with further contexts and processes (Callon, 1998). As Callon observes, in a paradoxical way, in order to make disentanglement possible so that locally stabilised entities can be freed to move across contexts, it is important to produce entanglements (Barry & Slater, 2002a). This is crucial to how, while technology and organization aim at stemming change, in the process of doing so they are also “generated by it” (Tsoukas & Chia, 2002).

All these have important implications for information systems research. The technological and the human or organisational cannot be separated. Both are indeterminate entities partici-

pating in particular local performances of the material. Contrary to notions such as ‘imbrication’, which seek to convey the idea of an “interweaving” of separate human and material agencies arranged as “distinct elements in overlapping patterns so that they function interdependently” (Leonardi, 2011), the forming and dissolving of relations conveyed by ‘entanglement’ and ‘disentanglement’ provides a radical alternative to “interweaving” or “interactions”, which presume the prior existence of independent entities. By focusing on some of the types of complex “intra-actions through which the boundaries and properties of the ‘components’ of phenomena become determinate” (Barad, 2003) and tracing them in a setting of digital systems development, we have sought to make a contribution to the growing interest in sociomateriality found in information systems research by clarifying the importance of entanglement to views of sociomateriality that emphasise performed relations and also showing empirically how this relates to the development of digital systems such as computer games.

REFERENCES

- Akrich, M. 1992. The De-Description of Technical Objects. In W. E. Bijker & J. Law (Eds.), *Shaping Technology/Building Society*: 205-224. Cambridge, Massachusetts (USA): MIT Press.
- Austin, R. & Darso, L. 2009. Innovation Processes and Closure. In N. Koivunen & A. Rehn (Eds.), *Creativity and the Contemporary Economy*: 55-110. Copenhagen, Denmark: Copenhagen Business School Press.
- Barad, K. 2003. Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter. *Signs: Journal of Women in Culture and Society*, 28(3): 801-831.
- Barad, K. M. 2007. Meeting the universe halfway: quantum physics and the entanglement of matter and meaning. Durham: Duke University Press.

Barry, A. & Slater, D. 2002a. Technology, politics and the market: an interview with Michel Callon. *Economy and society*, 31(2): 285-306.

Barry, A. & Slater, D. 2002b. Introduction: the technological economy. *Economy and society*, 31(2): 175-193.

Bijker, W. E. & Pinch, T. 1987. The social construction of facts and artifacts: or how the sociology of science and the sociology of technology might benefit each other. In W. E. Bijker & T. P. Hughes & T. Pinch (Eds.), *The social construction of technological systems. New directions in the sociology and history of technology*: 17-50. Cambridge (MA): MIT Press.

Birkinshaw, J., Hamel, G., & Mol, M. J. 2008. Management Innovation. *Academy of Management Review*, 33(4): 825-845.

Black, L. J., Carlile, P. R., & Nelson, P. R. 2004. A Dynamic Theory of Expertise and Occupational Boundaries in New Technology Implementation: Building on Barley's Study of CT Scanning. *Administrative Science Quarterly*, 49(4): 572-607.

Brown, J. S. & Duguid, P. 2001. Knowledge and organization: A social-practice perspective. *Organization Science*, 12(2): 198-213.

Callon, M. 1998. An essay on framing and overflowing: economic externalities revisited by sociology. In M. Callon (Ed.), *The Laws of the Markets*. Oxford, UK: Blackwell.

Callon, M. & Muniesa, F. 2005. Economic Markets as Calculative Collective Devices. *Organization Studies*, 26(8): 1229-1250.

Collins, H. M. 1981. Introduction: Stages in the Empirical Programme of Relativism. *Social Studies of Science*, 11(1): 3-10.

Czarniawska, B. & Sevón, G. 2005. *Global ideas. How Ideas, Objects and Practices Travel in the Global Economy*: Liber & Copenhagen Business School Press.

- Ewenstein, B. & Whyte, J. 2009. Knowledge Practices in Design: The Role of Visual Representations as 'Epistemic Objects'. *Organization Studies*, 30(1): 07-30.
- Gherardi, S. & Nicolini, D. 2000. To Transfer is to Transform: The Circulation of Safety Knowledge. *Organization*, 7(2): 329-348.
- Girard, M. & Stark, D. 2003. Heterarchies of Value in Manhattan-Based New Media Firms. *Theory, Culture & Society*, 20(3): 77-105.
- Heidegger, M. & Stambaugh, J. 1996. *Being and time: a translation of Sein und Zeit*. Albany, NY: State University of New York Press.
- Hutchby, I. 2001. Technologies, Texts and Affordances. *Sociology*, 35(2): 441-456.
- Jones, M. & Karsten, H. 2008. Giddens's Structuration Theory and Information Systems Research. *MIS Quarterly*, 32(1): 127-157.
- Jones, M. 2011. Untangling sociomateriality, *3rd International Symposium on Process Organization Studies*. Corfu, Greece.
- Kanawattanachai, P. & Yoo, Y. 2007. The impact of knowledge coordination on virtual team performance over time. *MIS Quarterly*, 31(4): 783-808.
- Kline, R. & Pinch, T. 1996. Users as Agents of Technological Change: The Social Construction of the Automobile in the Rural United States. *Technology and Culture*, 37(4): 763-795.
- Knorr Cetina, K. 2004. How Are Global Markets Global? The Architecture of a Flow World. In K. Knorr Cetina & A. Preda (Eds.), *The Sociology of Financial Markets*. Oxford: Oxford University Press.
- Laet, M. D. & Mol, A. 2000. The Zimbabwe bush pump: mechanics of a fluid technology. *Social Studies of Science*, 30: 225-263.
- Langley, A. 1999. Strategies for Theorizing from Process Data. *The Academy of Management Review*, 24(4): 691-710.

- Latour, B. 2005. Reassembling the social. An introduction to actor-network-theory. Oxford: University Press.
- Law, J. & Mol, A. 1995. Notes on materiality and sociality. *The Sociological Review*, 43(2): 274-294.
- Leonardi, P. M. 2011. When Flexible Routines Meet Flexible Technologies: Affordance, Constraint, and the Imbrication of Human and Material Agencies. *MIS Quarterly*, 35(1): 147-167.
- Majchrzak, A., More, P. H. B., & Faraj, S. 2011. Transcending knowledge differences in cross-functional teams. *Organization Science*.
- Millo, Y., Muniesa, F., Panourgias, N. S., & Scott, S. V. 2005. Organised detachment: Clearinghouse mechanisms in financial markets. *Information and Organization*, 15(3): 229-246.
- Mol, A. & Law, J. 1994. Regions, networks, and fluids: anaemia and social topology. *Social Studies of Science*, 24(4): 641-671.
- Nandhakumar, J., Rossi, M., & Talvinen, J. 2005. The dynamics of contextual forces of ERP implementation. *The Journal of Strategic Information Systems*, 14(2): 221-242.
- Orlikowski, W. & Scott, S. 2008. Sociomateriality: Challenging the Separation of Technology, Work and Organization. *The Academy of Management Annals*, 2: 433-474.
- Orlikowski, W. J. & Baroudi, J. J. 1991. Studying Information Technology in Organizations: Research Approaches and Assumptions. *Information Systems Research*, 2(1).
- Orlikowski, W. J. 1992. The Duality of Technology: Rethinking the Concept of Technology in Organizations. *ORGANIZATION SCIENCE*, 3(3): 398-427.
- Orlikowski, W. J. & Barley, S. 2001. Technology and institutions: What can research on information technology and research on organizations learn from each other? *MIS Quarterly*, 25(2): 145-165.

- Orlikowski, W. J. 2007. Sociomaterial Practices: Exploring Technology at Work. *Organization Studies*, 28(9): 1435-1448.
- Orlikowski, W. J. 2010. Engaging Practice in Research: Phenomenon, Perspective, and Philosophy. In D. Golsorkhi & L. Rouleau & D. Seidl & E. Vaara (Eds.), *The Cambridge Handbook on Strategy as Practice*: 368. Cambridge, UK: Cambridge University Press.
- Pickering, A. 1995. *The mangle of practice : time, agency, and science*. Chicago: University of Chicago Press.
- Pinch, T. 2008. Technology and institutions: living in a material world. *Theory and Society*, 37(5): 461-483.
- Rescher, N. 2007. The Promise of Process Philosophy. In C. V. Boundas (Ed.), *Columbia companion to twentieth-century philosophies*: 143-155. New York, USA: Columbia University Press.
- Roberto, M. A. & Carioggia, G. M. 2003. Electronic Arts: The Blockbuster Strategy. *Harvard Business Review*.
- Sandberg, J. & Tsoukas, H. 2011. Grasping the Logic of Practice: Theorizing Through Practical Rationality. *Academy of Management Review*, 36(2): 338 - 360.
- Scarbrough, H. & Swan, J. 2001. Explaining the Diffusion of Knowledge Management: The Role of Fashion. *British Journal of Management*, 12(1): 3-12.
- Scott, S. V. & Orlikowski, W. J. 2009. Getting the Truth: Exploring the Material Grounds of Institutional Dynamics in Social Media, *EGOS*.
- Slater, D. 2002. From calculation to alienation: disentangling economic abstractions. *Economy and society*, 31(2): 234-249.
- Slife, B. D. 2004. Practice Seriously: Toward a Relational Ontology. *Journal of Theoretical and Philosophical Psychology*, 24(2): 157-178.

Suchman, L. A. 2007. ***Human-machine reconfigurations : plans and situated actions*** (2nd ed.). Cambridge ; New York: Cambridge University Press.

Thrift, N. & Dewsbury, J.-D. 2000. Dead geographies and how to make them live.

Environment and Planning D: Society and Space, 18: 411-432.

Tschang, F. T. 2007. Balancing the Tensions Between Rationalization and Creativity in the Video Games Industry. ***ORGANIZATION SCIENCE***, 18(6): 989-1005.

Tsoukas, H. & Chia, R. 2002. On Organizational Becoming: Rethinking Organizational Change. ***ORGANIZATION SCIENCE***, 13(5): 567-582.

Tsoukas, H. & Langley, A. 2010. Introducing 'perspectives on process organization studies. In S. Maitlis & T. Hernes (Eds.), ***Process, sensemaking, and organizing***: 1-26. Oxford, UK: Oxford University Press.

Walsham, G. 1995. Interpretive Case Studies In IS Research: Nature and Method. ***European Journal of Information Systems***, 74(4).

Weick, K. E., Sutcliffe, K. M., & Obstfeld, D. 2005. Organizing and the process of sensemaking. ***Organization Science***, 16(4): 409-421.

Woolgar, S. 2002. After Word? On Some Dynamics of Duality Interrogation. ***Theory, Culture & Society***, 19(5-6): 261-270.