The Untapped Grid: Rethinking Educational Comics for a Post-Digital Academy

Towards a Visual Epistemology of Learning, Research, and Knowledge Production

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Abstract

Still considered emerging, the promising field of data comics (DC)—framed within the broader domain of educational comics (ECs)—struggles to establish itself in academia. In an increasingly visual/multimodal world with exponential data growth, effectively visualising and understanding complex information and concepts is crucial. Yet, approaches connecting DC/ECs with data visualisation (DV) and education remain scarce, challenging comics' viability beyond niche interests.

In response, this doctoral thesis redefines DC and ECs as tools for visualising and investigating complex data/phenomena in higher education (HE). DC combine the narrative, representational, and spatiotemporal principles of comics with DV techniques, offering a format that transcends traditional models and bridges the gap between visual and verbal communication. Fully harnessing this potential requires reconceptualising comics, centring the visual and leveraging multimodal affordances for HE teaching and research.

To achieve this, the thesis proposes conceptual prototypes—the *Educational Comics to Come* (ECtC)—designed to overcome the predominant linear 'strip' approach inherited from traditional text-based formats. These prototypes emphasize comics' spatial, multilinear, and diagrammatic potential, fostering critical and creative inquiry.

This research follows a speculative qualitative methodology, positioning the researcher as a bricoleur integrating critical analysis of literature (ECs, DC, DV) with a corpus analysis of comics case studies. Findings highlight comics' transformative potential in HE, advocating integration into academic curricula to enhance data comprehension and innovative knowledge production. By embracing multidisciplinary approaches including visual literacy, multimodality, and transdisciplinarity, this study provides a foundation for rethinking ECs as dynamic tools. It also posits the *comics-fact* as a unique epistemic event emerging from reader interaction with the medium's visuo-spatial structure.

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Finally, I owe a conceptual debt to the creators, artists, and writers who taught me to see the world between the panels. This thesis is, in many ways, an attempt to articulate the transformative power of their work.

Author's Declaration

I declare that this thesis is my own work and has not been submitted in substantially the same form for the award of a higher degree elsewhere.

Commonly Used Abbreviations

- **CBR** Comics-Based Research
- **CS** Comics Studies
- **DC** Data Comics
- **DV** Data Visualization
- **EC** Educational Comics
- **ECtC** Educational Comics to Come
- **ER** External Representation
- **HE** Higher Education
- **MERs** Multiple External Representations
- **PoC** Proof of Concept
- **VL** Visual Literacy

In this thesis, the term *comics* is treated as a singular noun (e.g., '*a comics* is…') to emphasise its ontological status as a unified medium rather than a collection of discrete artefacts. Accordingly, acronyms such as Data Comics (DC), Educational Comics (EC), and Educational Comics to Come (ECtC) retain their base form for all grammatical contexts. These designate conceptual categories **or** theoretical frameworks—not enumerations of individual works—and thus function grammatically as singular entities (e.g., '*ECtC challenges* traditional pedagogy'; '*DC constraints* emerge from linear narratives').

Brief personal premise in the first-person singular

> With those who hold that a comic strip cannot be a work of art I shall not traffic
>
> **Gilbert Seldes, *The 7 Lively Arts*, (1924, p. 231)**

This thesis starts from my personal motivation as its author, as I have always been a comics fan[1]—a statement that in some circles is still often made with some sense of shame or eccentric preference—a *nerd*, in short (Figure 0-1). Being a scholar of this medium is even less common and is often perceived as an interest that is less academic and, therefore, less serious or valuable than others (Figure 0-2). There are undoubtedly complex reasons behind this passion—cultural, social, and temporal—but the one that drives this study is fundamental: comics have changed how I see the world. This foundational experience leads me to wonder how to articulate and share this transformative potential.



Figure 0-1: Image generated by DALL-E. Prompt: 'A comics portrait *of a typical comics nerd*'.

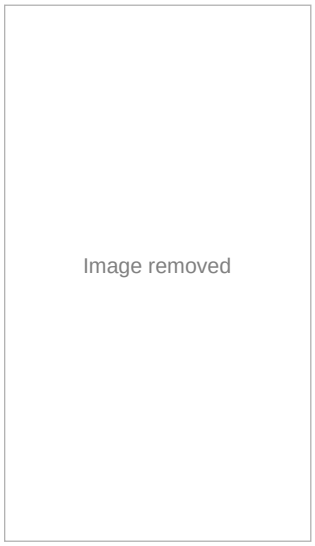


Figure 0-2: Image generated by DALL-E. Prompt: 'A comics portrait of a*n Academic comics scholar*'

Comics have influenced me in various ways, both personally and intellectually. They have opened me to different global cultural—and visual—perspectives, enriching my existential, experiential, and narrative vocabularies. More specifically, they

[1] The plural noun 'comics' is used here to indicate both the medium and the object, finding that it is the most respectful of the overall history of the medium. The term 'graphic novel', widely used in recent years, places more emphasis on the literary derivation of the comics (novel) rather than on its visual component (graphic). In this regard, see Tosti (2016). For a description of the different national nomenclatures, see Labio (2011).

have transformed how I perceive and understand comics. Reading and creating comics is a radically different experience than reading a novel or an academic essay. It is about engaging with time, imagery, and narrative in an inherently different form. Comics offer a unique temporal and spatial experience—broad, nonlinear, and multidirectional. Unlike traditional narratives, they enable the reader to navigate *physically* multiple layers of meaning, embedding stories within stories and experiences within experiences through distinctive structural strategies.

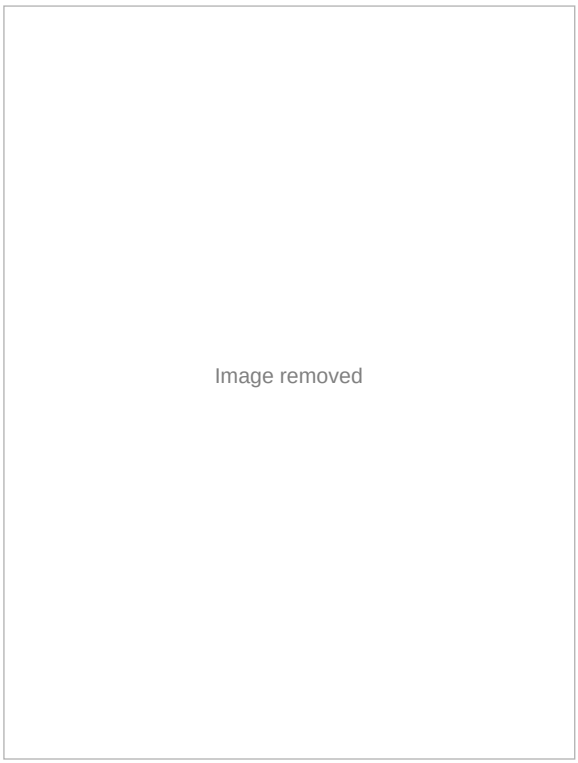


Figure 0-3: Frank King, *Gasoline Alley*, Sunday Page, *The Denver Post*, August 24, 1930. An early example of the comics medium's formal sophistication, this Sunday page illustrates the use of a continuous background and grid structure to create a navigable visual space.

Similarly, contrary to the widely held belief that comics are primarily for children, some comics are so complex that only a mature reader can grasp their full depth and meaning. Nevertheless, unlike most novels, the medium offered me access to asynchronous, parallel, and interconnected narratives at a young age—often in works marketed as *children*'s comics. In this sense, comics are a particular kind of map—one that can be navigated in multiple directions, embedding stories within stories across a physical page.

In this sense, comics are a particular kind of map—one in which the reader can lose themselves, find themselves, and emerge transformed. The first map I explored was a comics page depicting a beach on a sunny August day in 1930, drawn by Frank King (Figure 0-3). I hope to convey, at least in part, that same sense of discovery here. American comics artist Jack Kirby famously warned aspiring creators, 'Kid, comics will break your heart'; yet, beyond this cautionary note lies their profound power: comics can irrevocably change the way we think.

This is the inspiration behind my thesis: what is the potential of comics to open up new ways of thinking in one of the fields where they are least used—higher education (HE) [2]—and how can this potential be realised?

[2] Although images have long been used in scientific and academic publications (Smith, 2006), the use of comics is still a relatively recent occurrence in HE, which is why I embarked on this challenging and hopefully rewarding journey.

Preliminary remarks on the visual material used

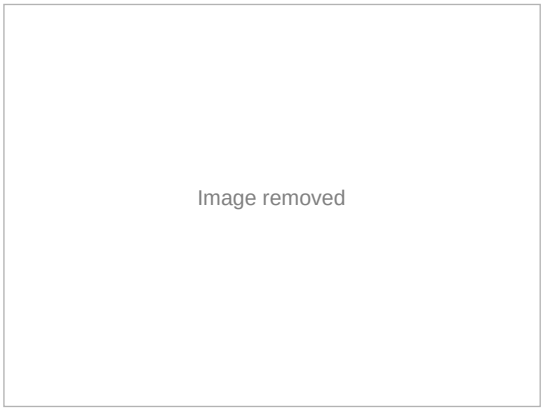


Figure 0-4: A memetic adaptation of a scene from *It's Always Sunny in Philadelphia* (FX), commonly known as the Pepe Silvia meme. This image is used here to humorously illustrate the complexity of explaining interdisciplinary research, a central challenge for the field of comics studies.

> [...] the relation of language to painting is an infinite relation. It is not that words are imperfect, or that, when confronted by the visible, they prove insuperably inadequate. Neither can be reduced to the other's terms: it is in vain that we say what we see; what we see never resides in what we say. And it is in vain that we attempt to show, by the use of images, metaphors, or similes, what we are saying; the space where they achieve their splendour is not that deployed by our eyes but that defined by the sequential elements of syntax.
>
> Michel Foucault, 2018 [1966], p. 10

This dissertation acknowledges this challenge and aims to explore how visual and textual elements can interact dynamically rather than subordinate one to the other. In theory, a dissertation on comics and data visualisation could be conducted entirely in visual form; in practice, such an approach exceeds the scope of this project. As Boehm (1986, p. 203) notes,

interpreting the silence of images as a lack of linguistic clarity risks making them disappear as 'mute language'. As Barbieri (2011, p. 24) states,

> since writing has become the main instrument of transmission of the organisation of the world (or rather, of our knowledge about it), every other instrument of transmission of the organisation of the world has to reckon with it, and is subject to its organising influence.[3]

This tension is particularly acute in DC and ECs, where visual elements are often treated as supplementary rather than as independent means of knowledge production.

To navigate this, the thesis adopts the concept of *iconotext* (Nerlich, 1990; Louvel, 2011; Wagner, 1995), treating visual and textual elements as interdependent rather than hierarchically ordered. Images are not used here as illustrations or paratextual elements; they are integrated within the argument itself. Figure 0-4 offers a self-referential commentary on the challenge of explaining complex, multidisciplinary research—a challenge this thesis takes seriously.

[3] All translations are my own unless a specific published translation is cited.

1. Exploring the Present and Proposing Enhanced Use of Comics in Academia

1.1. Overview: Exploring the Role of Comics in Higher Education. Current Limitations and Future Perspectives

> Our mistake in academia could be that we assume a binary model of knowledge/understanding = the written word. I believe we need to move to the next step and reflect and integrate visual data more deeply into our research practices and contexts.
>
> (Roger, 2017, p. 6)

Although increasingly acknowledged for their educational potential, comics still lack full academic legitimacy. They remain marginalised within logocentric and visually conservative pedagogical models that have traditionally relegated them to a subordinate role.

This scepticism is longstanding: by the 1940s, comics were already condemned as a 'poisonous' influence on youth (Sterling, 1940), reflecting similar concerns in France and elsewhere. For decades, they faced global criticism and censorship (Wertham, 1954; Rubenstein, 1998, pp. 96–108; Bell, 2006, pp. 89–103; Schodt, 1986, p. 128). Yet, their pedagogical value has long been acknowledged. Since the 1920s, comics have supported literacy in several countries—including the U.S., Italy, and China—particularly among reluctant readers (Sones, 1944; Witek, 1989; Hatfield, 2005a; Rifas, 2010; Davidson, 2008; Tilley et al., 2016; Tribull, 2017).[4] Their application in informal and technical education also spread, notably in U.S. and Japanese military training during and after World War II (Eisner, 1951; Ishinomori, 1988; Horton, 2018).

A persistent logocentric approach (Thomas, 1983; Becciu, 1971, p. 46) has continued to marginalise comics, undervaluing their structural and semiotic specificity while prioritising verbal 'readability' over page composition. In many contexts, pedagogy remains anchored to

[4] Comics were primarily regarded as tools for reading and literacy development aimed at children, particularly reluctant readers (Murray and Nabizadeh, 2020; Heaney, 2007), an attitude that lasted for a long time and reverberated to this day (Crawford, 2004; Tiemensma, 2009; McTaggart, 2005; Schwarz, 2002; Snowball, 2005; Ullery, 2019).

text-based models, limiting engagement with the multimodal potential of comics. Consequently, the effectiveness of Educational Comics (ECs)—particularly beyond literacy support and outside the humanities—remains contested internationally (Syma and Weiner, 2013b; Caldwell, 2012).

This is especially relevant in HE, where ECs warrant further exploration within a comparative and international pedagogical framework. As a medium that blends narrative, visualisation, and diagrammatic reasoning, comics are well-positioned to address the demands of increasingly multimedia educational environments, offering alternative ways of organising, expressing, and generating knowledge.

Although research on comics in education is expanding—albeit unevenly (Barberis and Grüning, 2021)—it remains concentrated in lower education levels (Humphrey, 2014; Tilley et al., 2016; Cheesman, 2006; Kirtley et al., 2020; Davidson, 2008; Caldwell, 2012; Alverson, 2017; Akcanca, 2020). Comics are primarily used as textual support rather than as autonomous modes of communication (Irwin, 2014; Kara and Brooks, 2020; Dahlan et al., 2015). Addressing this involves conceptual, terminological, and practical challenges—not only regarding the medium itself but also the function of figurative imagery in education and society and evolving notions of visualisation and data.

A more strategic, widespread use of comics in HE—including teaching—demands a reconceptualisation of the medium: one that challenges persistent preconceptions, foregrounds its distinct qualities, and repositions its value beyond textual norms. Such a shift is increasingly necessary as communication moves from speech and typography to image-based paradigms (Avgerinou, 2009; Moernaut et al., 2020), and reading, writing, and knowledge practices evolve accordingly. This paradigm shift is not merely technological; it reflects a deeper transformation in the cognitive and epistemic frameworks that underpin learning itself.

This shift is not trivial. It entails questioning the authorial dominance in academic writing, adopting alternative cognitive logics (Humphrey, 2015, pp. 1–4), and embracing different rhetorical models.

From early schooling, formal education trains individuals in linear, verbal reasoning, while visual communication remains largely unaddressed. As Trumbo (2000, p. 386) notes, there is 'scant research on the role of visual literacy and science visualisation among scientists or scientific communicators', and little comparable training in visual communication. As Emig (1977, pp. 122, 127) states, writing is traditionally regarded as 'a unique mode of learning—not merely valuable, not merely special, but unique' and 'a central academic process' to be preserved. The entire academic infrastructure, from lectures to assessment, reflects this logocentric tradition.[5] As Hyland (2013, p. 53) affirms,

> universities are ABOUT writing and that specialist forms of academic literacy are at the heart of everything we do: central to constructing knowledge, educating students and negotiating a professional academic career.

Consequently, the role of the visual in academia remains marginal or ancillary (Roger, 2017; Blummer, 2015), as 'using visual data as opposed to the written word opens disciplines up to issues that threaten their well-marked definitions of research and their familiar boundaries of the acceptable' (Roger, 2017, p. 5). As Banks (2007, p. 40) notes, although 'seeing and knowing are mutually constitutive, the former is not a passive medium (through representation) for the latter, as the linguistic communication model would presume'. Unsurprisingly, then, comics still struggle to establish themselves—not as mere objects of research, but as epistemic tools of inquiry—that is, instruments that actively participate in the production and organisation of knowledge (Bahl, 2015).

As Singh (2017, p. 4) observes, 'comics have always been used to convert data into stories'. While historically addressed to low-literacy audiences or younger readers, the medium has gained credibility in recent decades. The rise of graphic journalism, graphic medicine, and the broader acceptance of the GN format have contributed to its growing recognition as a valid educational and informational tool—albeit still in its early stages (Farthing and Priego, 2016; Williams, 2012; Weber and Rall, 2017; Beaty, 2021; Chute, 2016).

[5] Academic writing is a learned practice, often perceived as difficult (Pelias, 2003) and a source of frustration (Whitehead, 2002).

Despite recent efforts to systematise the use of ECs, and the emergence of methodological contributions and frameworks that have improved their academic reception, this medium remains underrepresented and underutilised in HE (Blanchard and Raux, 2019; Davis, 2010; Barberis and Grüning, 2021).[6] While a generational shift has led to a rise in comics-oriented research—and, to a lesser extent, teaching—positions, their adoption remains limited.

This marginalisation is shaped by several interrelated factors. Educational cultures remain rooted in logocentric frameworks that hinder the acceptance of multimodal didactic modes (Lacković, 2020; Buckley and Nerantzi, 2020) (see Figure 1-1 and Figure 1-2), while comics continue to be widely perceived as juvenile or unsuitable for serious academic content (Aleixo and Sumner, 2016; Tribull, 2017). A broader distrust of the image as a bearer of precise meaning reinforces iconophobic attitudes (Addison, 2003; Lacković and Olteanu, 2020), compounded by insufficient development of visual and multimodal literacies beyond conventional textual norms (Archer, 2006). Consequently, in educational contexts, comics are still treated primarily as supplements to text or as tools for dissemination and simplification, rather than as autonomous modes of inquiry (Downey, 2009; Jonsson and Grafström, 2021).7 Their use remains largely confined to sequential storytelling and linear data presentation, leaving untapped their potential for multilinear, synchronic, and systemic representation (see Section 4.3).

This final point stems from two main factors. First, much of the literature on ECs reflects a scarce, outdated, or utilitarian knowledge of the medium, often reduced to the notion of *sequential art* (Duffy, 2009; Tribull, 2017). Second, a predominantly 'in vitro' approach prevails: ECs are typically produced within academic contexts for academic purposes, leading to a short circuit between producers and scholars—frequently the same

[6] Some exceptions are found in the social sciences—particularly in ethnography, anthropology, sociology, and art education (e.g., Flowers, 2017; Crowther, 1990; Newman, 1998; Jacob, 2014; Parker, 2017; Barberis and Grüning, 2021; Aman and Wallner, 2022; Della Puppa et al., 2021) where engagement with visual and representational modes is more established (Roger, 2017, p. 1).

[7] Although exceptions exist—mainly within the humanities and social sciences—these remain marginal, partly due to the relative novelty of this approach. Comics-Based Research (CBR; see Section 1.2.3) has been proposed as a way to reduce the gap between the communicative and investigative functions of EC.

individuals. As a result, those researching ECs often model their analyses on comics created specifically for education, which are not always of high quality[8] and are frequently self-produced. This narrows their perspective and limits engagement with the broader, more diverse comics landscape, thereby introducing a risk of bias (Caldwell, 2012; Farinella, 2018b; Tatalovic, 2009; Wallner, 2020, p. 79).

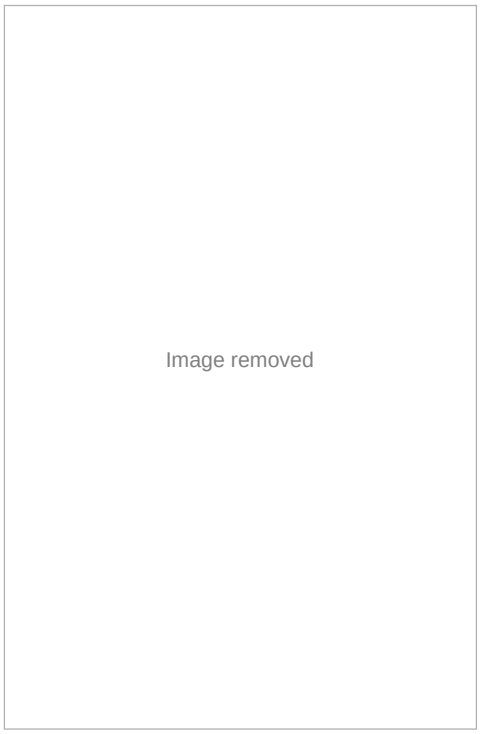


Figure 1-1: 'Learning from Comics on the Wall: Sequential art narrative design in museology and multimodal education' (Duffy, 2009), documenting the exhibition *Out of Sequence*. Despite adopting a comics-inspired format, the page remains heavily text-based, resembling an illustrated essay more than comics proper—highlighting how even well-intentioned experiments often replicate logocentric, sequential conventions.

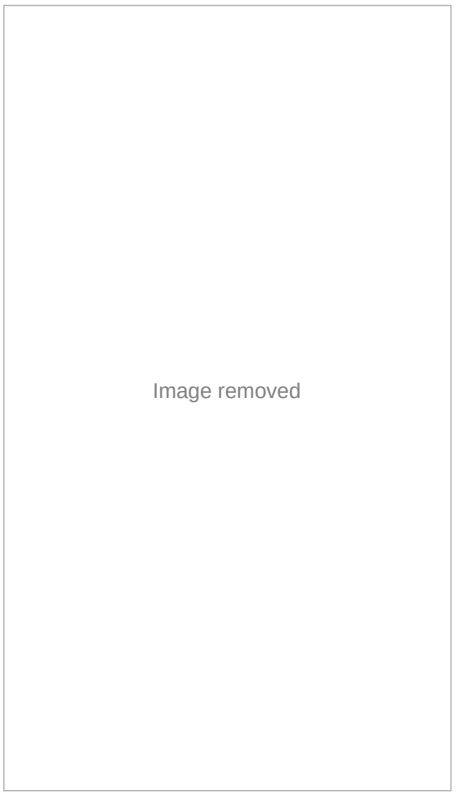


Figure 1-2: Page from *Thinking Inside the Boxes* (Thomas, 2012), a comics-based component of a Master's thesis. Despite its graphic format, the page exhibits several typical limitations of academic ECs: overreliance on textual exposition, minimal visual sequencing, and limited semiotic integration—resulting in a structure closer to illustrated argumentation than to comics as a distinct narrative form.

[8] The exploration of comics' potential is often shaped by the technical tools employed—frequently anonymous, semi-automated platforms—alongside aesthetic appeal and basic readability. While quality is inherently subjective, it significantly affects how comics are perceived and understood as educational tools (Topkaya et al., 2023).

Beyond these conceptual limitations, several practical obstacles hinder the adoption of comics in HE and research. Researchers and educators often lack visual and comics literacy, as well as the technical skills to create or assess comics effectively.[9] Standards for publication, citation, and peer review remain vague, and the available corpus of educational and scientific comics—though growing—is still limited and inconsistent in quality. Moreover, large-scale implementation entails significant costs, particularly in acquiring the skills necessary for production.

Nonetheless, the conceptual, creative, and economic investment required to establish comics-based programmes in HE appears justified, given their alignment with the evolving educational and informational landscape. The environment is increasingly multimedia and multisensory, and the modes of informing, communicating, and teaching are already undergoing transformation. Reading on screens differs from reading on paper, and the digital ecosystem—comprising networks, devices, applications, and users—responds to cognitive needs that differ substantially from those of the past. These needs are not only multimodal but also multilinear, and they both influence and are influenced by emerging epistemological frameworks (Burbules, 2005; Herrenschmidt, 2007; Flusser, 2011b).

This tension is amplified by a contemporary condition characterised by interconnection and complexity, in which individuals navigate hyper-structured, multimodal informational environments that stand in contrast to the linear, monomodal transmission models still prevalent in HE (Kellner, 2004; Kędra and Žakevičiūtė, 2019; Buckley and Nerantzi, 2020). Engaging critically with these new modalities of knowledge production is not merely a matter of adapting to a trend, but a pedagogical and epistemological necessity, particularly given that immersion in highly visual environments does not automatically translate into the ability to decode them effectively (Metros, 2008; Brumberger, 2011) (see Chapter 3).

[9] Defining what constitutes a 'good' comic remains inherently ambiguous. Nonetheless, factors such as aesthetic appeal, visual clarity, and other partially subjective criteria play a role in evaluating the effectiveness of EC.

Comics are uniquely positioned to address these challenges. As an inherently multimodal and multimedia medium, they place visual reasoning at the core of meaning-making. Their structure operates at the intersection of linear sequencing and more complex spatial, diagrammatic, and multilinear forms—oscillating between the strip and the grid (Cabero, 2019)—and, as distant descendants of maps, chronologies, diagrams, and tables (Tosti, 2019), they provide a conceptual space where sequential progression coexists with spatial relationships, enabling multiple concepts, temporal viewpoints, and representational layers to be articulated simultaneously (see Figure 1-3, Figure 1-4, Figure 1-5). These properties, examined in detail in Chapter 4, make comics a valuable model for rethinking knowledge representation in HE.

Realising this potential requires moving beyond a domesticated view of the medium. Scientific processes are rarely as linear as their communication implies: thinkers such as Kuhn (1962) and Feyerabend (2020 [1975]) have long challenged the idea of a universal, methodical progression, and as François Jacob (1988, p. 318; cited in Grinnell, 1996, p. 333) remarked, writing a scientific paper means substituting order for the disorder that animates laboratory life. Comics, with their spatial and layered logic, do not impose order on complexity but articulate it—rendering uncertainty visible as part of the knowledge process rather than concealing it behind retrospective, *post hoc* structures. They can also render visible often-neglected dimensions of research, such as collaboration, subjectivity, and emotional experience (Loughran and Mannay, 2018), offering a more authentic picture of the scientific endeavour (Osborne, 2014, p. 183) and contributing to bridging the divide between the natural sciences and the humanities (see Figure 1-3; Gould, 2003). In this sense, what Rey (1982) called a 'multi-ordered delirium' is not a flaw to be corrected but an epistemic affordance to be mobilised. It is precisely this potential that this thesis seeks to explore through the Educational Comics to Come (ECtC).

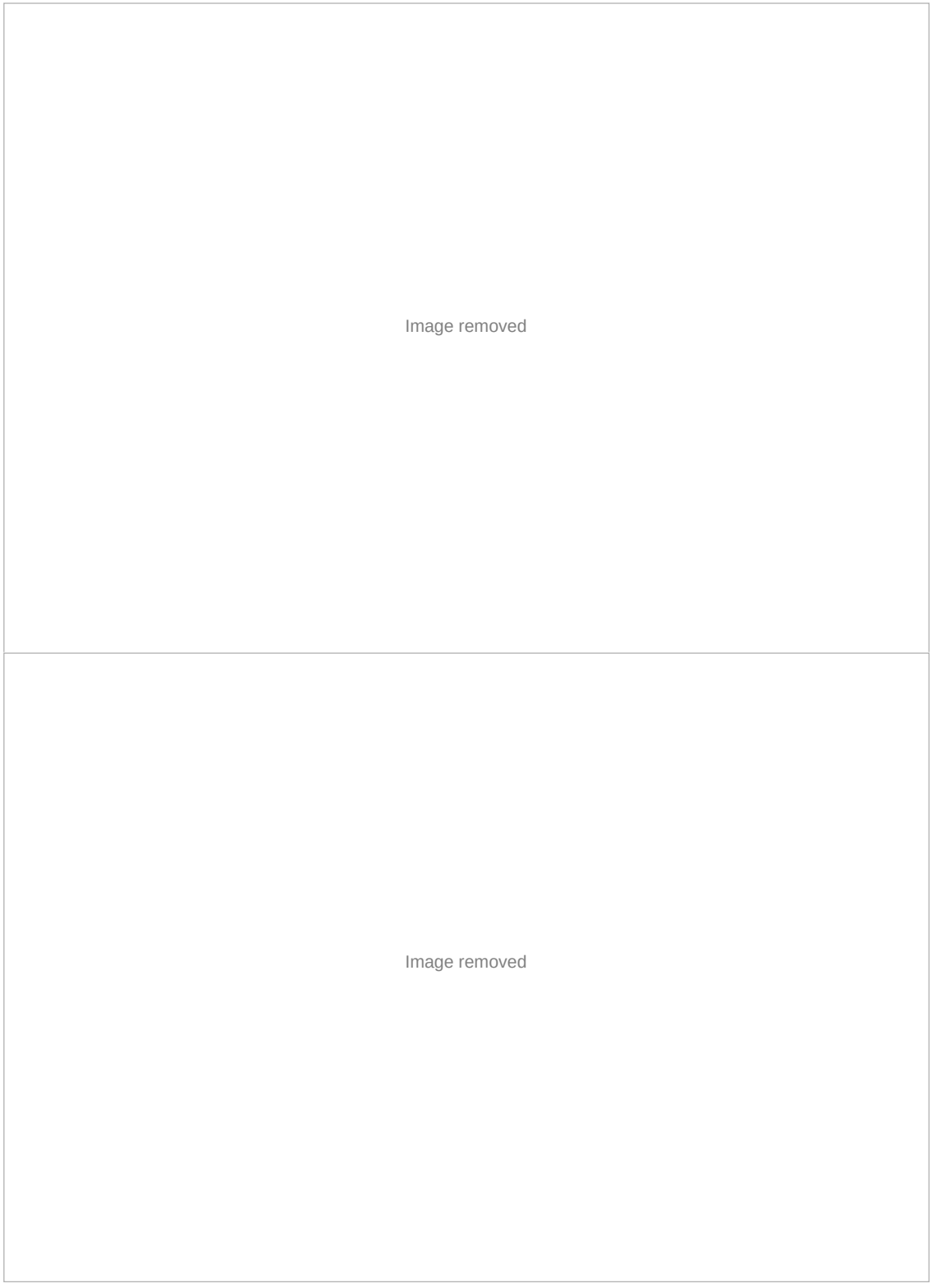


Figure 1-3: Two double-page spreads from *Alpha…Directions* (Jens Harder, 2009). This visual history spans 14 billion years, blending scientific data, artistic interpretation, and myth. Minimal text accompanies densely layered imagery, producing a work that is both chronologically linear and conceptually multilinear, readable from multiple perspectives and directions.

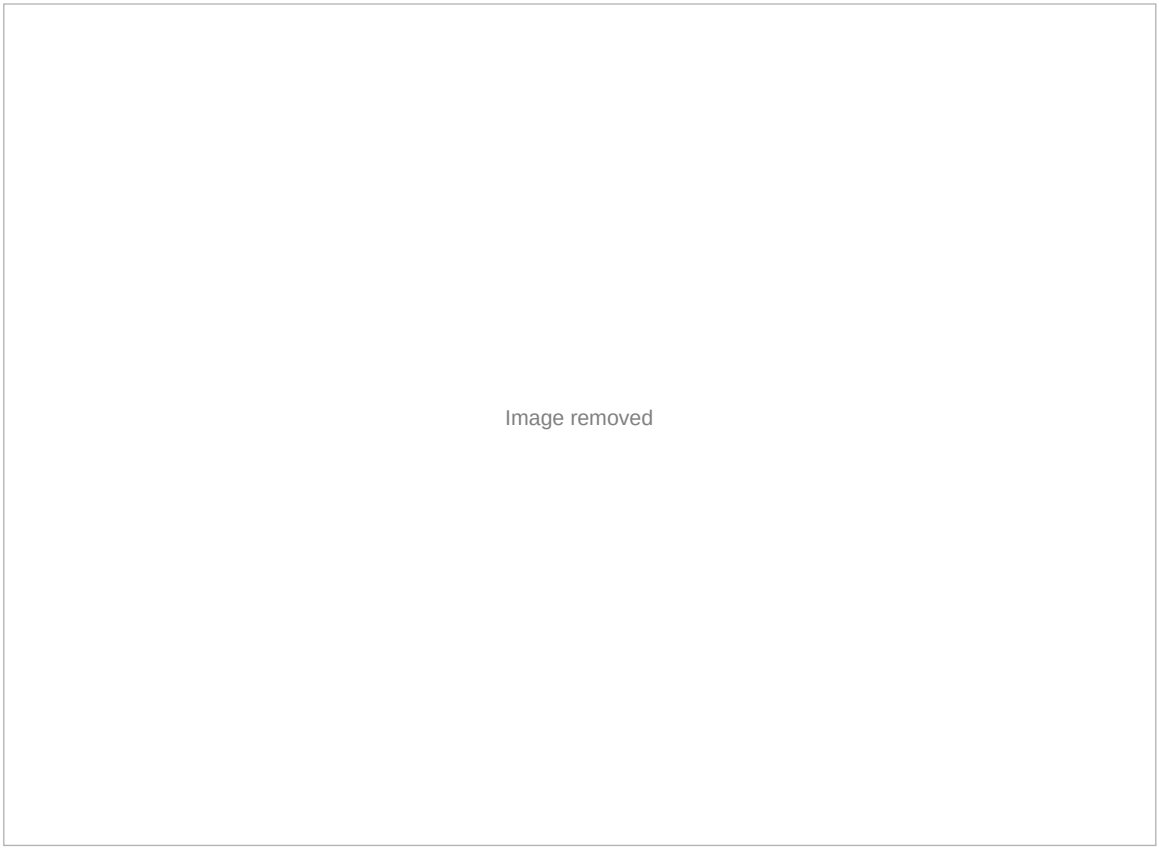


Figure 1-4: A double page from *Here* (Richard McGuire, 2014). This work exemplifies temporal layering: each panel captures the same physical space at different moments in time.

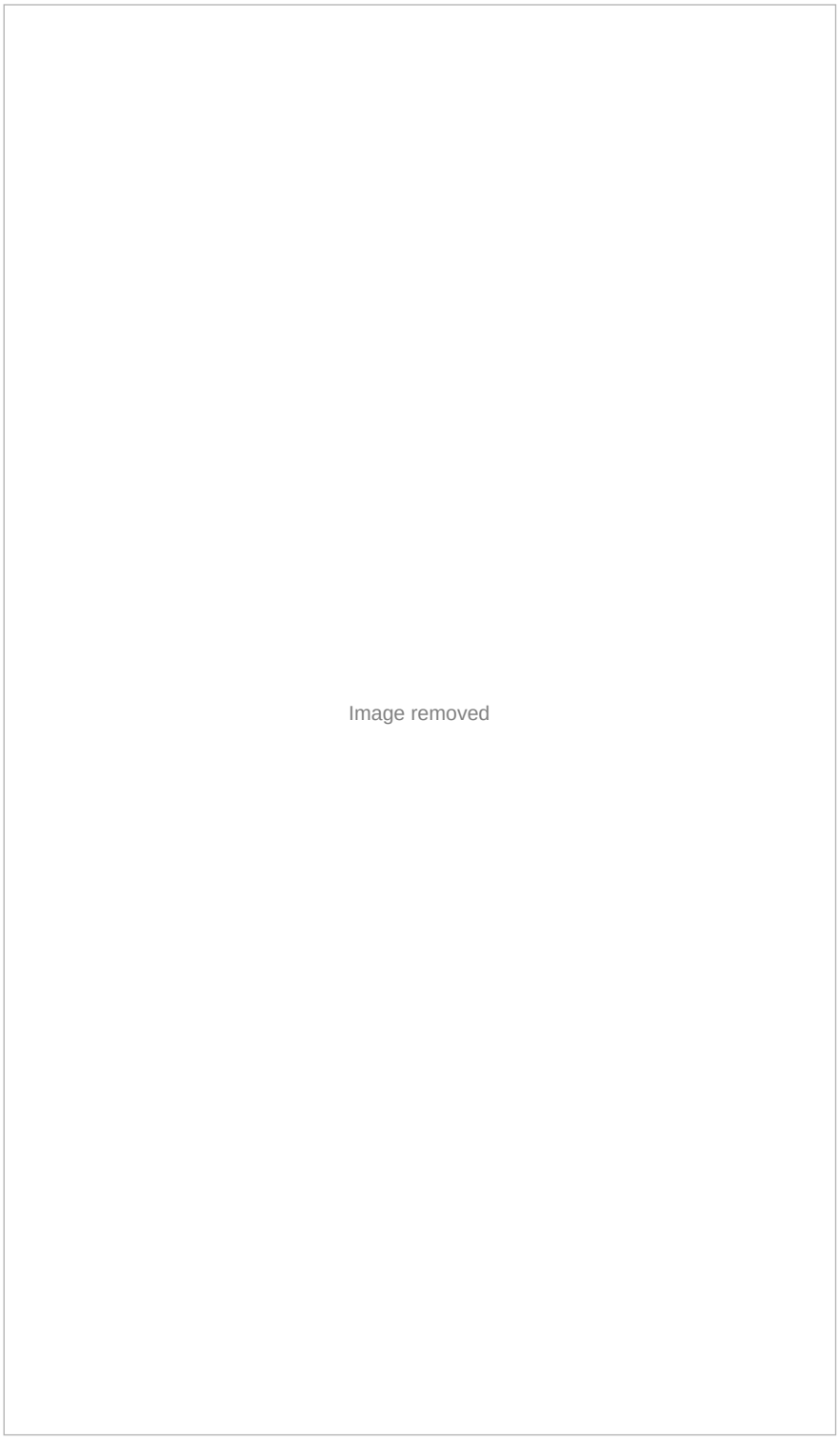


Figure 1-5: 'Big Tex' (Chris Ware, 1996, p. 28), from *The Acme Novelty Library*. The same scene is depicted across fifteen panels, each offering a distinct temporal slice. Together, they construct a fragmented temporality and a unified visual space—illustrating the potential of comics to articulate time through spatial composition.

1.2. Comics and Academia: A Literature Review

1.2.1. Comics in Academic Research

Since the late 1990s, academic interest in comics has grown slowly but steadily within the English-speaking world, particularly in the United States. This expansion is linked to increasing recognition of the medium's cultural and social relevance, leading to its inclusion in university curricula and, more broadly, in school, public, and academic libraries—making it a more attractive market for publishers (Tilley et al., 2016, p. 360; Versaci, 2001; Kakalios, 2002; Retalis, 2008, p. 5; Steirer, 2011, pp. 266–267; Westrup, 2002; Hall and Lucal, 1999; Snyder, 1997; Feder, 2002).

In parallel, university-level courses dedicated to comics studies (CS) have proliferated, alongside a smaller number of courses using comics to teach subjects in the humanities (Tilley et al., 2016; Whitt, 2013, p. 52). The development of CS and the institutional uptake of comics have largely reflected the disciplinary backgrounds of the scholars involved, which has also shaped the pedagogical uses of the medium (Jacobs, 2020, p. 132).

As Barberis and Grüning (2021, p. 136) observe, CS are usually characterised by the '*little relevance given to comics' visual dimension* and the *greater attention devoted to its literary features*, such as the language, narrative and storytelling' (emphasis added). This tendency reflects the field's frequent overlap with media and literary studies, particularly in relation to extra-diegetic themes such as race, gender, and trauma.[10] Their analysis, however, remains partial: the authors themselves acknowledge its limitation to English-language sources. Lefèvre (2017) notes that the comics studies field effectively excludes non-English-speaking authors with a few exceptions.

Notable differences also exist across national contexts. While American scholarship has tended to frame comics as a literary genre, centred on a canon of single-authored graphic novels produced since 1986—such as *Maus*, *Persepolis*, and *Fun Home* (Beaty, 2020, p. 54)—European research, particularly in France where comics have a longer institutional trajectory,

[10] Similar critiques appear in Ecke (2011) and Steirer (2011).

often regards them as a form of graphic storytelling (Baetens, 2001, p. 8). In both cases, however, the study of comics has been shaped by what Beaty (2020) calls 'typical comics'—a limited canon that usually excludes mass and industrial production—contributing to a restricted view of the medium.

The complexity of defining comics as an object of study, including terminological instability and lack of a stable disciplinary identity, further complicates the development of comics studies, which remains underfunded, fragmented, and institutionally marginal (Hatfield, 2017; Di Paola, 2019a).[11] As Di Paola (2019a, p. 239) notes, the absence of a stable disciplinary identity often pushes scholars working on comics to the margins of academic systems that discourage interdisciplinary integration, arguing that a more structured dialogue is needed to develop shared methods. However, even influential frameworks such as visual language theory risk reducing the semiotic richness of a medium that is dynamic and continuously evolving (Di Paola, 2019a, p. 233).

This logocentric and literary framing continues to shape CS, often sidelining the visual dimension. Its influence extends, sometimes implicitly, to ECs, which frequently adopt a textual orientation and reflect persistent assumptions of simplicity and linearity. These dynamics continue to shape both the scholarly treatment of ECs in HE and the principles guiding their production. This inherited logocentrism is precisely the intellectual barrier that this thesis seeks to dismantle, arguing that the true potential of ECs lies in embracing, rather than sidelining, their unique visual and spatial affordances.

Although the use of comics in HE for both teaching and research is increasing (Humphrey, 2014), their institutional integration remains limited and cautious (Blanchard and Raux, 2019; Davis, 2010). While pioneering studies date back to the 1970s (e.g., Tisseron, 1977; Bourdieu, 1975), academic literature still covers the topic unevenly (Baudry, 2015). The number

[11] Lent (2010) notes that comics studies originated outside academic institutions, a condition that persists: as Berthou (2015) observes, many scholars working on comics continue to operate—and often publish—beyond formal academic structures.

of studies dedicated to ECs remains limited (Topkaya et al., 2023, p. 933) or 'virtually non-existent' (Rocamora-Pérez et al., 2017, p. 1119).

Barberis and Grüning (2021, p. 134) identify a consolidation of academic interest in comics from the 2010s, coinciding with the creation of book series and research networks.[12] However, 'educational works that stress the educational goals and eventual uses of comics in schools and in higher education' (Barberis and Grüning, 2021, p. 135) have consistently represented a marginal portion of comics-related scholarship, further declining between 2016 and 2021. This discrepancy underscores a structural gap between research and teaching (see Figure 1-6).

[12] Examples of such research networks include the Gesellschaft für Comicforschung (Germany), the Canadian Society for the Study of Comics, the Comics Research Hub (UK), the Malmö University Comics Hub (Sweden), the Réseau régional de recherche de la Bande Dessinée (France), the Oxford Comics Network (UK), the Nordic Network for Comic Research (Denmark), and ReOPen (UK).

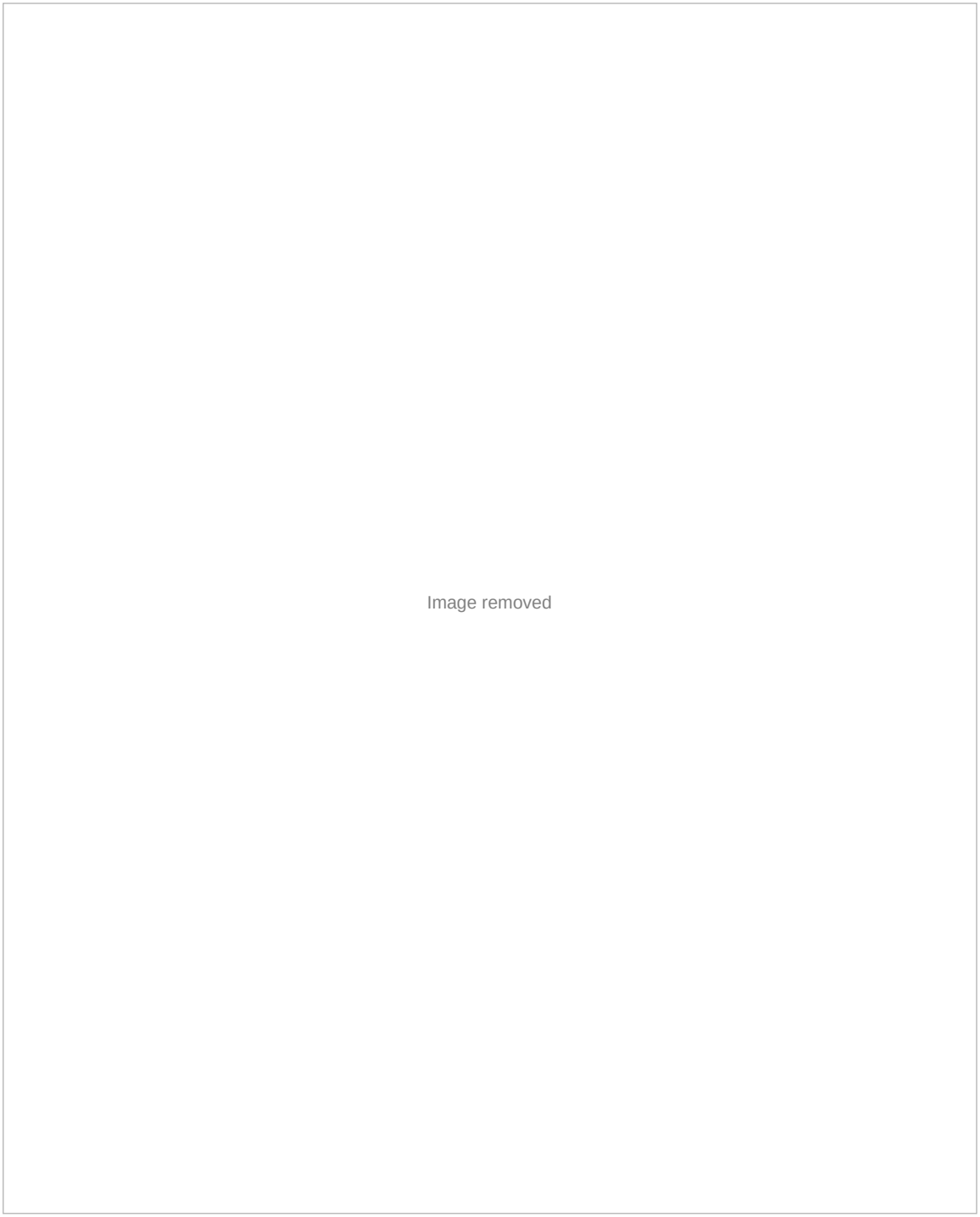


Figure 1-6: Page from *Understanding Rhetoric: A Graphic Guide to Writing* (Losh et al., 2017, p. 25*)*, a textbook for first-year college students. The dialogue reflects the ongoing perception of comics as unfamiliar or inappropriate within academic settings, particularly as instructional material.

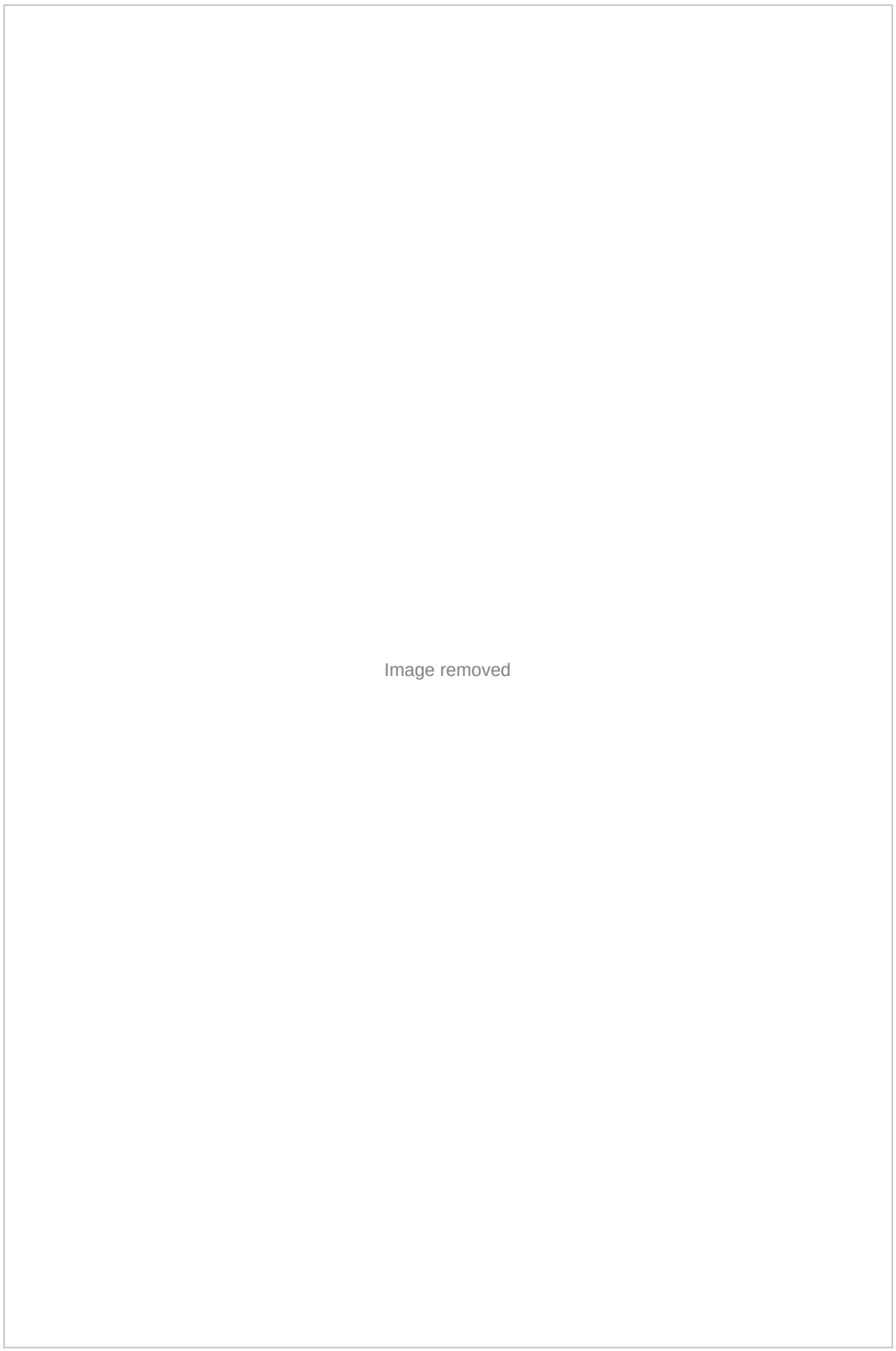


Figure 1-7: Page from *Unflattening* (Nick Sousanis, 2015b), a pioneering example of a doctoral dissertation fully realised in comics form. The work combines philosophical reflection with complex visual composition to explore alternative epistemologies.

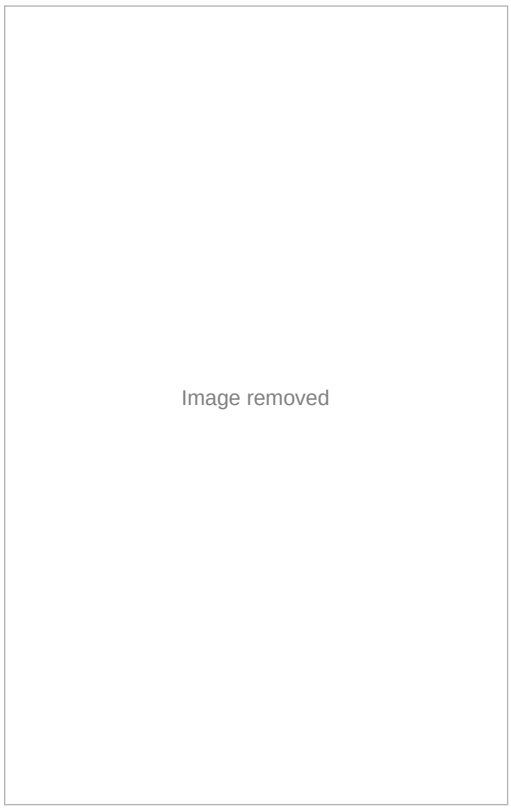


Figure 1-8: Page from *Designing Digital Art and Communication Tools Inspired by Traditional Craft*, a PhD thesis proposal by Rubaiat Habib Kazi (2014). One of the earliest examples of comics-form academic work in a STEM field, the piece integrates visual narrative with technical exposition.

Recent years have seen a modest institutional expansion—dedicated journals, edited volumes, and a small number of doctoral dissertations in comics form, most notably Sousanis's *Unflattening* (2015b) (see Figure 1-7) and, earlier, Tisseron (1976). Yet these developments remain concentrated within the humanities (Davis, 2010) and, as the following sections will show, have not fundamentally challenged the logocentric orientation that shapes both comics studies and educational applications.

More broadly, the use of comics in academic outputs is expanding across disciplines—from gender studies and anthropology to medicine and the social sciences (Kuttner et al., 2021, p. 198; Syma and Weiner, 2013b, p. 1)—although adoption in STEM fields remains limited and consistent peer-review standards are still absent. Exceptions exist: Rubaiat Habib Kazi (2014) completed a PhD in Computer Science in comics form (see Figure 1-8), and Veronica M. Berns accompanied her PhD thesis in chemistry with comics (Tenenbaum, 2015). Some initiatives, such as Taylor & Francis's *Cartoon* [sic] *Abstracts* (2014; Tribull, 2017, p. 459) (see Figure 1-9), have attempted to increase scholarly engagement through visual formats, but have also attracted criticism. Van Oudheusden et al. (2021) (see Figure 1-10) satirised such efforts as symptomatic of a managerial research culture that privileges speed and visibility over substance—a reaction that, even when parodic, underscores the tensions surrounding comics' legitimacy in academic discourse.

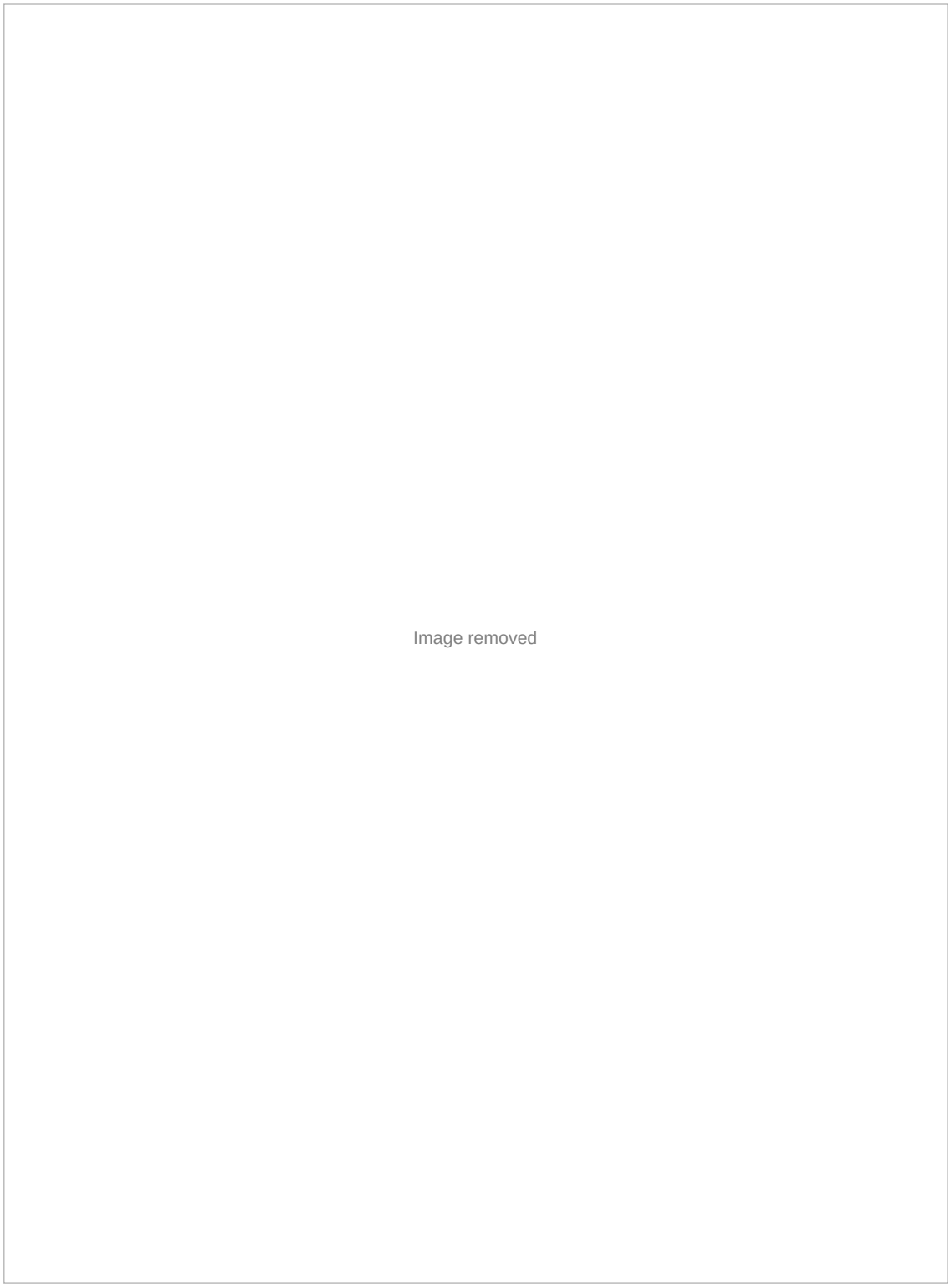


Figure 1-9: One of the *Cartoon Abstracts* published by Taylor & Francis (2018), designed to summarise academic articles in comics form. This initiative reflects ongoing efforts to enhance accessibility and engagement in scholarly communication through visual media.

Despite growing academic recognition of comics as a culturally and pedagogically relevant medium, assessing their educational effectiveness remains a complex and fragmented field. Methodological inconsistencies and conceptual divergence reflect the same disciplinary tensions and cultural divides that have shaped the consolidation of comics studies. This complex and often contradictory landscape—where comics are simultaneously gaining academic ground yet remain under-theorised in educational contexts—necessitates a shift from institutional analysis to a practical evaluation of their effectiveness, a challenge that the following sections will address.

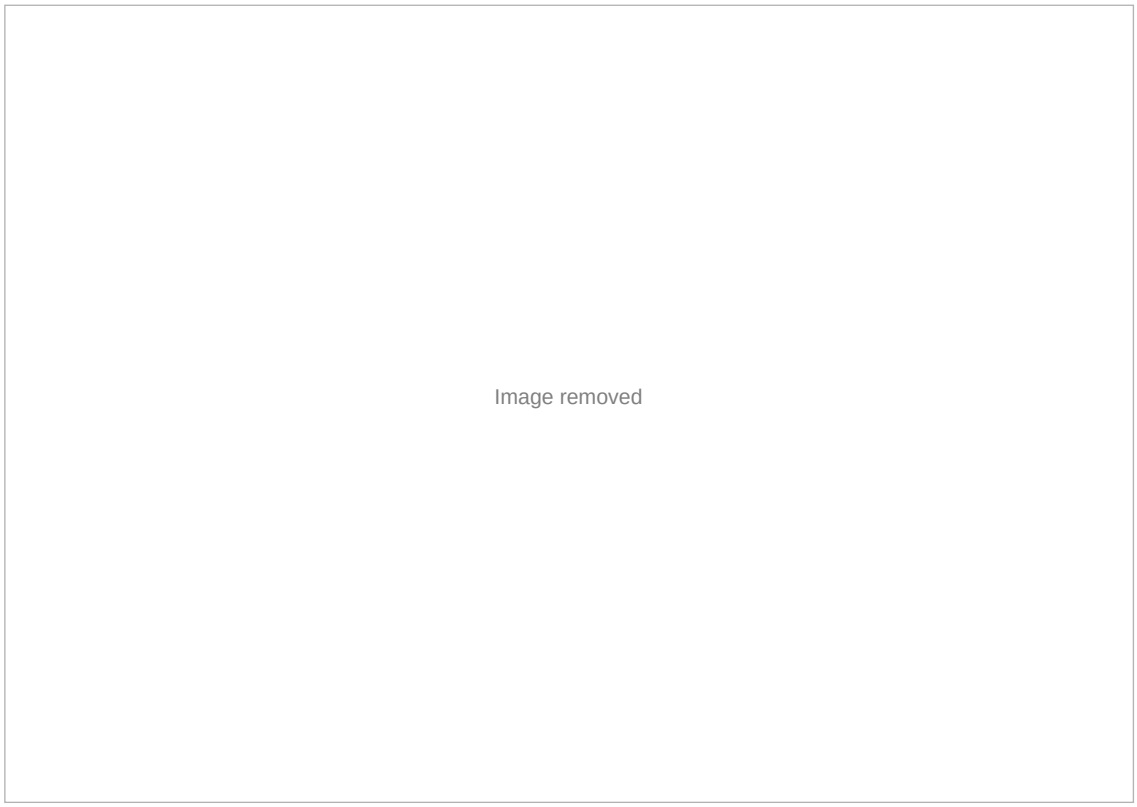


Figure 1-10: Excerpt from 'The Bullshit Cartoon Abstract' (Van Oudheusden et al., 2021), a satirical academic comics critiquing the performative turn in scholarly communication. The piece illustrates how visual formats risk being co-opted into a managerial culture that values speed and visibility over substantive inquiry.

1.2.2. On the Problematic Evaluation of the Effectiveness of Comics as an Educational Tool

Assessing the effectiveness of ECs or SCs requires navigating a domain characterised by terminological inconsistency and a 'multifaced and confusing range of non-fictional comics' (Plank, 2017, p. 31) described as 'perennially disorganised' (Rifas, 1991, p. 87) in terms of terminology. These works are variously labelled as 'educational', 'scientific', or 'cartoon' comics (Shurkin, 2015), frequently without distinction between formats such as strips, single-panel cartoons, comics, and illustrations. This lack of taxonomic clarity complicates the evaluation of their pedagogical efficacy and obscures the relationship between specific formal attributes and learning outcomes.

A systematic review by Mota et al. (2021) examined 28 scientific studies published over the past two decades—primarily in the United States and Brazil—focusing on the role of comics in science education and communication across both formal and informal learning contexts and age groups. Findings suggest that comics perform at least as well as, and occasionally better than, traditional educational resources in facilitating knowledge acquisition and stimulating learner engagement. However, some studies report negligible differences between text-only materials and text-image hybrids such as comics, noting that student preference for the comics format does not always correlate with increased effectiveness (Farinella, 2018b; Walsh et al., 2021).

Despite recent growth, research in this area remains limited, with several studies exhibiting methodological weaknesses and insufficiently articulated objectives (Farinella, 2018b; Tatalovic, 2009; Tribull, 2017). A common benchmark for success is that scientific comics should, at a minimum, not hinder comprehension (Hosler and Boomer, 2011, p. 316; Tribull, 2017, p. 458). Furthermore, many studies rely on small, heterogeneous samples and are often conducted by the same individuals who authored the comics under evaluation (Caldwell, 2012; Farinella, 2018b; Tatalovic, 2009; Wallner, 2020, p. 79), raising concerns over potential bias and lack of external validity (Farinella, 2018b, p. 2).

Methodological accounts detailing how comics are created for educational case studies often lack precision and rely on subjective interpretations (e.g., Friesen et al., 2018; Aisyah et al., 2017; Morel et al., 2019), limiting comparability across studies. Research on the role of visual context in procedural learning has shown that comics can enhance comprehension particularly when learners possess limited prior knowledge (Walsh et al., 2023). Similarly, benefits appear to be more pronounced among average-performing students than among high achievers (Lin and Lin, 2016). As noted by Lo et al. (2019, p. 1104), 'the roles and benefits of comics in education [...] still have not been well defined in the existing body of library literature'. Such ambiguity is unsurprising, given the substantial variation in the design, style, and conceptual underpinnings of the comics under investigation.

This variability stems from the absence of a shared definition of what constitutes a work of comics. As a result, many studies adopt inconsistent or incompatible methodological frameworks, failing to distinguish between fundamentally different formats—such as linear comic strips and multilinear page layouts—or even conflating comics with single-panel cartoons or illustrations. Wysocki's (2021) expansive description of comics as encompassing 'cartooning, graphic novels, webcomics, manga, the funnies that fill awkward corners of newspaper and magazine pages, and that weird picture book for adults you read that one time' underscores this issue, arguably overextending the boundaries of the medium to the point of analytical incoherence.

The field remains markedly heterogeneous, particularly in the context of educational and scientific applications. Comics used in these domains form a diverse and fragmented corpus. Furthermore, many creators of ECs or SCs operate outside their disciplinary expertise: scientists producing comics are rarely trained cartoonists, educators, or cognitive scientists (Hosler and Boomer, 2011; Jee and Anggoro, 2012). Consequently, the communicative efficacy of such works often rests on tenuous foundations.

Given comics' inherently composite nature, the absence of a shared definition makes it difficult to isolate the specific contribution of the medium to learning outcomes. As Witek (1989, p. 34) argues, the interdependence of words and images in comics forms a unique narrative gestalt—a dynamic examined in detail in Chapter 4, particularly Sections 4.1 and 4.5.

Research on ECs has predominantly focused on their application with children and adolescents, while studies addressing adult learners and HE remain comparatively limited (e.g., Clark, 2013; Chase et al., 2014; Fananta et al., 2019; Sabeti, 2011; Edwards, 2009; Bergin, 2005; Frey and Fisher, 2004; Mamolo, 2019; Syma and Weiner, 2013b; Murakami and Bryce, 2009). Even at lower educational levels, persistent obstacles—particularly attitudinal and institutional—mirror broader stigmas equally relevant in HE contexts.

A longstanding challenge concerns the perception of comics, shaped by entrenched prejudices transmitted across educational stages (Millard and Marsh, 2001). A study of secondary school teachers in the UK identified three recurrent beliefs: that comics are intended for children, are only suitable for low-achieving pupils, and lack readily available, high-quality teaching resources (Aleixo and Sumner, 2016, p. 400). Similarly, school librarians and educators often frame comics as superficial or purely recreational, rather than as complex texts with pedagogical value (Lo et al., 2019; Moodie and Calvert, 2018; Sabeti, 2011, p. 147) and 'as pedagogic tools with no inherent value in their own right' (Sabeti, 2011, p. 147). The perception of comics as a juvenile medium contributes to discouraging adolescents from engaging with them (Serantes, 2019; Moeller, 2016).

Furthermore, primary teachers seem to be unaware of the reading habits of their students, and 'a considerable percentage of primary and secondary pupils [which] read comics/graphic novels outside of class [...] feel that texts such as these are not encouraged by schools' (Clark et al., 2008, p. 55). More generally, there is still a stigma toward comics, and educators fear using them (Tribull, 2017). As White (2017, quoting Yu, 2015, p. 1) notes, 'one technical communication textbook reportedly warned that comics could "trivialise" or "downplay the seriousness" of information or cause an audience to regard the author as "unprofessional" or "condescending"'.

Pedagogical approaches to comics tend to replicate those used for traditional printed texts, overlooking the multimodal and post-typographic nature of the medium. As Serafini (2012b, p. 30) argues, such approaches fail to address the interpretive demands of multimodal texts, which require navigating visual design, compositional logic, and spatial organisation. Moreover, the narrative function of comics in education is frequently reduced to testimonial

modes—dominated by 'talking heads'—or excessively personalised accounts, which may lack perceived objectivity (Baetens, 2017). Written language often continues to dominate, with comics remaining largely restricted to humanities disciplines.

Nevertheless, the expressive and conceptual potential of comics has grown. As Murray and Nabizadeh (2020) observe, virtually any subject can now be approached through the medium. Syma and Weiner (2013b, p. 1) assert that the question is no longer whether to use comics in education, but how and for what purposes. This shift echoes Tisseron's (1977) earlier formulation: the issue is not whether to use ECs, but rather which comics, for which pedagogies—a question that necessitates the development of new conceptual models, such as the ECtC proposed in this thesis.

To date, the response to Tisseron's question has primarily taken the form of applications within literacy and the humanities. However, comics are increasingly being explored in scientific domains, where SCs are emerging as valuable tools for communicating complex ideas and facilitating understanding across disciplinary boundaries.

1.2.3. A Focus on Science Comics and Comics-Based Research

Within the context of the 'hard sciences', ECs are typically referred to as *Science Comics* (SCs), a form of visual storytelling used to support science education and communication. SCs have been promoted as tools for fostering interest in science-related studies and careers among diverse audiences, including students, professionals, and children (Hamidah et al., 2021; Kim et al., 2012). Farinella (2018b) emphasises their potential to make scientific content more accessible and engaging for a wider audience (Figure 1-11), while Tatalovic (2009) provides a foundational overview of the genre, suggesting its relevance for enhancing scientific literacy.

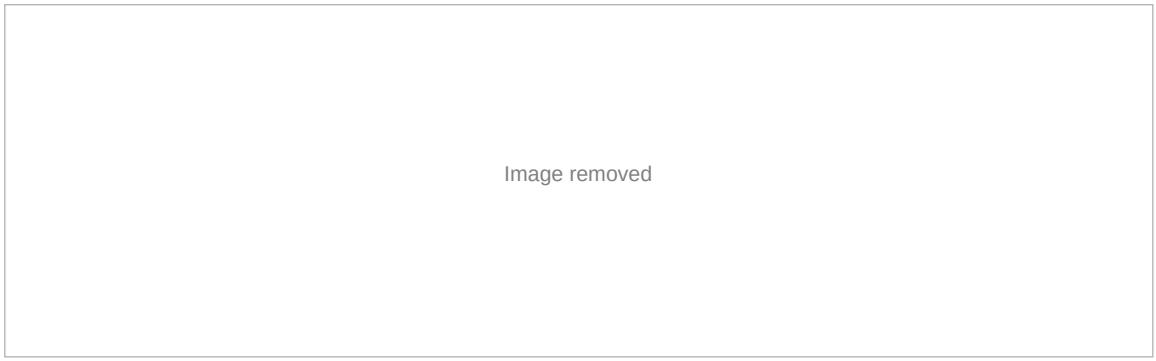


Figure 1-11: Comparative overview of empirical studies on the use of science comics in educational settings. The data highlight a predominant focus on school-aged learners and literacy support, underscoring the marginal use of science comics for advanced disciplinary engagement in higher education contexts. Source: Farinella (2018b).

Despite their broader potential, SCs have been studied primarily as support texts for children's scientific literacy (Tatalovic, 2009), including pre-literate learners (Koutníková, 2017), adolescents (de Hosson et al., 2018; Spiegel et al., 2013), non-major students (Hosler and Boomer, 2011), and within science popularisation (Scavone et al., 2019; Farinella, 2018a; Friesen et al., 2018). This trend reflects the broader applied orientation of ECs towards introductory learning and literacy support, rather than advanced disciplinary engagement or academic research in HE contexts.

In many cases, comics are used to present findings in informal or visually appealing ways, yet they are rarely deployed as investigative instruments—particularly regarding their visual dimension. As such, they remain peripheral to the knowledge production process.

SCs have been shown to support engagement, creative thinking, and the explanation of abstract concepts (Akcanca, 2020; Spiegel et al., 2013), often through narrative frameworks. Specific features of the medium, such as anthropomorphisation, have been found to further support the learning of abstract concepts (Dorion, 2011), although the pedagogical impact of explanatory agents—such as narrators or 'talking heads'—remains ambiguous (Walsh et al., 2021). However, it remains unclear whether such benefits result from narrative per se or from the comics medium itself (Jee and Anggoro, 2012, p. 205), and balancing educational and entertainment aims can prove difficult.

Although SCs have primarily been explored as tools for science communication and literacy, their potential within HE and academic research remains underdefined. A related development is Comics-Based Research (CBR), an emerging practice in which comics are used as artefacts within qualitative and humanities-based inquiry (Kuttner et al., 2017, 2021), reflecting a broader interest in the epistemological affordances of comics.

In practice, however, most CBR examples rely heavily on verbal content—through speech balloons or captions—while the visual component serves a supportive rather than autonomous role. This imbalance reinforces a linear reading structure, leaving key affordances of the medium—such as spatial layouts and non-linear panel arrangements—underutilised. Furthermore, most work is developed within research communities by scholars without substantial comics experience, which may constrain the medium's aesthetic and interpretive openness (Kuttner et al., 2021). Despite these limitations, CBR's core contribution lies in positioning comics as epistemic artefacts rather than ancillary formats for dissemination—though it also reflects a familiar tension: even innovative scholarly practices can reproduce conventional paradigms of knowledge production.

The following sections will examine academic projects that employ comics explicitly as pedagogical tools in HE. This analysis will help clarify the current state of the field, highlighting recurring patterns, limitations, and opportunities for integrating comics into HE learning environments.

1.2.4. A Closer Look at Educational Comics in Higher Education: Research, Trends, and Limitation

Although the use of comics within academia is still predominantly associated with introductory or simplifying functions (Irwin, 2014), research on comics explicitly designed as teaching tools in HE remains limited. Comics textbooks, with few exceptions, are rare (Kara and Brooks, 2020, p. 1775). The following review examines a selection of such studies, focusing on comics created or adapted for instructional use in HE contexts and excluding works that treat comics primarily as objects of analysis, personal research artefacts, or tools for outreach and dissemination. Included are experimental applications involving small student groups, provided they were developed for academic learning environments. The corpus includes both comics purposefully created for pedagogical use and non-educational comics repurposed for teaching, from Nagata's (1999) early use of manga panels in biochemistry instruction onward. This review of existing studies serves a dual purpose: first, to systematically map the current landscape of ECs in HE, and second, to identify the specific limitations and unexplored potentials that justify the conceptualisation of the ECtC. This distinction between purpose-built educational comics and entertainment comics repurposed for instruction reflects a broader division in the field. Recent scholarship on comics pedagogy—such as Aman and Wallner (2022)—focuses predominantly on primary and secondary education (K-12), where classroom experimentation is most developed. The present thesis addresses a comparatively underexplored level: Higher Education, where the medium's epistemic potential, rather than its versatility across school subjects, is the central concern. Appendix G provides supporting documentation for this review: Table G-1 offers a structured overview of the selected studies; Table G-2 distinguishes between self-produced and commercial comics; Table G-3 synthesises reported advantages and disadvantages; and Table G-4 maps terminological variation across the corpus.

1.2.5. General Commentary

Evaluating the effectiveness of ECs in HE is inherently complex. It requires assessing not only the information conveyed and the knowledge or skills acquired, but also whether these outcomes are attributable to ECs as a medium, to individual components (e.g., images or text), or to their interaction. A key question is whether results derive from the narrative presentation of information—suggesting that prose alone might suffice—or whether they reflect distinctive advantages of the comics format (Hosler and Boomer, 2011, p. 316). Furthermore, in contexts where comics still carry cultural stigma, it is important to demonstrate that their use does not lead to a decline in student understanding (ibid.). Some studies, therefore, focus more on confirming the absence of negative effects than on exploring the potential added value of ECs. Categorising such a heterogeneous and subjective field also poses difficulties, although broad tendencies can be identified.

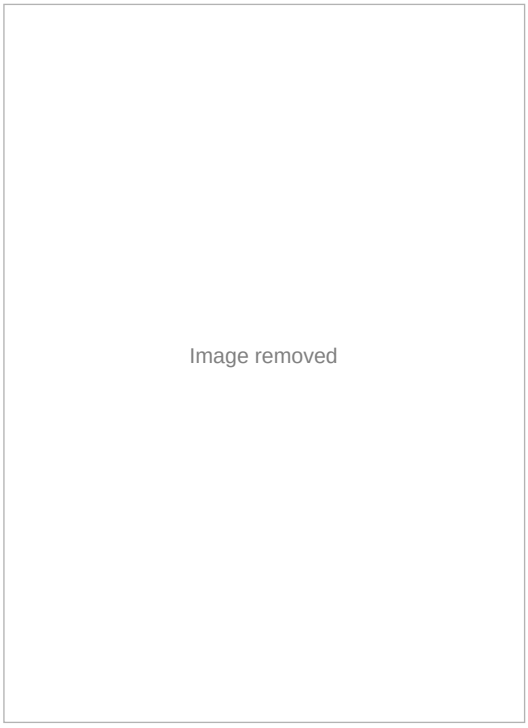


Figure 1-12: A page from *The Cartoon Guide to Chemistry* (Gonick and Criddle, 2005, p. 19), an example of a so-called 'graphic guide'—a text-heavy educational comics in which images primarily serve to support an extended verbal explanation.

Chandra and Jin (2022) distinguish between *text-heavy* ECs—those relying primarily on verbal narration with supporting visuals—and *light-text* ECs, where the image plays a more central role and typically requires more elaborate artwork and longer production timelines. Most ECs in HE fall into the *text-heavy* category, aligning with graphic guides or academic

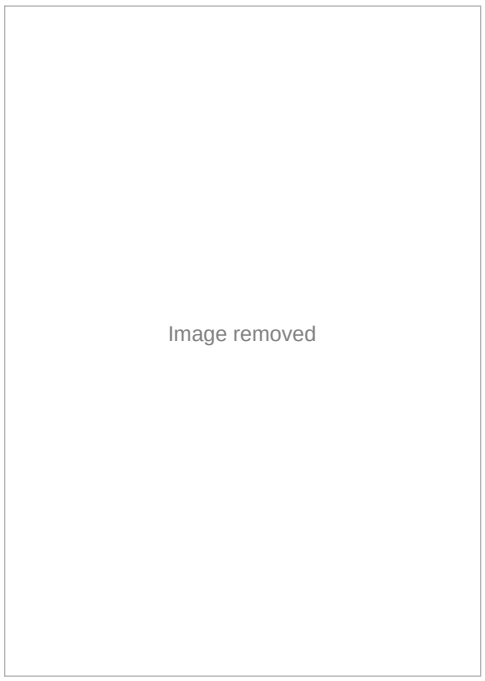


Figure 1-13: A page from *Atlas Black: Managing to Succeed*, formerly used as a business textbook in HE until 2013 (Short et al., 2009; image reproduced from Crook, 2010, p. 356). The example illustrates key features typical of text-heavy EC, including extensive verbal content, the use of visual metaphors, and a humorous tone.

comics textbooks (see, for example, Figure 1-2, Figure 1-1, Figure 1-12, Figure 1-6 and Figure 1-13), where images often function as illustrative or connective devices. In the absence of text, these images generally lack autonomous meaning.

Other recurring features include humour and visual metaphor, which can enhance attention, motivation, and engagement (Garner, 2006; Van der Sluis, 2021) but also increase cognitive load or risk undermining content seriousness, particularly when culturally specific or excessive (Farinella, 2018a; Santanna, 2023), dynamics examined more closely in Section 1.2.6.

Storytelling is central to most ECs, contributing to retention, engagement, and interpretive learning (Karimi et al., 2021; Astiz, 2020). However, effective storytelling and comics creation more broadly require specific competencies. Teaching and researching through ECs involves medium-specific techniques distinct from those of other academic disciplines (Barberis and Grüning, 2021, p. 132). These competencies are often underestimated or assumed. As Gerde and Foster (2008, p. 253) observe, educators must be thoroughly familiar with the comics they employ, including their plotlines, topic, and broader context. Without this foundational knowledge, even

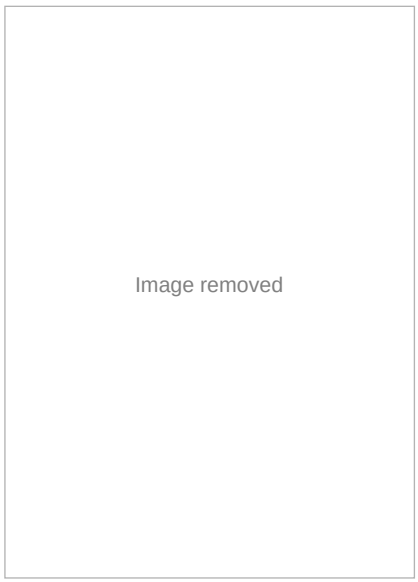


Figure 1-14: A page from *Sapiens: A Graphic History* (Harari et al., 2020, p. 18), a contemporary example of a graphic guide combining didactic narration, illustrative visuals, and conceptual humour within a text-heavy structure.

interested educators may feel unprepared to integrate ECs effectively (Blanchard and Raux, 2019).

Across the reviewed studies, most ECs—whether self-produced or adapted—fall into the text-heavy category and make extensive use of storytelling, humour, and visual metaphor. However, the authors' expertise in comics is not always evident, and detailed, up-to-date theoretical reflection on the medium is often lacking. The prevailing model remains that of *sequential art*, while the spatial and temporal affordances of comics—beyond linear narration—are frequently overlooked.



Figure 1-15: First page from 'Missed It' (Green and Rieck, 2013), the first graphic medicine article published in *The Annals of Internal Medicine*. Notably, the term comics was avoided in the original publication, replaced by expressions such as *graphic novel*, *graphic article*, or *article in graphic novel format* (Humphrey, 2014). The piece employs a realist black-and-white drawing style and structured grid layout, combining influences from mainstream American comics and cinematic visual storytelling, influenced by medical TV serials.

This issue also intersects with broader taxonomic ambiguity. As Humphrey (2014) notes, when 'Missed It' (Green and Rieck, 2013), the first graphic medicine article published in *The Annals of Internal Medicine* (Figure 1-15), appeared, the word *comics* was absent—replaced by terms such as *graphic novel*, *graphic article*, or *article in graphic novel format*. For Humphrey, this lexical choice reflects an implicit effort to confer cultural legitimacy upon the medium. As shown in Appendix G, Table G-4, variation in terminology persists across the academic literature. These overlapping issues—of textual dominance, theoretical simplicity, and taxonomic ambiguity—collectively highlight a field that has yet to fully grapple with the unique epistemic affordances of the comics medium.

A rare exception within this landscape is offered by Amin (2022), whose contribution to the otherwise predominantly K-12-oriented volume edited by Aman and Wallner (2022)

develops a structured method—the 'Interrogative Mode'—for guiding undergraduates through critical analysis of comics as a multimodal text. Responding to a documented shortcoming whereby the medium is typically treated "as a means to an end, and not an end in and of itself" (Amin, 2022, p. 40), her approach addresses how students without prior visual training can learn to analyse the visual-verbal interplay of comics and produce academic-level critical work.

1.2.6. Assessing the Impact of ECs in HE

Educational comics: benefits, challenges and biases

As Appendix G, Table G-3 illustrates, ECs are broadly associated with benefits such as enhanced engagement, comprehension, and critical thinking, alongside persistent challenges including academic resistance, oversimplification, and production costs. However, many studies were designed to promote ECs and often analysed works created by the researchers themselves, introducing potential bias; these studies are largely qualitative, with small samples and, in some cases, lacking empirical support, relying instead on participant opinions (e.g., **10**).[13] Among the few wide-ranging reviews, **33** concludes that ECs significantly improve both academic performance and learner attitude, while also identifying criticalities such as excessive dialogue, weak character identification, and unclear visuals. Moreover, attributing these effects solely to the comics medium remains problematic, as reported benefits may derive from elements such as humour or multimodal interaction that also appear in other formats, such as illustrations or editorial cartoons.

Furthermore, the generalisability of findings remains limited. Study **19**, for example, highlights the accessibility of ECs across age and ethnic groups, while 11 points to their role in fostering inclusion by incorporating non-European or non-English materials. Yet in both cases, the claims refer to individual works, not to the medium as a whole.

Further Dimensions of Analysis

An often-overlooked dimension in the literature concerns the role of ECs in developing visual literacy: by design, comics require readers to decode visual sequences and synthesise verbal

[13] Reference numbers used in this section correspond to those listed in Appendix G, Tables G-1 to G-3.

and visual content, promoting a distinct form of literacy still underexplored in educational settings (see **11**; **12**). Furthermore, **28** reports that comics are often used selectively, displaying only individual panels to clarify concepts rather than as autonomous learning materials, thus reinforcing their subordinate role in academic instruction. A related issue is the tendency to evaluate ECs through isolated components. Study 7 (pp. 193, 195) argues that the visual, narrative, and knowledge-transfer dimensions must be perceived as coherent and integrated; fragmentation not only generates confusion but may also undermine motivation and discourage sustained engagement. Furthermore, the elevated engagement often attributed to ECs may stem from novelty rather than intrinsic pedagogical value (1; 5; 27; 33; 37). Study 24 observed improved attitudes towards anatomy but no clear effect on learning outcomes. As 8 (p. 6) emphasises, readers may find ECs enjoyable without this translating into learning gains, a discrepancy that depends on the reader's prior literacy skills and the specific characteristics of the comics itself. More broadly, engagement must be contextualised: as 25 (p. 585) observes, it is not a matter of whether one likes or dislikes comics in general, but of which types they prefer; furthermore, the medium may prove ineffective if it lacks depth, scope, or conceptual completeness (27, p. 292).

ECs: SUPPLEMENTARY OR TRANSFORMATIVE?

Consequently, reviewing this literature, one should ask, 'Of which comics are we talking about'? **13** specifies: 'the comics of which I speak are not *New Yorker* cartoons [...] or Sunday funnies [...] but rather something I will call "graphic narratives" or "graphic stories"'. The authors also added that comics 'can be delivered in a variety of format [...] and may be expressed via different genres'. (p. 471). This level of awareness of the medium is usually scarce. Probably consequently, comics literacy is scarcely investigated even though comics are considered popular among youngsters, and from some comments, the latter seems to be variously aware of the medium's specificities. In short, regarding ECs in the HE, what has been

said about ECs generally seems to apply, namely that comics literacy and readers' predisposition have yet to be thoroughly investigated (Caldwell, 2012; Tatalovic, 2009).

THE DELICATE BALANCE: ENGAGEMENT VS. OVERSIMPLIFICATION

Some features are difficult to categorise as purely advantageous or disadvantageous. Enjoyability often depends on anthropomorphising study subjects through the 'talking head' technique—what Versaci (2001, p. 62) describes as 'putting a human face on a given subject'—which, depending on discipline and execution, can enhance retention and prevent boredom (**34**) or distract from the educational message. Humour, visual metaphors, and visual gags can similarly boost engagement but may alienate students or obscure content if culturally specific or excessive (**25**; **34**). For instance, a Japanese folk reference is misinterpreted by non-Japanese students in **25** (p. 590), while a US comic well-received by an American focus group is not by a Swiss one in **7**. Excessive humour or a childish tone, alongside reliance on non-serious genres like superhero comics, can engage students but risk making them feel patronised (**7**, p. 196). Moreover, humour is subjective and prone to misinterpretation, while fictional elements may lead students to question the accuracy of the material (Barone and Eisner, 2011, p. 119; Marsh et al., 2012, p. 451).

The risk of oversimplification is not intrinsic to the medium but depends on how ECs are designed. Surprisingly, few studies (e.g., **12**, pp. 270–271; **34**) consider the aesthetic dimension of comics, yet factors such as visual quality, colour use, and script quality significantly influence both effectiveness (**33**, p. 932) and students' perception of comics as valid educational tools (**7**). The lack of focus on aesthetics may partly reflect its subjectivity and the fact that many scholars are also the creators of the comics under study, introducing potential bias. Nevertheless, the artistic dimension, especially design, plays a key role not only in engaging students but in ensuring the effective transmission of educational content.

For example, (**14**) assesses the impact of self-published humorous comic strips on medical students' comprehension of anatomy. While the findings on effectiveness are mixed (**14**, p. 212), students critique the comics' structure, citing issues such as

- 'I don't like two-dimensional caricatures'.
- 'I feel an aversion to the adult jokes'.
- 'Order of episodes is not systematic'.
- 'It would be better to lengthen each episode beyond 4 frames'.

Interestingly, students often provide refined aesthetic evaluations, sometimes surpassing the creators' expectations. Study **34** notes that students prioritise high-quality drawings, suggesting a preference for a style that is accessible yet not overly personal or authorial.

Furthermore, inconsistencies between the story and the educational intent, as well as the inclusion of non-comics elements like visualisations and tables, are often viewed negatively. Students criticise these as replicating traditional textbook content, with one remarking, 'just tables like in a textbook' (**34**, p. 74).

As two participants in the previously mentioned study comment on *Sapiens* (Harari et al., 2020, p. 18),[14] one of the comics examined (Figure 1-14),

> This is not a comic book, but a collage type. And the grandmother, and the man, and the girl could be talking squirrels, nothing would have changed. They are just talking heads with explanations between different other stories. Then a TV series, then a comic book in a comic book. These jumps from topic to topic quickly tired me. I stopped remembering these prehistoric dudes after the second page. And I didn't lose anything! (**34**, p. 72),

Another participant similarly remarks:

> There is too much information in it. Too many pictures. Too much text. Too many things (**34**, p. 74).

[14] *Sapiens: A Graphic History* is a graphic adaptation of Yuval Noah Harari's *Sapiens: A Brief History of Humankind* (2014)

Academic perspectives and future directions

Beyond these specific considerations, the role of ECs in HE remains contested. While some scholars advocate their use as valuable academic outputs rather than mere dissemination tools (**20**; Vigurs et al., 2016, see Figure 1-16), others are more cautious.

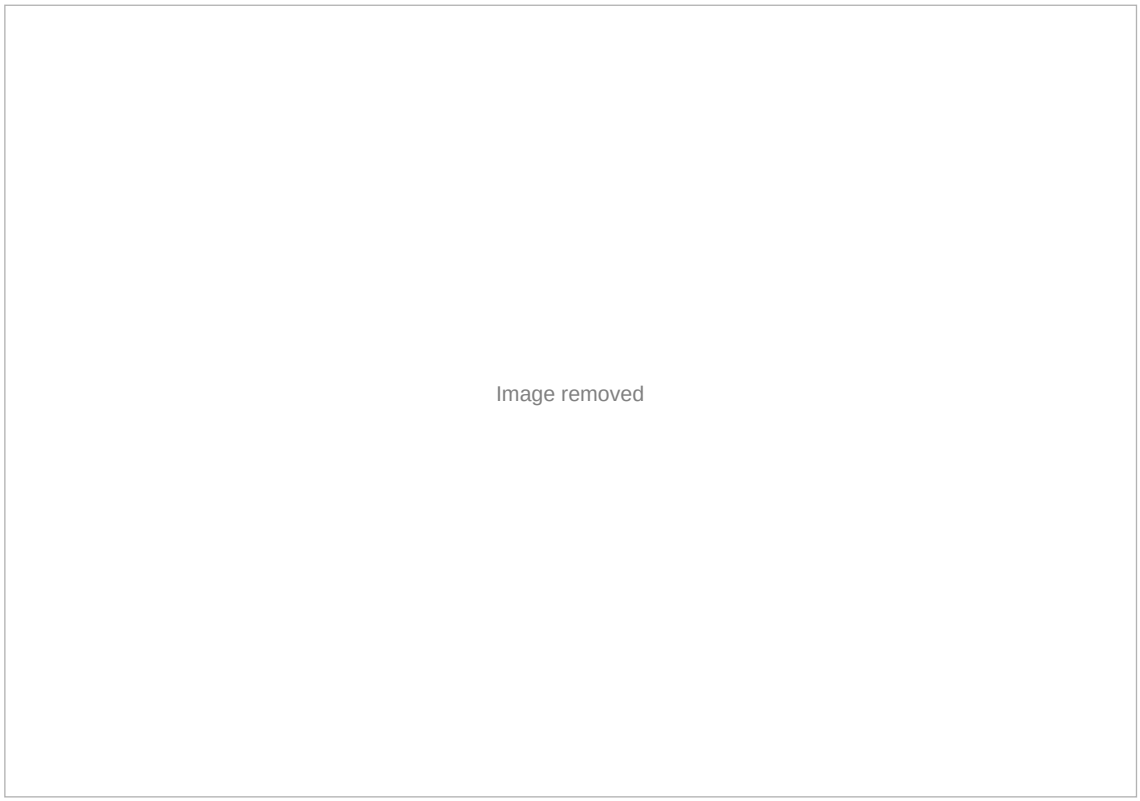


Figure 1-16: A double page from *Higher Fees, Higher Debts: Greater Expectations of Graduate Futures?* This research-informed comics (Vigurs et al., 2016) highlights the financial pressures and career expectations faced by graduates.

Study **15** insists on their introductory function, noting their usefulness for building interest and imparting key ideas, but pointing out that 'the graphic format may have its limits for presenting the most nuanced academic information' (p. 19). Study **29** specifies that comics are valuable for 'inexperienced researchers' (p. 1762), while **6** frames them as tools for 'illustrating theoretical concepts, providing levity and increasing student interest in the written text' (p. 389). This limited perception is compounded by economic factors, copyright restrictions, and a prevailing view that combining text and images is acceptable only in children's books, not in

HE where students are expected to read 'real books' (**19**, p. 6). Furthermore, misconceptions about comics, sometimes perpetuated by researchers themselves, may limit academia's interest (**18**). As a result, 'producers must make a concerted effort to reach academia, and academia must embrace new types of material to enhance teaching' (**18**, p. 18). Such efforts could open up new possibilities for the field, but they require broader awareness and understanding of the medium.

Summarising key points from research by **7**:

- Educational comics have a clear objective: to transfer knowledge.
- The visual, narrative, and knowledge-communication dimensions must be coherent to convey the message effectively.
- Comics' often strong openness to interpretation can cause confusion and misinterpretation.
- Creators must tailor content to the target audience.

A key challenge for ECs is balancing their visual, narrative, and informational elements. Comics may become ineffective if these components are misaligned. However, the literature rarely addresses recurring characteristics—such as excessive written text, simplistic narratives, schematic drawings, and the often-subordinate role of images—which are especially evident in comics produced for research. This gap limits a deeper understanding of their impact.

As **7** points out, inconsistencies between the intended educational purpose and the final product are common. For instance, **27** criticises that the comics for their study were not sufficiently in-depth, questioning whether ECs are expected to replicate traditional academic methods or offer new pedagogical approaches.

While oversimplification—when seen as intentional incompleteness—can sometimes be beneficial, **13** describes how students, when interpreting 'the incomplete visual data' inherent to comics mimic the diagnostic process in medicine, where synthesising fragmented information is key to diagnosis (p. 474). Similarly, **29**'s study on comics for teaching qualitative

research finds that the elisions and omissions in comics fostered productive ambiguity in class discussions (p. 1762).

In contrast, students in **8**—who were surveyed about their attitudes towards comics in HE—expressed surprise at how academic and analytical comics could be. One commented that comics made them 'think outside the normal textbook' and taught them 'how you have to think differently in college' (p. 41). Another added that comics 'made me want to read more of them. But learn, not just for fun, but you're learning and you're having fun. Which we don't get enough of here in school' (p. 42). The study suggests that 'students today have different needs and educators need to meet those needs' (p. 45), although it remains unclear how these 'different needs' are addressed by comics beyond broad assertions.[15]

Interim reflections on ECs in HE

Beyond these institutional and economic barriers, a more fundamental challenge remains internal to the field itself. ECs in HE must move beyond imitating traditional textbooks. Expanding engagement beyond the novelty effect requires rethinking both ECs design and the didactic models that support their use, models still rooted in a logocentric tradition that, as Lemke (2002, p. 321) argues and as will be further examined in Chapter 3, is not merely an epistemological preference but a political ideology that systematically devalues pictorial representation, reinforcing dominant power structures within academia. In this context, **17** (p. 21) notes how comics challenge these structures, where 'writing which discusses other pieces of writing, even when the object of study is something that can't easily be expressed in prose writing'. Furthermore, **17** (p. 1) critiques the authorial centrality of academic writing, advocating for a multimodal scholarship that challenges its uniformity and authoritative tone. Beyond theoretical discussions, **17**'s experience in composing a scholarly paper in comics form

[15] For instance, **11** (p. 249) argues that comics, regardless of content, are inherently inclusive due to their familiarity and accessibility to students compared to traditional textbooks (p. 249).

offers valuable insights: writing by hand, structuring pages as integrated units, and using visual quotations rather than verbal explanations altered the writing process and revealed new aspects of representation. As **17** (p. 4) observes, this process leads to 'a different kind of thinking', one that should also translate into a different kind of reading and learning.

Despite these possibilities, research on ECs remains constrained by outdated theoretical models, often relying on McCloud's and Eisner's sequential art framework without fully addressing the medium's educational potential. Moreover, ECs are frequently conceptualised as simplified, visually enriched versions of traditional textbooks, with teachers depicted as talking heads. The lack of ambition in academic comics stems from both internal and external constraints: the limited involvement of professional comics artists often results in aesthetic and narrative limitations, and **16** explicitly calls for closer collaboration between academics and comics professionals. The humorous, caricatural, and metaphorical approaches that dominate educational comics today trace a continuous lineage from early graphic guides, with few attempts at genuine innovation. The introduction of comics into the classroom can also be perceived as cultural appropriation or inappropriate, especially by instructors unfamiliar with the medium. This scepticism is reflected in student responses:

> These are just stupid attempts of the olds for which I feel Spanish shame (**34**, p. 61).

Ultimately, ECs should be more than visually appealing extensions of traditional textbooks. They must challenge entrenched academic hierarchies, encourage multimodal thinking, and foster different ways of reading and learning. As **17** (p. 21) observes, creating comics rather than writing about them necessitates a fundamental shift in cognitive and expressive processes. If ECs are to reach their full potential in HE, they must embrace this capacity for epistemic transformation rather than remain trapped in conventional didactic structures. It is precisely to break free from these structures that this thesis proposes the Educational Comics to Come (ECtC).

1.3. What are the Possible Futures for ECs in HE?

The question of which ECs should exist in HE remains largely unresolved. In 1977, Serge Tisseron, reflecting on his medical thesis presented in comics form, challenged the assumption that academic discourse must rely exclusively on text. He argued that integrating images and text in comics mirrors the multimodal nature of medical diagnosis, where linguistic, bodily, and gestural messages must be interpreted together. His work was among the first to propose comics as a legitimate research and educational tool, recognising their potential to complement, not replace, traditional texts.

Tisseron also identified challenges that persist today, particularly the role of cultural perceptions in shaping the reception and effectiveness of ECs. He noted that the legitimacy of comics in education is influenced not only by their pedagogical design but also by societal biases, which often lead to comics being perceived as informal or juvenile. His conclusion remains prescient and unresolved:

> The disorder of the traditional pedagogues [...] risks leading us towards a type of educational comics that can satisfy neither comics creators who want to be real authors nor pedagogues who want to encourage the awakening and not the sleep of the recipients. [...] the question on the public stage will no longer be 'for or against educational comics', but 'which comics, for which pedagogy?' (Tisseron, 1977, p. 20).

This issue is closely tied to the cultural positioning of comics within HE. As Humphrey (2014) notes, academic recognition of comics has largely been mediated through the adoption of the 'graphic novel' format. This reinforces a literary paradigm prioritising narrative depth over the medium's visual and diagrammatic potential. While legitimising certain forms of comics, this process has marginalised those with a pedagogical focus, especially in disciplines outside the humanities.

As Méon (2015) observes, the cultural acceptance of comics depends on their integration into pre-existing academic hierarchies, limiting their potential as distinct epistemic tools. Without a fundamental shift in how comics are conceived within educational and research contexts, they risk remaining adjuncts to written texts—used either to 'clothe grammar exercises with new clothes' or facilitate writing assignments, rather than being

recognised for their ability to organise and communicate knowledge in non-linear, multimodal ways (Rouvière, 2017).

A reconceptualisation of ECs in HE must proceed in several stages:

- **Reinterpreting the comics medium** within education, visual literacy, multimodality, and inter- and transdisciplinarity. Comics are complex meaning-making systems that support diverse cognitive processes.
- **Investigating the social, informational, and cultural landscape**, examining how the role of images, specifically comics, has evolved in contemporary digital environments.
- **Examining knowledge representation** in educational contexts, questioning how comics convey information and shape conceptions of knowledge.
- **Exploring the relationship between representational images, abstract visualisations, and meaning-making**, focusing on the diagrammatic and networked structures of *comics* layouts.

Given that comics are historically practice-driven rather than theory-driven, any speculative approach to the *Educational Comics to Come* (ECtC) must draw on comics' spontaneous manifestations, not just formal ECs. Much of the existing literature on ECs is based on a small corpus, often produced within the research community. To identify the potential of future ECs, it is necessary to analyse those already present in HE and examine comics that, while not explicitly educational, contain elements applicable to learning and knowledge production.

Comics occupy a critical position at the intersection of educational domains. They bridge text and image (see Section 4.2), integrating traditional and emerging learning modalities (see Section 3.6). They align with contemporary needs for visualised texts (Black, 2013), reflecting the hypertextual, networked logic of online learning and the digital landscape described by Castells (2011) (see also Chapter 3). In HE, where visual literacy, spatial reasoning, and alternative literacies are becoming increasingly essential (Vitella, 2020), comics offer a model for rethinking how knowledge can be structured and conveyed. This conceptual

premise will later inform the development of five speculative prototypes designed to embody this new approach (see Chapter 7).

The next section, *Research Aims, Objectives, and Questions*, will explore these ideas further, investigating how comics' multilinear, diagrammatic, and spatial properties can be leveraged for knowledge production and scientific communication in HE. Because comics do not merely illustrate knowledge—they participate in its construction—this dissertation shifts focus from what ECs are to what they *could be*. In doing so, it aims to expand their conceptual and methodological boundaries, opening new possibilities for their epistemic role in contemporary education.

1.4. Research Aims, Objectives and Questions

This dissertation aims to explore, in greater depth and detail, the collaboration, borrowing, and integration strategies between comics and data visualisation to identify potential future convergence scenarios. By building upon and extending existing studies on DC specifically and on DVs and ECs more broadly, it first highlights their advantages and limitations before expanding their imaginative, methodological, and applicative boundaries. It examines not only how comics facilitate nonlinear, parallel, and synchronous narratives—enhancing new perspectives on a given theme or subject—but also how recursive and synchronic narrative patterns, as well as the seemingly simple grid layout, offer compelling possibilities for rewriting and reconfiguration. Drawing on concepts from various disciplines, this study investigates how ambiguity, recomposition, and branching narratives—with their capacity for 'multiple or uncertain endings' (Anderson, 2011, p. 125)—can be instrumental in developing an educational, presentation and research model explicitly based on comics that can be adapted to the educational and informational needs of the contemporary cyber-digital world.

The central question of this thesis is, therefore, the following:

- How and to what extent can comics support data visualisation for scientific discourse development to inform HE teachers and researchers of the potential of comics across disciplines?

More specifically, the following sub-questions will be explored:

- How can data visualisation tools use comics' modalities to make data presentation, comparison, investigation and narration more efficient?
- What are the arguments for comics being a more widely accepted means of scientific communication and dissemination in the HE context?
- Does any aspect of comics as a medium represent an obstacle to such development?

Furthermore, while numerous studies on data comics focus on their ability to evoke emotions and empathy in readers (Alamalhodaei et al., 2020)—an important consideration—this research will adopt a different focus. It will specifically investigate how a non-linear, diagrammatic approach can foster a form of comics-thinking based on spatial visualisation, and how this in turn can generate multiple perspectives to represent intertwined events and provide at-a-glance comprehension.

1.5. Structure and Key Terminology

Structure

This thesis is structured into eight chapters, each contributing to a progressive exploration of the theoretical, methodological, and practical dimensions of ECs and DC in HE. The chapters establish a comprehensive framework that situates comics within contemporary educational discourse, examines their theoretical foundations, evaluates current applications, and proposes innovative models for their future use.

- Chapter 1, **Exploring the Present and Proposing Enhanced Use of Comics in Academia**, introduces the research problem and outlines the study's objectives. It examines the current state of comics in HE, addressing their practical uses and theoretical challenges. The chapter advocates for a shift from traditional linear models, proposing new, multimodal, spatial, and diagrammatic approaches that can transform comics into tools for knowledge representation, critical inquiry, and multimodal learning in HE.
- Chapter 2, **Embracing the *Not-Yet*: A Dual Methodological Approach to Comics in Higher Education**, outlines the study's dual methodological approach. This approach combines (1) a speculative qualitative analysis, conducted through the lens of the researcher as a *bricoleur* integrating interdisciplinary and multimodal strategies, with (2) the conceptual design of prototypes, developed through a *Proof of Concept* (PoC) framework, which introduces a visual epistemology for inquiry-based learning in HE.
- Chapter 3, **Visual Literacy and Educational Frameworks in the Post-Digital Age**, explores the epistemological and pedagogical shifts in contemporary education. It focuses on post-digital theories and rhizomatic pedagogies, highlighting the importance of visual literacy in an increasingly multimodal world. This chapter

positions comics as powerful tools for developing visual literacy, fostering critical multimodal thinking, and enabling new forms of knowledge representation and interaction in HE.

- Chapter 4, **Comics as an Elusive Medium: Definitions, Boundaries, and Epistemic Potential**, examines the complex nature of comics as a medium that resists easy definition. Positioned between text and image, narrative and diagram, comics challenge traditional knowledge representation models. The chapter argues that comics' ability to blend various forms of representation makes them uniquely powerful epistemic tools. It explores how comics can represent knowledge in multimodal, spatial, and diagrammatic ways, transforming information into interactive, visual experiences that promote deeper understanding and reinterpretation.

- Chapter 5, **Situating ECtC: Comics as Epistemic Tools Beyond Data Comics and Visualisation**, situates comics within the broader field of External and Multiple External Representations. It critiques traditional data visualisation approaches, particularly those based on minimalism, and explores how ECtC can engage with complex phenomena. The chapter positions ECtC as epistemic tools that go beyond simple representation, offering innovative ways to explore, engage with, and construct knowledge in HE.

- Chapter 6, **Selection Criteria for Educational Comics to Come (ECtC)**, establishes a framework for evaluating and designing ECs within the context of post-digital, multimodal, and transdisciplinary approaches to HE. It outlines multimodal and transdisciplinary criteria for ECtC, ensuring that they are practical tools for teaching and epistemic objects capable of fostering dynamic, inquiry-based learning. These criteria are essential for guiding the development of conceptual prototypes that can help reshape the role of comics in education.

- Chapter 7, **Conceptual Prototypes of ECtC**, presents a series of hypothetical models that rethink the structural and epistemic potential of comics in education.

These prototypes explore innovative ways to represent and structure knowledge, focusing on their ability to support inquiry-based learning and critical engagement. By leveraging comics' diagrammatic, multilinear, and spatial affordances, the prototypes offer new approaches to organising complex information and encouraging active exploration and knowledge construction.

- Chapter 8, **Conclusions: Towards an Epistemology of Educational Comics to Come**, synthesises the study's findings, reflecting on its contributions to comics studies and education, and outlining potential future research directions.

- **Appendices** provide essential technical documentation and implementation frameworks for the conceptual prototypes developed in Chapter 7. They are categorised by function: **Appendix A** details visual encoding strategies and design specifications for Prototype 1; Appendices **B–E** provide implementation frameworks and narrative scripts for Prototypes 2–5; Appendix **F** provides a comparative taxonomy of all five prototypes; **Appendix G** provides an overview of selected studies on Educational Comics in Higher Education. This modular documentation serves three core purposes: (**1**) preserving analytical coherence in Chapter 7 by relocating granular details, (**2**) providing reproducible templates for educators and researchers, and (**3**) formally encoding the transdisciplinary design logic underpinning ECtC.

KEY TERMINOLOGY

To support conceptual clarity throughout this thesis, the following terms are defined in their specific operational senses. Fuller definitions and theoretical grounding are provided at the points indicated.

- **Visual Literacy (VL)**—the set of abilities required to understand and critically interpret visual information, and to use images as tools for thought and

communication. Central to the pedagogical framework of this thesis. *Defined in Section 3.4.*

- **Epistemic potential**—the concrete capacity of a medium or representational form to actively structure thought, support inference, and generate insight—used here not in the abstract philosophical sense, and extending beyond the reader's mere completion of narrative gaps, but as a functional property of the comics interface that actively participates in knowledge production. *Defined in Section 4.1.*

- **Grid / layout**—the spatial architecture of the comics page (where 'grid' refers specifically to the regular panel arrangement, 'layout' to the broader spatial organisation), functioning not as a passive container but as an active relational matrix that structures complex temporal and conceptual relationships. *Discussed in Section 4.4; operationalised in Chapter 7.*

- **Gutter**—the interstitial space between panels. Not a passive gap but a site of readerly inference, semantic rupture, and virtual potential—simultaneously a topological threshold, a diagrammatic scaffold, and a zone of emergent meaning. *Discussed in Sections 4.4 and 4.8.*

- **Meshwork and wayfaring**—terms adopted from Ingold (2007) to describe the reader's navigation of a comics page as exploratory path-making through a dynamic entanglement of lines, rather than linear transport between fixed points. *Defined in Section 4.9.*

- **Comics-fact**—an emergent epistemic event—an instance of insight, affective resonance, or conceptual connection—generated through the reader's active engagement with the comics' spatial organisation and multimodal elements. *Defined in Section 4.8.*

- **Post-minimal visualisation**—an approach to visual knowledge representation that moves beyond first-wave minimalist paradigms—with their 'less-is-more' ethos and maximal data-ink ratio—towards a second wave embracing informational density,

figurative representation, aesthetic complexity, and productive ambiguity as legitimate epistemic tools. *Defined in Sections 5.2.4 and 5.3.*

- **Beyond clarity**—a critical position that refuses to treat clarity as the primary or sufficient measure of visualisation's epistemic value, recognising that interpretive richness can be epistemically more powerful than univocal readability for complex, multi-layered phenomena. *Defined in Section 5.3.1.*

- **Operative iconicity**—the capacity of images to act as active cognitive instruments—rather than passive representations—that do epistemic work through their visual form, structuring thought and enabling inference (Krämer, 2017). *Defined in Section 5.3.2.*

- **Productive ambiguity**—deliberate interpretive openness in a representation—distinct from vagueness or incoherence—where resistance to a single fixed reading activates inferential engagement and generates meaning through what is left open. *Defined in Section 5.3.3.*

- **Time Planes**—one of three spatiotemporal categories proposed in this thesis (alongside *Time Points* and *Time Intervals*) to classify how comics structure time. Time Planes occur when multiple temporal lines coexist within the same spatial configuration, enabling non-linear, simultaneous reading. *Defined in Section 7.4.3.*

- **Hyperobject**—a term coined by Morton (2013a) to designate entities so massively distributed in time and space that they resist localised human understanding. Used in this thesis to frame the representational challenge that ECtC are uniquely positioned to address. *Discussed in Sections 7.5 and 7.6.*

- **ECtC (Educational Comics to Come)**—the original contribution of this thesis: a speculative framework for reimagining educational comics as diagrammatic, cartographic, and multimodal epistemic interfaces for HE, moving beyond linear and logocentric models. *Introduced in Section 1.4; developed in Chapters 6 and 7.*

1.6. Conclusions

> [...] readers of comic books can find meanings that the creators never even intended.
>
> Letizia, 2020, p. 39

In an era characterised by an overwhelming influx of data and increasingly complex phenomena, there is an urgent need for more effective ways to process, visualise, and comprehend information. Traditional data visualisation (DV) methods, while valuable, often fall short in representing multi-scalar, interconnected, and dynamic realities. Moreover, the vast volume of data is not merely an informational challenge; it is reshaping the conception of knowledge itself, demanding interdisciplinary and multimodal approaches that transcend traditional academic silos.

At the same time, reading and learning practices have evolved in the digital age, moving from logocentric, linear, and paper-based methods towards more networked, hypertextual, and visual modes of reception. In this shifting landscape, comics stand at the intersection of multiple literacies—visual, multimodal, and interdisciplinary—yet remain underutilised in HE. Despite their popularity across various domains, comics have historically oscillated between being dismissed as trivial entertainment and being co-opted as simplified educational tools. However, they hold far greater potential: they are not only a medium for research but also a means of inquiry, capable of representing complex scientific and conceptual phenomena in novel ways.

The envisioned 'iComics turn' (Diamantopoulou, 2018) has yet to materialise, but this thesis argues that exploring the intersection between comics and data visualisation—while respecting the distinct affordances of each—can lead to new insights in both fields. Comics can function not only as engaging companions to traditional textbooks but as investigative tools in their own right, offering alternative frameworks for knowledge construction. Their

inherent multimodality enables them to structure and communicate intricate scientific narratives, facilitating inquiry-based learning and critical engagement with content.

Furthermore, comics' spatial and temporal affordances allow readers to navigate information in non-linear, exploratory ways, mirroring the fragmented yet interconnected nature of contemporary knowledge. By bridging disciplines and promoting transdisciplinary thinking, comics can foster a holistic understanding of complex issues. Additionally, their adaptability across formats—maps, diagrams, hypertexts—suggests new possibilities for interactive and self-paced learning experiences.

This dissertation is intended for a broad range of practitioners—educators, researchers, visualisation designers, comics artists, and scholars—who seek to integrate comics more fully into HE and beyond. By reimagining comics as epistemic tools, this research aims to contribute to the growing discourse on multimodal and transdisciplinary education, paving the way for innovative approaches to learning and knowledge representation.

2. Embracing the *Not-Yet*: A Dual Methodological Approach to Comics in Higher Education

2.1. From Theory to Practice: A Methodological Introduction to Educational Comics in Higher Education

> The contemporary debate over higher education is, then, both narrow and is marked by an insecurity about how we might move forward. We require, therefore, in the first place, a *proliferation* of ideas of the university, if only to begin to demonstrate that things could be other than they are. The imagination can be a powerful agent for opening up thinking and for freeing the university from its self-imposed conceptual shackles. And we require the boldest of ideas; ideas that are not 'cabined, cribbed, confined'. Through the imagination, we can come to realise vividly that the university can be conceived and even taken forward in quite different ways. We can escape our present limited horizons.
>
> Ronald Barnett, *Imagining the University* (2013, p. 5)

This chapter develops a methodological framework that aligns with the literature review and research questions outlined in Chapter 1. It embraces Barnett's (2013) call for a radical reimagination of the university, positioning comics as both an object of study and an epistemic tool that challenges rigid academic structures. By adopting a dual methodological approach, this study explores how comics can contribute to alternative forms of knowledge production in HE, bridging theory and practice. This dual framework structures the remainder of the thesis: the first pillar, speculative analysis, is developed throughout Chapters 3, 4, and 5, while the second, prototype design, is executed in Chapters 6 and 7.

To execute this dual approach, the thesis first addresses its analytical pillar. Embracing the 'elusive' nature of comics (Di Paola, 2019a), the speculative analysis is conducted through a flexible *bricolage* methodology (Denzin and Lincoln, 2011) to investigate a selected corpus. The

second pillar is then addressed through the conceptual design of prototypes, which are developed via a structured Proof of Concept (PoC) framework (Kendig, 2016) based on criteria outlined in Chapter 6.

The dual approach—combining the eclectic stance of bricolage with the structured speculative experimentation of PoC—allows theoretical insights to be translated into testable, concrete educational applications. The *bricoleur* approach—rooted in recognising that qualitative research, 'has no theory or paradigm that is distinctly its own' (Denzin and Lincoln, 2011, p. 5)—provides an adaptive, interdisciplinary perspective crucial for studying a hybrid medium like comics. In parallel, the PoC ensures that speculative insights are not merely theoretical but grounded in structured concepts that can be practically applied in HE contexts.

Comics in HE can be understood through the lens of 'not-yetness'—an 'unfulfilled but promising potential' (Veletsianos, 2016, p. 7)—positioning them as pedagogical tools not yet fully embraced but ripe for exploration and integration. Di Paola (2019b) advocates for a transdisciplinary approach to comics studies, precisely because the medium inherently challenges the artificial barriers between academic disciplines. Unlike interdisciplinary approaches, which combine insights from multiple fields while maintaining disciplinary boundaries, transdisciplinarity moves beyond them, creating new epistemic frameworks. This perspective is crucial for comics, which function as hybrid knowledge artefacts that bridge visual, textual, and spatial logics. In this sense, comics are not merely objects of study but epistemic tools that enable alternative ways of structuring and communicating knowledge. Their transdisciplinary nature allows for a holistic perspective, integrating insights from visual studies, literature, education, and beyond, which is especially important in HE, where interdisciplinary and transdisciplinary approaches are increasingly valued (see Section 3.6.2).

The bricoleur's eclecticism and PoC's structured experimentation are complementary, enabling comics to be explored as epistemic tools in HE. Bricolage's flexibility aligns with comics' hybrid nature, while PoC ensures speculative insights are translated into testable concepts. These methodologies underpin the thesis's exploration of *Educational Comics to Come* (ECtC), emphasising their value as pedagogical tools. ECtC are conceptualised as an evolving

category, transcending traditional ECs models by embracing hybridisation, multimodality, and speculative inquiry. This study leverages bricolage's flexibility and PoC's structured speculative approach to rethink comics' role as epistemic tools and propose a framework for multimodal academic engagement.

2.2. Researcher as a Bricoleur: Theoretical Foundations and Challenges

This section introduces the concept of the *bricoleur* researcher, outlining the theoretical underpinnings of this approach and its inherent challenges, particularly as they apply to CS in HE.

Drawing from Lévi-Strauss's (1966) *savage mind*, the *bricoleur* works with 'whatever is at hand' (p. 17), employing a finite yet heterogeneous toolkit. Unlike the *engineer*, who represents the scientific mind, the *bricoleur* acquires knowledge abstractly and subjectively, communicating 'not only with things [...] but also through the medium of things' (p. 21). This approach maintains rigour (Kincheloe, 2011; Denzin and Lincoln, 2011; Roberts, 2018) by assembling existing elements to find new meanings, despite common misconceptions, such as Kincheloe's (2011, p. 680) summary: 'bricolage, oh I know what that is; that's when you really don't know anything about research but have a lot to say about it'. Berry (2004, p. 103) clarifies that while 'there are no methods or procedures to constructing knowledge through *bricolage* as research', it possesses a non-hierarchical, non-linear structure that 'works inwardly, playfully, complexly and rigorously', reflecting both comics' nature and the complexity of digital-age education. Consequently, research design becomes an emergent, adaptable process (Weinstein and Weinstein, 1991; Denzin and Lincoln, 2011), rendering bricolage particularly suited to CS, a field characterised by fluid disciplinary boundaries and inherent multimodality. Comics, like bricolage, resist rigid categorisation, combining text, image, and spatial arrangement to challenge conventional academic frameworks.

Specific challenges for the *bricoleur* researcher in this domain include navigating the extensive and often poorly indexed corpus of ECs, managing terminological ambiguity and conceptual boundaries within DV (where consensus on defining data and visualisation is lacking), and overcoming the linear, text-derived limitations prevalent in much comics scholarship. The diversity and volume of comics production also complicate defining a representative analytical corpus.

This multifaceted, inherently multimethod stance (Flick, 2018) is consistent with qualitative research's interdisciplinary—and at times counterdisciplinary—nature (Grossberg et al., 1992, p. 4; Denzin and Lincoln, 2011, p. 5), allowing for a nuanced, exploratory, and subjective approach through multiple lenses that cuts across the humanities, social sciences, and physical sciences.

Rooted in a postmodern context where multiple approaches to knowing coexist (Richardson, 2000, p. 928), bricolage faces critiques for its eclecticism and lack of fixed methodology, particularly in educational settings oriented towards evidence-based practice (Gough, 2010). Yet, as Gough (2010, p. 9) argues,

> the language of complexity [...] destabilises the instrumentalist rationality that 'programs' educational systems to privilege orderly and predictable processes culminating in stable output.

This is precisely the kind of rationality this thesis seeks to move beyond. Its capacity to integrate multiple approaches further mirrors the multimodal nature of comics themselves, a medium that, like multimodality more broadly, represents 'a stage of development through which many disciplines naturally pass' (Bateman, 2022, p. 41).

2.2.1. Interdisciplinary and Multimodal Dimensions

Developing new pedagogical and imaginative applications for comics in HE necessitates envisioning paths beyond and prior to empirical validation, particularly given the scarcity of systematic studies in this area (Dunst et al., 2018; see Chapter 1).

Given their predominantly visual nature, comics are often associated with visual communication. This research, therefore, inevitably draws upon visual analysis. However, such an approach must not be confined to studying images alone. Visual methodologies, originating in social sciences and ethnography (Bailey and McAtee, 2003; Mannay, 2016), have expanded beyond analysing visible phenomena to encompass conceptual and abstract visualisation (Pauwels and Mannay, 2020, p. 1). This expansion is pertinent in HE, where logocentric paradigms often marginalise visual and multimodal literacies. To fully account for comics' complexity, visual analysis must extend beyond image-based approaches (Van Leeuwen, 2020, p. 468) and embrace multiple interdisciplinary perspectives.

Indeed, as Van Leeuwen (2005, p. 7) notes, visual communication is not a distinct discipline but an interdisciplinary field intersecting with language, communication, anthropology, sociology, media studies, and computing science. Similarly, comics studies remain pluralist and 'undisciplined', adopting a problem-focused rather than method-focused stance, acknowledging that no single discipline can fully address the medium's complexities. While DV often relies more on practical adaptation than rigid theorisation (Parsons, 2022), comics exhibit a similar tendency, evolving through iterative creative processes. This adaptability necessitates a multidimensional approach considering not only formal structure but also contexts of production and use. For instance, an EC explaining a scientific concept requires understanding visual semiotics, narrative theory, the specific scientific discipline, and the crucial spatial interplay between panels from which meaning emerges. A *bricoleur* researcher synthesises these elements, assessing how text, images, and spatial relationships shape understanding and reader engagement.

However, formal structure is only one aspect; the contexts of production and use are equally vital in determining how ECs are perceived and utilised (Pauwels and Mannay, 2020, pp. 2–3). Variations in engagement depend on factors such as how ECs are created—whether by professional comics makers, educators, or interdisciplinary teams—and how students and educators interact with them, including whether they are treated as traditional textbooks or navigated differently, fully leveraging their multimodal potential. Recognising these contextual dimensions is essential for understanding ECs' pedagogical role and impact in HE.

Comics, therefore, cannot be encapsulated within a single methodological framework, instead requiring an interdisciplinary, multidimensional approach that transcends rigid disciplinary boundaries. This aligns with a non-dualistic, uncompartmentalised, or *synechistic* view (Johnson and Gray, 2010) of methodology as a fluid, interconnected continuum of approaches, or what Niglas (2010, p. 216) terms a 'multidimensional set of continua'.

This methodological openness prepares the ground for speculative inquiry. A speculative approach, rather than being detached theoretical play, offers a means of envisioning underexplored applications. As Meskus and Tikka (2022, p. 1) remind, while speculation is not a rigid methodology, it remains a disciplined practice within defined constraints. Adopting a speculative, interdisciplinary lens allows comics research to move beyond existing theoretical limitations, expanding its epistemological and pedagogical potential.

2.2.2. Speculative Application to Comics Studies

This section explores how a speculative approach aligns with the bricoleur's methodology for application to comics in HE, particularly for teaching complex scientific concepts or fostering critical thinking. As discussed in Section 2.1, comics in HE embody 'not-yetness' (Veletsianos, 2016, p. 7), their potential remaining largely unexplored. Rather than treating this epistemic uncertainty as a deficiency, speculative inquiry embraces it as a generative space: what Barnett and Hallam (1999, p. 142) term a condition of 'radical and enduring uncertainty, unpredictability, challengeability and contestability'. This study therefore employs speculation as a disciplined tool for conceptualising new possibilities for comics as epistemic and pedagogical instruments.

An analogy can be drawn with design, as both fields involve iterative experimentation over fixed theoretical paradigms. Burdick (2009) notes that design is increasingly theorised in academia, often without professional designers, leading to fragmented understanding. Similarly, comics in HE are often used pedagogically without engaging comics practitioners or visual storytelling experts. This raises questions about whether such uses fully exploit the medium's affordances or risk reducing comics to simplified didactic tools, neglecting their potential as multimodal knowledge artefacts. Just as Burdick (2009, p. 3) observes that designers are often 'nowhere to be found' in academic contexts, comics artists are largely absent from ECs conceptualisation in HE. Consequently, as with design, 'most projects are still designed by scholars, research assistants, or IT staff' (Uboldi and Caviglia, 2015, p. 209). While successful ECs are often produced by researchers and educators knowledgeable about comics or collaborating with professionals, determining efficacy remains challenging, influenced by both design and subjective user perception. The resulting spectrum of eclecticism and amateurism in academically produced comics mirrors tensions in the academic appropriation of design.

Speculative methods actively create the futures they envision, not merely reflecting on existing practices (Ross, 2017, p. 221). This performative quality is crucial for comics in HE,

where new applications are shaped through experimentation. A speculative perspective allows exploration of how comics can challenge traditional paradigms, imagining them as integral to multimodal, interdisciplinary learning. Speculation generates hypotheses, frameworks, and prototypes that encourage critical engagement, rather than seeking definitive answers, thereby reimagining comics' role in academic discourse.

This speculative approach aligns closely with the bricoleur's epistemology outlined in Section 2.2. Bricolage is itself a 'critical, multi-perspectival, multi-theoretical and multi-methodological approach to inquiry' (Rogers, 2012, p. 1). A common critique concerns expertise: navigating multiple disciplines risks superficiality. However, as Kincheloe (2011, p. 679) stresses, the bricoleur avoids both superficial breadth and unidisciplinary parochialism by synthesising insights across domains, drawing connections inaccessible from within rigid frameworks, operating, like a 'quilt maker or a jazz improviser' (Denzin and Lincoln, 2011, p. 5), within liminal zones 'where disciplines collide' (Kincheloe, 2011, p. 689).

Building on Denzin and Lincoln's (2011) tripartite framework—methodological eclecticism, theoretical synthesis, and critical interdisciplinarity—this research adopts a *bricoleur* approach resisting disciplinary silos (Kincheloe, 2011). Methodologically, it interweaves archival analysis, comparative case studies (Pickvance, 2001), and thematic coding (Mihas, 2023) to interrogate comics' pedagogical potential, identifying patterns, frameworks, and cross-disciplinary connections, ensuring historical depth and cross-sectional insights for a dynamic exploration within HE.

Theoretically, it integrates perspectives from feminist, queer, and visual studies, treating tensions generatively. Critically, it foregrounds the dissolution of boundaries (theory/practice, expert/amateur, comics/HE) defining both the medium and contemporary academia. Aligning with Rogers' (2012) view of the bricoleur engaging in multiple, sometimes conflicting readings, this study embraces methodological and theoretical pluralism to capture comics' complexity in educational contexts.

Thus, this multi-perspectival stance resonates with the speculative ethos of 'not-yetness' (Veletsianos, 2016). By refusing to privilege a single methodology or theory, the

analysis mirrors comics' own hybridity, using their liminality to prototype pedagogical futures. As Ross (2017) argues, speculation is performative: here, it materialises through the bricoleur's deliberate entanglement of archival rigor ('what comics have been') and critical fabulation ('what they might become'). This interplay underscores the investigation's provisional nature. Rather than offering conclusive models, this study embraces speculation to navigate uncertainties surrounding comics in HE. However, any speculative endeavour must recognise its constraints. While generative, speculation carries risks; without empirical validation, its approaches remain hypothetical, requiring future research. This study mitigates this by grounding speculation in existing theoretical frameworks and systematic case study analysis to provide structured conceptual insights. The subsequent section will address these methodological and conceptual limitations.

2.2.3. Limitations

Before exploring the potential of comics in HE through a speculative lens, it is crucial to acknowledge the limitations that inform this inquiry. These limitations fall into two broad categories:

1. Constraints in the existing body of research.
2. The specific methodological and practical boundaries of this study.

While the recent phenomenon of data comics (DC) remains underexplored, related fields such as ECs and DV have a longer history. However, much of the existing research tends to examine pedagogical strategies rather than the medium-specific affordances of comics as epistemic tools (e.g., focusing solely on whether comics improve test scores, without analysing how their multilinear nature impacts learning processes).

A further challenge is the lack of consensus regarding terminology and conceptual boundaries within DV, information visualisation, and infographics (see Chapter 5). This ambiguity complicates the categorisation of DC and their role within visual knowledge representation. Similarly, the vast and under-indexed corpus of ECs presents another obstacle, making systematic analysis difficult.

Given the scope of this dissertation, no attempt is made to offer an exhaustive overview of all forms of DC and ECs. Instead, the focus is on identifying overarching trends and critical gaps. The corpus selection process, while striving for inclusivity, remains necessarily subjective. Starting from prior expertise in the field, additional targeted research was conducted, yet the impossibility of covering all global productions must be acknowledged. Some traditions—such as Japanese manga and less accessible national comics industries—are only marginally addressed. While these omissions do not undermine the validity of the research, broader cross-cultural studies could offer additional insights in future investigations.

Specific challenges also arise in examining webcomics and digital comics designed for screen-based reading. Many of these artefacts remain difficult to trace due to their ephemeral

nature, the lack of formal archives, and the disappearance of Flash-based content following the discontinuation of *Adobe Flash* in 2020. Although digital preservation tools such as the *Internet Archive* provide partial access to lost works, gaps remain.

Rather than treating these constraints as obstacles, this study views them as points of reflection that reinforce the need for an adaptive and iterative research framework. By acknowledging these limitations, the analysis can situate itself within the broader landscape of comics research while seeking to generate hypotheses and conceptual models that stimulate further inquiry.

2.3. Conceptual Foundations for Prototyping ECtC

This section introduces *prototyping* as a key methodological approach, bridging the *bricoleur*'s flexible methodology with the practical development of ECtC. Prototyping, as conceptualised here, is an iterative, exploratory approach aligned with this research's speculative nature. Rather than seeking definitive models, it enables envisioning and testing new possibilities for comics as epistemic tools in HE.

Building upon the *bricolage* approach, which facilitates flexible, interdisciplinary inquiry, prototyping serves as a complementary methodological tool. While *bricolage* allows for an adaptive analysis of existing works, prototyping extends this by using conceptual models to envision alternative applications of comics in HE. To achieve this, the prototyping methodology will: define conceptual prototypes, explaining their research role, broader methodological context, and application to ECtC; explain the approach to selecting and analysing comics examples throughout the thesis, clarifying their rationale (with detailed criteria for specific case studies further elaborated in Chapter 6); and analyse examples of mainstream and independently produced comics that inform the conceptual prototypes developed in later chapters.

Rather than presenting ECtC as fixed models, this part positions them as adaptive, evolving prototypes. It embraces multimodality and hybridisation to explore comics' potential beyond prescriptive educational frameworks. Subsequent sections will establish prototyping's theoretical foundations, examine the role of Proof of Concept (PoC) in validating ideas, explore how existing comics serve as design prototypes, and address this approach's methodological limitations.

2.3.1. On Design as a Research Method, Models and Prototypes

> At present, each media commodity becomes, at the instant of its release, an archive to be plundered, an original to be memorized, copied, manipulated—a starting point or springboard for receivers' creativity, rather than an end into itself.
>
> De Kosnik, 2016, p. 4

De Kosnik's notion of media as a resource for creative reinterpretation is central to prototyping and resonates with both the *bricoleur* approach adopted herein and comics' remediating tendencies. In contemporary research, design is firmly established as an autonomous practice essential for exploration, creation, and transformation. Unlike traditional science, which primarily describes and explains, or art, which often focuses on individual expression, design is fundamentally concerned with creating artefacts and systems that address human needs and improve the human condition. Simon (1969) asserts design belongs to the 'science of the artificial', a field that reshapes the world by creating artefacts and systems for emerging needs in complex, uncertain contexts. While scientific models often prioritise analysis and prediction, design embraces the intentional transformation of reality through practical engagement (Fallman, 2003).

Adopting design as a method shifts perspective, making it an exploratory process where problems and solutions co-evolve. Schön (1992) describes this as a 'reflective conversation' between designer and materials, where each phase expresses a vision and tests its coherence. This non-linear, intuitive approach generates situated, dynamic knowledge that adapts with the project's progression. Design's hybrid nature—drawing on analytical and creative thinking—and its reflective dimension enable it to address open-ended problems and adapt to evolving contexts, positioning it as a complementary method to natural and human sciences for innovation (Fallman, 2003).

As further explored in Chapter 5, design aligns more with practice than theory. Trends towards its scientisation or systematisation face criticism for oversimplifying its complexity. Dorst (2006) argues that problem-solving paradigms in design methodology often reduce its capacity to tackle creative, ill-structured challenges. Jensen and Andreasen (2010) note that design methods are typically applied situationally, requiring flexibility alongside scientific rigour. Sevaldson (2014) cautions against excessive scientisation, which risks alienating design from its artistic and craft-based origins. This iterative, dialogical nature of design resonates with the *bricoleur* methodology, where the designer leverages available resources, adapting context through trial and error, sharing a pragmatic, creative approach that rejects rigid processes for innovation driven by adaptability.

From this perspective, the term 'model' becomes problematic if implying rigid guidelines as often found in manuals or academic literature (e.g., Bach et al., 2018; Kuttner et al., 2017), contrasting with the flexible, exploratory methodology adopted here. Instead of prescribing rules, this approach prioritises identifying limitations constraining the medium's potential. Contextualised examples will be presented not as definitive solutions but as suggestions for designing more effective ECs, acknowledging unexplored possibilities in HE. Thus, the comics selected for Chapter 7 will serve as a PoC, demonstrating feasibility by exploring creative possibilities and illustrating potential pathways, rather than offering exhaustive corpus analysis. This methodology underscores experimentation and innovation through targeted examples.

Furthermore, the design process, especially early on, often embraces ambiguity productively—not as mere lack of clarity but as deliberate openness to multiple interpretations. As Gaver et al. (2003, p. 233) observe, ambiguity can be 'frustrating [...] but it can also be intriguing, mysterious and delightful'. This quality is valuable in design, allowing designers to 'suggest issues and perspectives [...] without imposing solutions' (Gaver et al., 2003, p. 240), fostering critical thinking and diverse interpretations in learning contexts.

Ambiguity is inherently relational, shaped by the interplay of source, message, and receiver (Eisenberg, 1984, p. 229). In visual representations, it arises from compromises in representation, abstraction, and subjective interpretation. Gill et al. (2011) note, 'all visual

representations have a level of ambiguity and inevitably imply some compromise from the original intent', making prototypes subject to multiple readings, particularly in multidisciplinary settings. This openness aligns with Whyte et al.'s (2008, p. 76) assertion that ambiguity is valuable when balancing 'focused reasoning and free association'.

In prototyping, ambiguity is a resource rather than a flaw. Early prototypes are often intentionally incomplete, leveraging ambiguity to stimulate exploration. As Suwa and Tversky (2002, p. 342) demonstrate, vague visualisations can trigger the '*detection of unintended relations and features*', initiating a cyclical process of reinterpretation (Suwa et al., 2000) central to creativity (Suwa, 2003).

Comics exemplify this pedagogical potential. Their blend of visual, textual, and spatial elements, combined with gutters and reader-driven meaning-making, creates inherent openness. ECs can harness ambiguity to promote active engagement and flexible comprehension, for instance, by omitting specific interpretations to prompt student debate. This aligns with their capacity for integrating linear/non-linear consumption, concreteness fading, and multimodal explanations, accommodating diverse cognitive needs.

2.3.2. Proof of Concept and Prototypes

This subsection defines PoC and prototypes, highlighting their role in validating ideas' feasibility and their connection to cognitive psychology. Comics, in this context, serve as conceptual prototypes for testing.

The PoC is widely used in academic research to ascertain the feasibility of ideas, methods, or technologies before large-scale implementation (Kendig, 2016), allowing scholars to test hypotheses and operational frameworks at early stages, thereby enhancing emerging theories' robustness (Jobin et al., 2021, pp. 3051–3052). Beyond viability, PoCs can influence epistemological and ethical categories, shaping future research and establishing transferable knowledge creation frameworks (Kendig, 2016, p. 750). However, PoCs are most effective when tied to prototypes, which transform abstract theories into practical, actionable forms (Elliott, 2021, p. 264).

Prototypes are described by Martin and Hanington (2012, p. 138) as 'the physical realisation of product or interface concepts [...] representing the creative translation of research and ideation into tangible form'. Houde and Hill (1997, p. 369) broaden this to any medium embodying a design idea. They are versatile tools, from physical artefacts to abstract representations or theories (Elliott, 2021, p. 263).

The prototype concept also draws from cognitive psychology, particularly concerning category structures. Rosch (1975, 2002 [1978]) describes prototypes as collections of common features among category members, not ideal examples. Lakoff (1987) similarly suggests categories are structured around prototypes with typical features, allowing variation. These insights parallel design, where prototypes are flexible frameworks capturing essential qualities. Prototypes help understand category structures by encapsulating shared features (e.g., Murphy, 2004; Hampton, 2006). Designers create prototypes embodying common, though not necessarily essential, elements, achieving greater flexibility and creativity for exploring new ideas (Brown, 2009; Cross, 2011).

Their adaptability enables prototypes to be dynamic tools for iterative exploration, blending creativity, intuition, and critical reflection, thereby fostering innovation and tangibly manifesting creative ideas (Gill et al., 2011; Lim et al., 2008). A prototype's novelty is often context-dependent: routine in one discipline can be innovative in another (Elliott, 2021, pp. 263–264). For example, while comics are established in CS, their application in HE, when viewed as prototypes, can reveal new characteristics.

Thus, here, the comics under analysis will not be treated as rigid models but as 'design prototype[s]' (Gero, 1987)—defined as 'a conceptual schema for representing a class of a generalised heterogeneous grouping of elements derived from similar design cases that provides the basis for the start and continuation of a design' (Gero, 1990, pp. 30–31). They serve as adaptable starting points for creative exploration. This inherent flexibility allows them to function as dynamic tools for testing ideas and as inspiration for reinterpreting or adapting solutions, even across different contexts.

2.3.3. Advantages of Using Conceptual Prototypes

This approach of using existing comics as conceptual prototypes offers several key advantages. Examining comics not originally intended for educational purposes allows for identifying innovative design strategies and narrative techniques potentially absent in more conventional ECs. This facilitates:

- **Leveraging Proven Knowledge through Creative Adaptation**: Designers often draw inspiration from existing solutions, adapting and reinterpreting them for new needs, thus combining prior knowledge with innovation to foster creativity (Cross, 2011).
- **Challenging Conventional Methods**: Traditional, prescriptive design methodologies (e.g., the systematic approach of Pahl and Beitz) often fail to address the nuanced realities of real-world design challenges (Jensen and Andreasen, 2010). Prototypes offer a more adaptable solution for diverse, unpredictable design problems.
- **Avoiding Fossilization**: A flexible approach, drawing inspiration from varied sources, prevents fixation on rigid structures that may no longer serve contemporary education's evolving needs. Designers adapt existing solutions to new contexts, reshaping established patterns (Lawson, 2005).

Building on these general design principles, this thesis treats existing comics as conceptual prototypes—sources of inspiration and experimentation rather than rigid models to be copied. The goal is not replication but the extraction of useful design principles, narrative strategies, and visual techniques adaptable for the specific context of HE. This approach specifically allows for *reinterpreting existing patterns*, using comics as a foundation for innovative educational solutions where proven elements are tailored to pedagogical needs, and *promoting innovation* through reinterpretation, leveraging concepts and structures from diverse contexts to address emerging educational challenges.

The comics analysed are therefore considered design prototypes, offering creative cues and possibilities for exploration. The primary objectives are to develop ECs that are unique and relevant, tailoring materials to contemporary HE needs and pedagogical priorities, and to adopt an iterative design approach, continuously refining ideas through feedback and emerging insights. Operationally, this involves categorising and reimagining comics through speculative redesign. This process prioritises 'the functionality that a user might benefit from, with little attention to how the artifact would look and feel, or how it could be made actually to work' (Houde and Hill, 1997, p. 6). This aligns with Buchanan's (1992) concept of *wicked problems* (i.e., complex, ill-formulated issues with confusing information and conflicting stakeholder values) in design thinking, highlighting the complexity and ill-defined nature of many design challenges, thus necessitating innovative, adaptable approaches.

The prototypes discussed in this thesis are *conceptual* rather than *fully realised artifacts*, emerging from critical analysis and speculative reimagining of existing comics. This acknowledges, following Lim et al. (2008), that prototypes are often most valuable for what they omit; their incompleteness creates space for interpretation, discussion, and further development. Furthermore, this process should be collaborative. Following Gero (1990) and Gill et al. (2011), these conceptual prototypes are intended to inspire collaboration among stakeholders (educators, researchers, comics creators, students) in designing and implementing ECs, informing the exploration of future applications.

2.3.4. Limits and Non-Validation Issues

A notable issue with the described procedure is that PoC typically involves exploration and validation phases, which can occur consecutively, in parallel, or synergistically (Jobin et al., 2021). In a speculative thesis such as this, however, the validation phase presents a challenge, as no new comics will be produced, preventing empirical testing and reducing validation primarily to conceptual analysis.

Gelfert (2016, 2018) argues that PoCs often serve as exploratory tools that shape future scientific practice, stating that 'exploration should stand alongside more traditional criteria for assessing models (such as explanatory, predictive, and representational success)' because it can guide inquiry even when traditional validation is limited (Gelfert, 2016, p. 267). This highlights exploration as a core function, emphasising PoCs' role in developing new hypotheses and research directions beyond immediate empirical validation. Elliott (2021, p. 264) further supports this, noting that PoC demonstrations, especially in early-stage research, often rely on arguments and heuristics rather than direct empirical evidence. He emphasises that PoC research involves establishing prototypes that fulfil their intended functions and justifying their further development, often using fallible heuristics. This suggests PoCs not only validate hypotheses but also expand scientific inquiry's epistemic and normative landscapes, functioning primarily as conceptual tools.

In conclusion, the PoC in this thesis demonstrates the feasibility of conceptual approaches within comics, underscoring the epistemic roles these models play in guiding future research. By prioritising theoretical reasoning over empirical testing, PoCs illuminate the medium's constraints and possibilities, opening new avenues for exploration and demonstrating their broader utility in academic research. Recognising exploration's vital role in scientific modelling is crucial; without it, PoC-driven innovations risk being perceived as accidental rather than deliberate advancements.

2.4. Conclusions

By intertwining the bricoleur's eclecticism with speculative prototyping, this chapter has advanced a methodology that embraces comics' not-yetness as a generative force for HE innovation. The dual methodological approach outlined—combining bricolage with PoC—provides the necessary flexibility to explore comics as epistemic tools, moving from theoretical speculation to structured conceptual experimentation.

While empirical testing remains outside this study's scope, the conceptual prototypes developed in Chapter 7 provide a structured basis for future research, including pedagogical testing, visual design innovation, and interdisciplinary integration with existing educational and scientific visualisation practices. These prototypes specifically explore comics' structural and epistemic affordances, such as diagrammatic storytelling, deep mapping, and transdisciplinary visualisation, as iterative, adaptable tools for expanding existing knowledge paradigms. The following chapter explores the epistemic shift from logocentric to multimodal knowledge structures in HE, establishing the theoretical groundwork for the analysis that follows.

3. Visual Literacy and Educational Frameworks in the Post-Digital Age

3.1. Introduction: Data, the Digital Age, and New Literacies

Ever see a bird hurt itself by flying into a glass window? The bird is not stupid; he simply did not have all the data.

Robert Heinlein, *The Puppet Master* (1990, p. 188)

Ever come across a digital-era bird smacking itself into a glass window? Our feathered friend isn't dim-witted; it's simply a victim of analog obstacles in a high-tech world.

[Chat-GPT: Prompt: 'Turn this sentence [Heinlein's above] into another about an analog bird in a digital world']. See Figure 3-1,

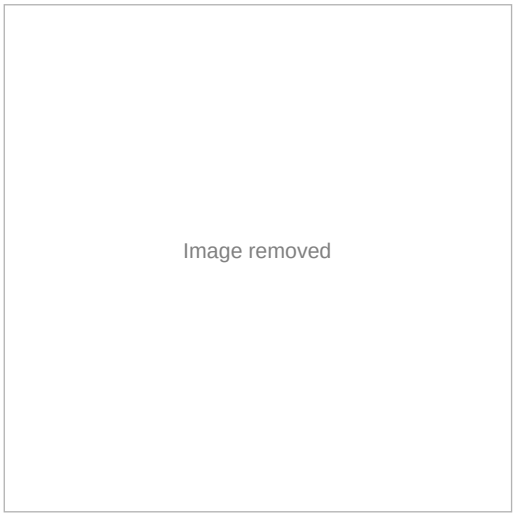


Figure 3-1: Microsoft Bing Image Creator, using the above sentence as prompt.

As Robert Heinlein suggested, lacking crucial environmental data can lead to failure, even for creatures with inherent abilities. Similarly, navigating the digital age demands not just intelligence but the capacity to interpret and adapt to new informational landscapes. Aligning

with the non-linear, adaptive methodology advocated in Chapter 2 and acknowledging the limits of purely empirical approaches in emergent fields, this chapter focuses on HE. It is understood here as an educational landscape increasingly defined by non-linearity, multimodality, and interconnectedness—a context in which, as with comics studies, theoretical frameworks and speculative inquiry are essential.

The contemporary environment is saturated with data, visual technologies, and multimodal media. The 'deluge' of data and information, presented in increasingly fragmented, interactive, and multisensory formats, reshapes how the world is accessed, processed, and understood. This shift profoundly impacts HE, where traditional, logocentric pedagogical models—reliant on linear, text-based transmission of established concepts—are challenged by the dynamic, networked nature of digital-age knowledge production. The rise of (big) data, for instance, has not only provided new material but has also reshaped what knowledge is and how to approach it, fostering interdisciplinary, collaborative, and networked approaches (Weinberger, 2011; McAuley et al., 2010; Fawcett, 2013).[16] Indeed, growing datasets create a 'network effect' interconnecting disciplinary areas (McAuley et al., 2010), promoting multi-, intra-, and transdisciplinary method (Fawcett, 2013). As Weinberger (2011, p. 5) states, 'knowledge is not the same as it was. Not for science, not for business, not for education, not for government, not for any of us'.

The inherently 'visual' contemporary digital and post-digital environment culminates a broader shift from 'the world told' to 'the world shown' (Kress, 2003a). Today, HE students, often described as *digital natives* and *multimodal learners*, are immersed in visual, interactive media, accustomed to navigating complex information spaces non-linearly and processing multiple sources simultaneously. They are active participants, shaping an evolving media landscape, their preferences challenging traditional educational models and demanding new ones (López et al., 2023; Luttrell and McGrath, 2021; Rothman, 2016; Szymkowiak et al., 2021; Artkan and Kaya, 2021; Hayles, 2012). This necessitates a move beyond traditional literacy towards a holistic understanding of communication encompassing *visual literacy* (VL)

[16] Big Data offers revolutionary potential for science (Anderson, 2008), yet meaningful interpretation still requires theoretical frameworks to move beyond raw data (Mazzocchi, 2015).

(Avgerinou, 2003, 2009; Elkins, 2009; Kędra and Žakevičiūtė, 2019; Kędra, 2018), *data literacy* (McAuley et al., 2010),[17] and *multimodality* (Chew and Mitchell, 2019).

However, effectively navigating this new landscape is not automatic; mere exposure to images and data does not equate to understanding. HE institutions face the challenge of fostering these crucial literacies whilst grappling with ingrained text-centric traditions (Lacković, 2020; Lacković and Olteanu, 2020). This tension between established practices and the demands of the digital age, and the active role of students in shaping this transformation, forms a crucial backdrop to this chapter. Although images and visualisations—'graphics'[18] or 'graphical representations[s] of data or concepts' (Ware, 2012b, p. 2)—have a long history in scientific dissemination, they are frequently relegated to marginal roles. Yet, in an increasingly networked epistemology, where knowledge is shaped by interconnected data and collaborative processes (Weinberger, 2011; McAuley et al., 2010), visual representations are fundamental to meaning-making.

Together, these themes trace a shift from linear, text-centric learning models towards more dynamic, interconnected, and visual approaches, increasingly defined by network epistemology (Jagoda, 2015, p. 109). The chapter examines visual literacy, *edusemiotics*, *rhizomatic learning* (RL), and transdisciplinarity, providing the theoretical framework for subsequent chapters on how these dynamics inform the use of comics in educational settings.

[17] Data literacy is crucial, involving recognition that data are not 'raw' (Gitelman, 2013) but contextually generated (Cobb and Moore, 1997, p. 801), and culturally produced and interpreted (Whitney, 2012, p. 21).
[18] '**Graphics** is the term used for external representations that leave a *trace* on a surface or screen' (Lacković, 2020, p. ix).

3.2. A Visual, Digital World

> The expressions 'world picture of the modern age' and 'modern world picture' both mean the same thing and both assume something that never could have been before [...] the fact that the world becomes picture at all is what distinguishes the essence of the modern age.
>
> Martin Heidegger, *The Age of the World Picture,* (1977, p. 130)

Heidegger's observation resonates strongly in the contemporary visual-digital environment. The Western shift from a book-based to an image-based conception of the world (Avgerinou, 2009, p. 28)—from a logocentric to an iconocentric perspective—has accelerated, particularly since the nineteenth century, with word-dominant media yielding to image-dominant and multimodal forms (Moernaut et al., 2020, p. 484).

This transformation is deeply intertwined with the rise of digital technologies. Debray (1992) identified distinct *mediaspheres—logosphère, graphosphère, vidéosphère*—marking shifts in dominant communication modes. Merzeau's (2007) *hypersphere* describes the current internet-driven environment of interconnectedness and constant information flow. This digital era reshapes reading, writing, and viewing habits (Herrenschmidt, 2007), fostering simultaneous over sequential reasoning. This departure from traditional linear engagement led Flusser (2011a) to ask, provocatively, 'Does Writing Have a Future?' He argued that while writing transforms scenes into sequential processes structuring linear time perception, images convey meaning holistically and synchronically (Flusser, 2002, p. 23), with each medium uniquely shaping temporal perception (Poster, 2011, p. xv), a crucial consideration in a multimodal landscape.

This transition from linear to surface thinking is a concrete change in information interaction. Digital environments present information as a spatial constellation of elements

(text, images, videos, hyperlinks), encouraging exploratory, non-linear engagement where meaning arises from actively juxtaposing and integrating multiple modalities. This impacts education, promoting holistic learning valuing creative thinking, problem-solving (Luke, 2003), and multimodality (Kress, 2003b; Gee, 2003). VL, 'the possibility that literacy can be achieved through images as well as texts and numbers' (Elkins, 2009, pp. 4–5), becomes fundamental to learning (Fransecky and Debes, 1972, p. 7), alongside digital and data literacy (Reedy and Parker, 2018; Reddy et al., 2020).

Moreover, 'digitisation' extends beyond online life. Digital hypertexts' 'placelessness' and immateriality influence embodied practices. The web itself is a 'rhetorical place', shaping meaning through a unique mobility that challenges and redefines informational pathways (Burbules, 2005, p. 83). This mobility concerns the cognitive agility needed to navigate complex information spaces, connect disparate sources, and construct knowledge dynamically.

The contemporary world exhibits 'hyper-visuality' (Lacković, 2020a, p. 443), with ubiquitous images (Classen, 1998, p. 1; Avgerinou, 2009, p. 28), even for the unrepresentable (Mirzoeff, 1999, p. 6). However, *being immersed* in visual culture does not equate to *understanding* it (Mirzoeff, 1999, p. 3); tools to decode images beyond textual analysis are often lacking (Mitchell, 1994, p. 16). In fact, as Nancy (2005) argues, images—despite the seeming intimacy between viewer and image—are intrinsically 'monstrous', always excessive, polysemic, and out of control. Thus, they are never fully contained or understood, functioning not as 'transparent windows on the world' (Rose, 2001, p. 6) but as interpretations. Visuality thus involves 'how we see, how we are able, allowed, or made to see, and how we see this seeing and the unseeing therein' (Foster, 2006, p. 116). While vision remains a dominant sensory modality (Hutmacher, 2019), its exclusivity is challenged by calls for integrated multimodal perception (Shimojo and Shams, 2001). For example, a geologist's VL allows them to 'see' a

rock formation (Figure 3-2, left) differently from a layperson, identifying features like faults and marker beds, often represented schematically (Figure 3-2, right).

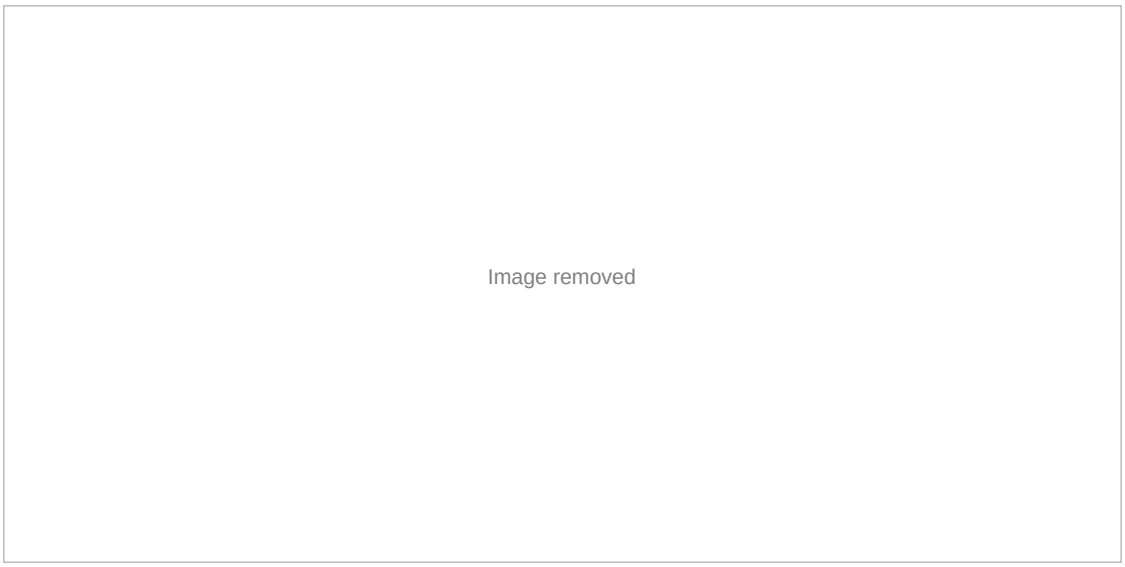


Figure 3-2: Disciplinary visual literacy shaping geological interpretation. The schematic (right) isolates key geological features (normal faults, marker bed) that a geologist identifies in the photograph (left), thereby demonstrating common conventions in geological illustration (adapted from Paxton et al., 2017, p. 1268).

This visual elusiveness—its resistance to full containment or explanation—can provoke fascination and resistance, especially in academic contexts prizing clarity. Moving beyond viewing images as mere illustrations requires shifting from a language-logic to a figural one (Lyotard, 2011), acknowledging visual signs' opacity and ambiguity. As Alloa (2012, p. 150), citing Boehm, suggests, only by acknowledging verbal language's limits and ceasing to reduce 'the patterns of iconic meaning' to pre-established ones can an 'image paradigm' emerge. True visual engagement requires 'unlearning how to recognize' (Lyotard, 2011, p. 153) and embracing meaning's multiplicity.

3.3. An In-Depth Look at Visual Studies: Logos and Eikon

> Dedicated to the barbarians, who are unable to read this book.
>
> Ian F. Svenonious, *Against the Written Word; Toward a Universal Illiteracy*
>
> MY TRIKE by Chuck. The author was five years old and had a face that looked as if it had been struck by a tornado of freckles. There was no title on the book, and no words inside, just picture.
>
> 'What's the name of your book?' I said.
>
> The little boy opened the book and showed me the drawing of a tricycle. It looked more like a giraffe standing upside down in an elevator.
>
> 'That's my trike', he said.
>
> 'Beautiful', I said. 'And what's your name?'
>
> 'That's my trike'.
>
> *The Abortion: An Historical Romance* (Brautigan, 1971, p. 25)

These two seemingly disparate epigraphs encapsulate the tension explored in this section: the longstanding dichotomy between logos (word) and eikon (image) in Western thought, and its implications for how visual communication is understood and valued, particularly in educational settings. To fully understand this shift's implications and effectively foster VL, examining the historical and philosophical roots of the word-image relationship is crucial.

This dichotomy between 'the seeable and the sayable, display and discourse, showing and telling' (Mitchell, 1996, p. 51), dating back at least to Plato's Phaedrus, has profoundly

shaped Western thought by privileging writing as the primary vehicle of rationality and truth while relegating images to a secondary, illustrative role. For centuries, studies on images continued this subordination, treating them primarily as text-dependent allegories, a suspicion that persists, as discussed, in contemporary HE.

Alloa (2021b, p. 482) reframes this by asking, 'What do we see when we look at pictures?', identifying three perspectives on the viewer-image relationship: Seeing-as (Wittgenstein), Seeing-in (Wollheim), and his own mediation, Seeing-with. The most productive for this thesis is the third: in Seeing-with, attention moves to how an image's formal elements (style, design) influence perception. Alloa explains that images are not transparent representations; they 'allow new visibilities to dawn' (Alloa, 2021b, p. 493), revealing new sides of reality rather than just new things. Referring to studies on operative iconicity (Krämer, 2017), Alloa (2021b, p. 494) further notes their insistence on the 'epistemic function of practical tools of visualisation, whether through sketches, outlines, plans, notes, or diagrams', a framework directly relevant to understanding how comics function epistemically.

The iconic turn in Visual Studies, particularly through W.J.T. Mitchell (1994, 2018) and Gottfried Boehm (2012; 2009), directly challenges text-image subordination. Scholars like Boehm and Mitchell argue that, due to their ambiguity and opacity, images possess an 'iconic intelligence' (Boehm and Mitchell, 2009, p. 106), a distinct visual logic capable of establishing an independent logos beyond verbal translation. However, while visual culture has attempted to 'correct the linguistic turn [...] by means of an iconic turn' (Pinotti, 2012, p. 32), it has not fully escaped logocentrism.

Unlike words, images function through spatial rather than sequential organisation, engaging perception and meaning simultaneously. This intrinsic 'monstrous' quality (Nancy, 2005), their excessive, polysemic nature, is not a weakness but a source of power, allowing images to reveal and generate meanings that challenge established frameworks. The educational challenge, therefore, is not merely to use images but to cultivate a critical VL that embraces ambiguity and recognises images' unique epistemic potential. This theoretical foundation on the logos-eikon dichotomy sets the stage for a deeper examination of VL and visual thinking.

3.4. Visual Literacy in Higher Education

> The words or the language, as they are written or spoken, do not seem to play any role in my mechanism of thought. The psychical entities which seem to serve as elements in thought are certain signs and more or less clear images which can be 'voluntarily' reproduced and combined. There is, of course, a certain connection between those elements and relevant logical concepts [...] Conventional words or other signs have to be sought for laboriously only in a secondary stage.
>
> Albert Einstein in Hadamard, 1954, p. 143 (1945)

Einstein's reflection underscores visual thinking's crucial role in cognition, even in fields traditionally associated with abstract verbal reasoning. Yet, as previously discussed, HE often struggles to fully embrace visual communication's potential. Following the *iconic turn* (see Section 3.3), as the visual domain gains epistemic autonomy, understanding how individuals interpret, analyse, and produce images becomes vital. However, while the growing presence of visual media might imply increased VL, the connection between *seeing* images and *understanding them* remains often tenuous (Pauwels, 2006, p. x).

From its inception, VL has been a multifaceted concept. Debes (1969a, p. 14), who introduced the term, described it as an 'amoeba' with unexplored parameters, referring to 'a group of vision-competencies' (Debes, 1969b, p. 27). Crucially, VL, including visual thinking, encompasses both 'the ability to "read", interpret, and understand information presented in pictorial or graphic images', and 'the ability to turn information of all types into pictures, graphics or forms that help communicate the information' (Wileman, 1993, p. 114). This *dual capacity* of interpreting and creating visuals is central to VL (Heinich and Smaldino, 1999;

Bleed, 2005; Brumberger, 2011), shifting emphasis from the 'finished product' to the process of visual thinking and image-making itself (Hermans and Schönau, 2022, p. 195).

Despite a considerable body of literature (e.g., Hattwig et al., 2013; Lacković, 2020; ACRL, 2022; Felten, 2008), a comprehensive definition of VL remains elusive (Avgerinou, 2009, p. 29). Embracing Kędra's (2018, pp. 69–71) call to move beyond definitional debates towards implementation, and given the perceived naturalness of looking and the lack of a unified VL theory, this thesis adopts Avgerinou's (2003, p. 36) definition: VL refers to 'a group of largely acquired abilities, i.e., the abilities to understand (read), and to use (write) images, as well as to think and learn in terms of images'.[19] Empirical research on VL in HE, however, remains scarce (Lacković, 2020, p. 96; Felten, 2008, p. 60), underscoring the challenge of integrating these skills into educational settings, compounded by the widespread assumption that vision requires no formal training (Kędra, 2018, pp. 69–71).

While images have long served as visual aids in science and education (Rendgen, 2014; Friendly, 2008), their empirical investigation is relatively recent (Schnotz, 2002, pp. 101–102), and they often face suspicion in academic contexts. Within HE, a persistent 'conceptual iconophobia' (Lacković and Olteanu, 2020, p. 608)—or an oscillation between iconophilia and iconophobia (Hayes, 2021, p. 130; Addison, 2003)—often relegates images to a secondary, illustrative role, subservient to words and propositional logic. This fear of the image, rooted in ancient beliefs about its deceptive potential (Addison, 2003, p. 122), has intensified in the 'post-truth' era, where even seemingly objective DV face scepticism (Jandrić, 2018, p. 107; Kennedy et al., 2016, p. 719).

This emphasis on textual communication creates a significant disconnect between the HE environment and students' image-saturated world (Romanato, 2017; Kędra and Žakevičiūtė, 2019, pp. 1–2). Today's students, often referred to as the *iGeneration* and raised with pervasive digital technologies, are accustomed to 'quick electronic perception'

[19] Despite criticisms of the term *visual literacy* — e.g., for potentially confusing analogies with linguistic grammar (Hermans and Schönau, 2022, p. 195) or equating viewing with reading (Statton Thompson et al., 2022, p. 118) — Avgerinou's (2003) definition is adopted in this thesis for its clarity on receptive and productive visual abilities.

(Tabachnick, 2007, p. 26) and multimodal environments, processing information differently from traditional text-based approaches (Daniels, 2018). As Rosen (2010, p. 3) observes, they

> *hate* school [...] it is not that they don't want to learn. They just learn differently [...] Literally, their minds have changed—they have been 'rewired.' With all the technology that they consume, they need more from education. The educational content is not the problem. It is the delivery method and the setting.

However, merely increasing image *quantity* in HE is insufficient. Crucially, both educators and students often lack the *critical visual literacy skills* needed to effectively interpret and utilise visual information (Matusiak et al., 2019; Matusitz, 2005; Felten, 2008, pp. 60–65; Brumberger, 2011; Hattwig et al., 2013). Moving beyond passive consumption requires a shift to a participatory, multimodal approach (Brown and Adler, 2008, p. 18; Kress and Leeuwen, 2006, p. 17), where VL is not an add-on, but a fundamental goal of a liberal education (Felten, 2008, p. 60). This integration faces challenges: educators' limited VL or difficulty in translating it into explicit pedagogical practice (Metros, 2008; Paxton et al., 2017; Cappello and Walker, 2016); misconceptions about images' role; and resistance to change from traditional logocentric teaching (Statton Thompson et al., 2022; Paxton et al., 2017; Paxton, 2012).

Impactful visual education may require early implementation in university curricula (Elkins, 2007, p. vii). Visual integration in HE necessitates rethinking educational frameworks to recognise images' epistemic potential to actively shape understanding. This, however, raises a key question: how can inherent image ambiguity be reconciled with academia's traditional emphasis on clarity? The next section will explore ambiguity beyond its negative connotations, examining its role in fostering deeper visual engagement.

3.5. Ambiguous Education

> The mind, at its best, is a pattern-making machine, engaged in a perpetual attempt to impose order on to chaos; making links between disparate entities or ideas in order to better understand either or both. It is the ability to spot the potential in the product of connecting things that don't ordinarily go together that marks out the person (or teacher) who is truly creative.
>
> Beadle, 2011, p. 12

This inherent human drive to find patterns and make connections, even amidst ambiguity, is central to artistic creation, scientific inquiry, and, as this section argues, fostering VL in HE. If clarity and precision are traditional academic hallmarks, what role can ambiguity play in education? Is it merely an obstacle, or can it be a source of insight and creativity? This section explores how tolerating uncertainty, and even deliberately cultivating ambiguity, can be a powerful tool for learning and knowledge construction.

Traditionally, ambiguity has been viewed negatively in education, associated with uncertainty or lack of clarity. A more nuanced perspective, however, recognises ambiguity—understood as openness to multiple interpretations—as a potent learning catalyst. Rather than treating ambiguity as a temporary state to be resolved by Aristotelian logic, educators can leverage it to encourage deeper engagement with visual information, precisely because it invites exploration and critical analysis. The value of exploring uncertainty, even error, in learning (Mellone and Tortora, 2015, p. 1434) often meets resistance within traditional educational structures. Suzawa (2013, 2014) highlights education's hostility towards ambiguity, particularly its challenge to hierarchical, purely constructivist models. Embracing ambiguity as

inherent potential—a source of 'unity and multiplicity, or nothing and something' (Suzawa, 2014, p. 56)—can foster more agile thinking (Veale et al., 2013, p. 19) and creative problem-solving.

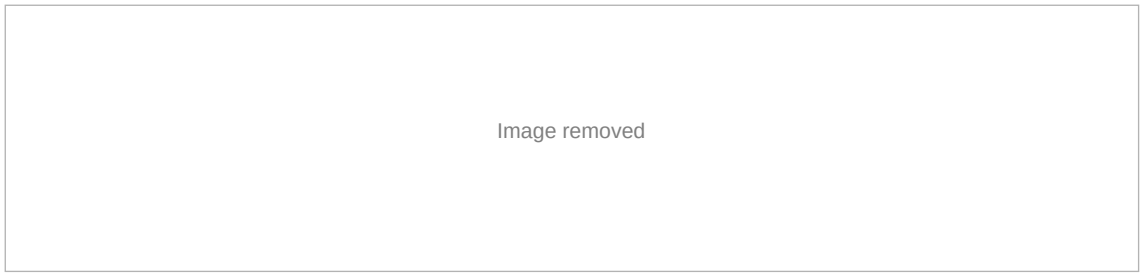


Figure 3-3: Three approaches to problem-solving: linear (left), exploratory (centre), and transformative (right). The diagram illustrates a conceptual progression from rigid, linear models to more agile and transformative approaches that embrace ambiguity. Source: Veale et al. (2013, pp. 19–21), adapted from Veale (2012).

Veale et al. (2013, pp. 19–21) illustrate this progression through three problem-solving models (Figure 3-3): from linear, solution-oriented approaches that treat ambiguity as obstacle, through exploratory strategies involving detours and dead ends, to what Boden (2004, 2009) terms transformational creativity—the capacity to redefine the problem space itself, uncovering goals invisible within original constraints. True innovation, as Boden argues, depends on tolerating 'incongruity, contradiction and failure' (Veale et al., 2013, p. 21). For VL education, this means encouraging students to explore multiple readings, tolerate uncertainty, and justify interpretations through critical visual analysis rather than seeking univocal correctness. This shift—from rigid, teacher-centred models towards flexible, relational approaches that better address the complexities of networked, multimodal environments—is the focus of the next section.

3.6. Post-Digital Educational Frameworks: Beyond Linearity and Towards Relationality

As the preceding sections have highlighted, integrating VL into HE requires more than merely adding images; it demands a fundamental shift in pedagogical approaches. Such a shift necessitates embracing ambiguity, fostering critical thinking, and recognising visual representations' epistemic potential.

This section turns to three emerging educational frameworks—*connectivism*, *edusemiotics*, and *rhizomatic learning* (RL)—that address the challenges and opportunities of the post-digital age through relationality, multimodality, and non-linearity. These qualities resonate strongly with the affordances of visual communication and are particularly relevant for fostering VL in HE. These frameworks not only reflect broader epistemological shifts but also offer fertile ground for integrating visual modalities into academic discourse.

The term 'post-digital', as employed here, describes not a chronological 'after' the digital, but a condition where the digital is inextricably interwoven with all aspects of life, blurring online/offline and physical/virtual distinctions (Fawns, 2019; Cramer, 2012; Czerniewicz and Carvalho, 2022). In this post-digital condition (Jandrić et al., 2019; Jandrić and Knox, 2022; Jandrić et al., 2018), where traditional linear educational models prove inadequate, new pedagogies are required that embrace complexity, connectivity, and the learner's active role in co-constructing meaning.

While the three frameworks explored here are not exhaustive, they exemplify a broader shift toward educational models that acknowledge the relational nature of knowledge, prioritise learner agency, and blur the rigid boundaries between traditional categories. Other approaches, such as heutagogy (Hase and Kenyon, 2000), which emphasises self-determined learning, also contribute to this evolving landscape.

Connectivism (Siemens, 2005) posits that knowledge is not an individual possession but is distributed across networks of people, resources, and technologies. Learning involves creating, navigating, and contributing to these networks (Siemens, 2008, p. 8). In connectivist

environments, students actively participate in knowledge creation through multimodal resources, and VL becomes vital for interpreting and producing visual information within what Wegerif (2007) terms dialogic spaces of collaborative exchange (Ravenscroft, 2011). While connectivism provides the foundational networked framework, edusemiotics and rhizomatic learning (RL), explored in the following section, offer more granular accounts of how meaning is constructed and knowledge co-created in these environments.

3.6.1. Edusemiotics and Rhizomatic Learning: Interconnected Frameworks for a Post-Digital Age

Edusemiotics and RL offer complementary perspectives on learning in the post-digital age, sharing an emphasis on relationality, emergence, and the rejection of rigid hierarchies. Edusemiotics, grounded in Peirce's semiotic theory, reframes education as a dynamic process of meaning-making through signs (Danesi, 2010; Semetsky and Campbell, 2018).[20] It views learning as actively interpreting and creating signs within interconnected systems (Deely and Semetsky, 2017; Olteanu, 2016; Stables and Semetsky, 2014), focusing on a micro-level, intrapersonal perspective. It 'does *not* mean semiotics applied to education as a pedagogical aid or teaching/research tool, but [...] "thinking" semiotics as the foundation for educational theory and practice at large' (Semetsky and Campbell, 2018, p. 245). Given the inherently semiotic nature of visual representations, edusemiotics provides a framework for understanding students' interpretation and creation of visual information. It highlights iconicity's role—the perception of resemblances—where icons offer concrete sensory experiences, bridging abstract concepts and tangible understanding, challenging traditional abstraction-focused theories (Lacković, 2020; Olteanu and Campbell, 2018; Lacković and Olteanu, 2020). This makes edusemiotics particularly relevant in disciplines where abstract visualisation is central, such as data communication or scientific modelling.

A particularly relevant approach within this framework is *inquiry graphics* (Lacković, 2020), which shifts the use of images from merely illustrative (expository) to inquisitorial. They encourage students to engage critically with micro-level visual details and macro-level conceptual frameworks, fostering analytical and interdisciplinary engagement. For instance, learners may trace how lines, shapes, or colours in a diagram connect to prior knowledge and

[20] Edusemiotics draws from biosemiotics, which examines sign processes in all living organisms (Barbieri, 2009; Cobley, 2010; Hoffmeyer, 2008). This grounding highlights semiosis (sign interpretation) as fundamental to all learning—digital or not—as an embodied, relational, and contextual meaning-making process, linking human cognition to broader biological phenomena.

aid in constructing meaning. Inquiry graphics structure this process, encouraging not just interpretation, but the deconstruction and reconstruction of knowledge itself.

This relational perspective aligns with Barad's (2007) concept of *entanglement*, where reality is a network of intra-actions, rejecting independently existing entities. Edusemiotically, signs dynamically emerge through relational interactions between learners, technologies, and contexts. Learning involves actively participating in this meaning creation within a complex web of learner-teacher-resource-world relationships. This relational perspective is further developed in Peirce's concept of the *included middle*, which challenges the binary logic of *either/or* and embraces the dynamic interplay of multiple perspectives (Olteanu and Campbell, 2018; Hazeldine and Spall, 2023; Semetsky, 2014; Deely and Semetsky, 2017). Meaning emerges through continuous interpretation and abduction—reasoning that generates new hypotheses (Hazeldine and Spall, 2023, pp. 85–86). Edusemiotics also encompasses an expressive dimension, acknowledging the inseparability of sign creation and interpretation (Semetsky, 2019), termed 'logic of artistic construction' (Dewey, 1998, p. 199, as cited in Semetsky, 2019, p. 4). However, edusemiotics has been criticised for a focus on individual meaning-making, potentially underemphasising social and cultural dynamics.

RL, inspired by Deleuze and Guattari's (1987) rhizome metaphor, similarly rejects fixed pathways and hierarchies. It envisions learning as a dynamic, *networked* process, characterised by multiplicity, interconnection, and the absence of central authority (Cormier, 2008; Khine, 2023). Like a rhizome, learning begins anywhere and proceeds in any direction. The teacher facilitates navigation within this complex landscape and co-creates meaning *within* the network (Bissola et al., 2017, pp. 208–214; Semetsky, 2006, 2013; Hazeldine and Spall, 2023, p. 89; Brailas, 2023). This resonates strongly with the multi-linear and spatial nature of visual communication, where meaning can be constructed through multiple pathways and connections.

Where *edusemiotics* offers a *micro-level*, intrapersonal perspective on meaning-making, RL provides a complementary *macro-level* lens, emphasising the design of learning ecosystems that foster collaboration, exploration, and emergent knowledge construction. Together, they

offer a comprehensive theoretical framework for post-digital learning environments that support visual, collaborative, and meaning-driven engagement.

The application of RL in formal education, however, remains contested. Key critiques concern its conflict with hierarchical curricula and cumulative disciplines (Karasavvidis, 2023; Harris, 2016), the difficulty of translating Deleuze and Guattari's philosophy into actionable pedagogy (Emke and Kukulska-Hulme, 2023), the challenge of measuring outcomes along non-linear pathways (Mackness et al., 2016), and potential inequities linked to uneven digital access (Koseoglu and Bozkurt, 2023). Balancing openness and structure remains RL's core tension (Gregoriou, 2008), underscoring the need for integrative approaches, notably transdisciplinarity, that can bridge fragmented knowledge frameworks.

3.6.2. Transdisciplinarity: Integrating Knowledge for Complex Challenges

Transdisciplinarity moves beyond the combination of different disciplines, aiming to transcend their boundaries and establish a new, holistic framework for understanding and addressing complex problems (Bernstein, 2015; Nicolescu, 2014). Unlike multidisciplinary or interdisciplinary approaches, which respectively juxtapose or integrate disciplines while maintaining their boundaries, transdisciplinarity seeks to dissolve them entirely, creating unified frameworks driven by the problem itself, with the goal of understanding the present world through the unity of knowledge (Nicolescu, 2014, p. 187). VL, by enabling the interpretation and creation of multimodal representations, can serve as a facilitating competence within this integrated approach.

Transdisciplinarity holds significant implications for HE, fostering collaborative learning and the co-production of knowledge among students, researchers, and societal actors (Fam et al., 2018; Nicolescu, 2012). This approach encourages a shift from 'science for society' to 'science *with* society' (Scholz and Steiner, 2015; Seidl et al., 2013) through stakeholder engagement, enhancing universities' responsiveness to real-world challenges by overcoming traditional disciplinary silos, as illustrated by Hall et al.'s (2020) work on creating visual spaces for knowledge intersection.

Implementing this approach in HE, however, presents significant challenges, including overcoming institutional resistance, adapting curricula, fostering a culture of collaboration, and revising traditional methods of assessment and funding often tied to specific disciplines (Daneshpour and Kwegyir-Afful, 2022; Hyun, 2012).

Unlike traditional visualisations, which often adhere to disciplinary conventions, transdisciplinary visualisations should integrate knowledge across fields. They must foster dialogue among diverse stakeholders, requiring a shift from mere data presentation to creating interactive visual spaces for knowledge intersection (Hall et al., 2020). This might involve platforms that allow users to explore complex datasets from multiple viewpoints, combine

quantitative data with qualitative narratives (e.g., visual storytelling), or use visual metaphors to bridge conceptual gaps.

However, this emerging field of visualisation faces challenges in reconciling differing epistemological frameworks, developing flexible and accessible visual tools without compromising rigour, and adapting visualisation to different audiences. These emerging practices, such as *knowledge cartography* (which maps conceptual relationships) and *deep mapping* (which integrates multiple perspectives), will be discussed further in Section 5.5.

3.7. Conclusions

This chapter has examined the evolving landscape of visual communication and its implications for HE in a post-digital world. The historical tension between logos and eikon, the increasing significance of visual and multimodal literacies, and the limitations of traditional, text-centric pedagogical models have been discussed. Furthermore, emerging educational frameworks—connectivism, edusemiotics, and RL—suggest a move towards more relational and multimodal understandings of knowledge and learning. These frameworks challenge the sequential, linear structure of traditional text-based learning, advocating for representational strategies that embrace ambiguity, simultaneity, and relational meaning-making.

The transition from a *linear* to a *surface* logic of information highlights the full epistemic potential of visual communication. As images function spatially rather than sequentially, they foster a more exploratory and interconnected mode of understanding. This shift necessitates pedagogical approaches that fundamentally rethink knowledge production and dissemination, rather than simply adding visuals to text-based learning but instead foregrounding visual communication as a primary mode of knowledge construction.

Among visual media, comics is a particularly potent model for this transformation: the medium embodies the move from *linearity* to *tabularity*, from *monomodality* to *multimodality*, and from a fixed path to a network of interpretative possibilities (Fresnault-Deruelle, 1976; Groensteen, 2007; Barbieri, 1991), mirroring the cognitive demands of the post-digital world. This chapter has shown that ambiguity is not an obstacle but a resource for critical thinking, creativity, and meaning-making. The following chapters will explore how comics, operating both sequentially and spatially, can serve not only as pedagogical tools but as epistemological catalysts in HE, particularly in fields where disciplinary boundaries are increasingly porous.

4. Comics as an Elusive Medium: Definitions, Boundaries, and Epistemic Potential

4.1. Introduction: Comics as an Epistemic Ecosystem

> I have always struggled with the definitions of art and science. To avoid categorization, I often take refuge in the fact that what I am doing—creating comics about science—is probably equally dismissed by both artists and scientists.[...] I became convinced that it is not despite comics' lack of definition but because of it that they can be so powerful. Using a medium that does not have many expectations attached to it enables me to reach a new audience for science.
>
> Matteo Farinella, 2017

Farinella, a comics creator and science communicator, encapsulates the productive ambiguity inherent in defining comics, suggesting this very elusiveness contributes to the medium's power in reaching new audiences for science. This chapter explores the complex and often indefinable nature of comics, moving beyond traditional attempts at rigid categorisation to investigate their potential as a significant epistemic tool, particularly within HE.

Throughout this thesis, 'epistemic' refers not to knowledge in the abstract philosophical sense, but to the concrete capacity of a medium or representational form to actively structure thought, support inference, and generate insight—functions that will be shown to be intrinsic to comics as a spatial and multimodal interface. Here, 'epistemic potential' specifically denotes this capacity as it operates through comics' unique structural and multimodal affordances—facilitating spatial reasoning, relational thinking, and the emergence of novel insights through active engagement with the page.

As Groensteen (2007 [1999], p. 12) observes, the search for a singular essence of comics yields not a definitive answer but a 'profusion of responses'. This inherent definitional elusiveness is not a weakness but a fundamental characteristic that fuels the medium's expressive and interpretive richness. Throughout critical history, numerous interpretative frameworks have emerged, often existing in tension. Some, such the comics artist Will Eisner (2005 [1985]) with his notion of 'sequential art' and McCloud (1994 [1993]), in his influential (though contested) definition of comics as 'juxtaposed pictorial and other images in deliberate sequence' (Figure 4-1), have emphasised sequentiality as the defining element. Others have prioritised the interplay between image and text, or, like Groensteen (2007 [1999], 2013 [2011]), the spatial organisation of the page. Faced with this diversity, scholars like Meskin (2007) have dismissed the pursuit of a single definition.

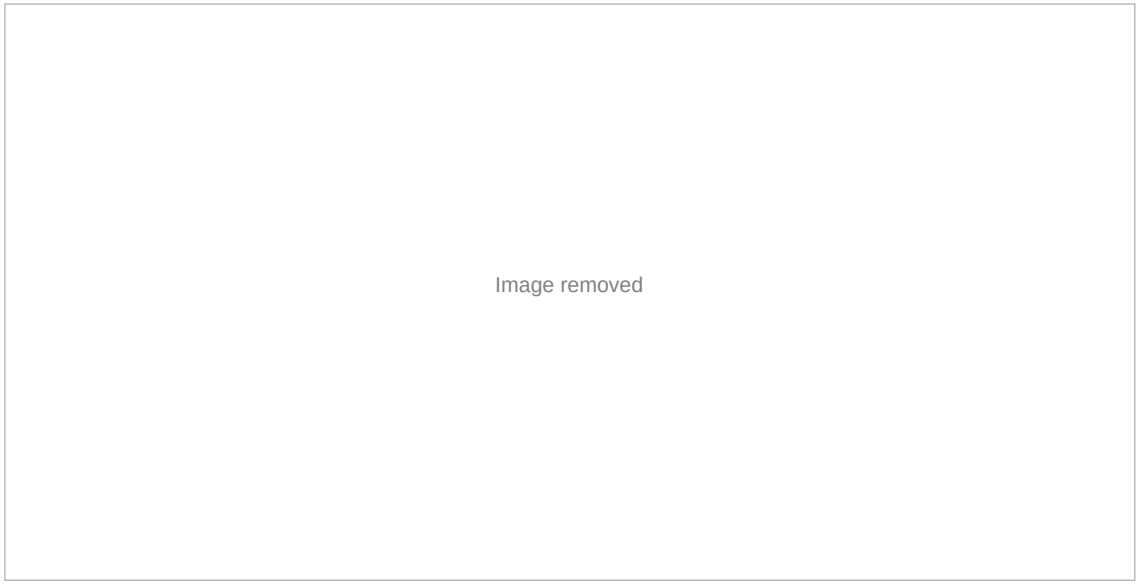


Figure 4-1: *Understanding Comics*, with example of McCloud's (1994 [1993], p. 9) definition, which emphasises the juxtaposition of images in deliberate sequence, a key concept in the debate regarding the medium's nature.

This challenge of definition is also intrinsically linked to the interdisciplinarity of CS. As Hatfield (2010, p. 2) notes, the field challenges 'the very idea of disciplinarity' by drawing upon and fostering dialogue with literary theory, semiotics, cultural studies, art history, cognitive science, and more, thereby fostering collaborations that reshape academic fields (Di Paola, 2019b; Horsman, 2015) (see Figure 4-2).

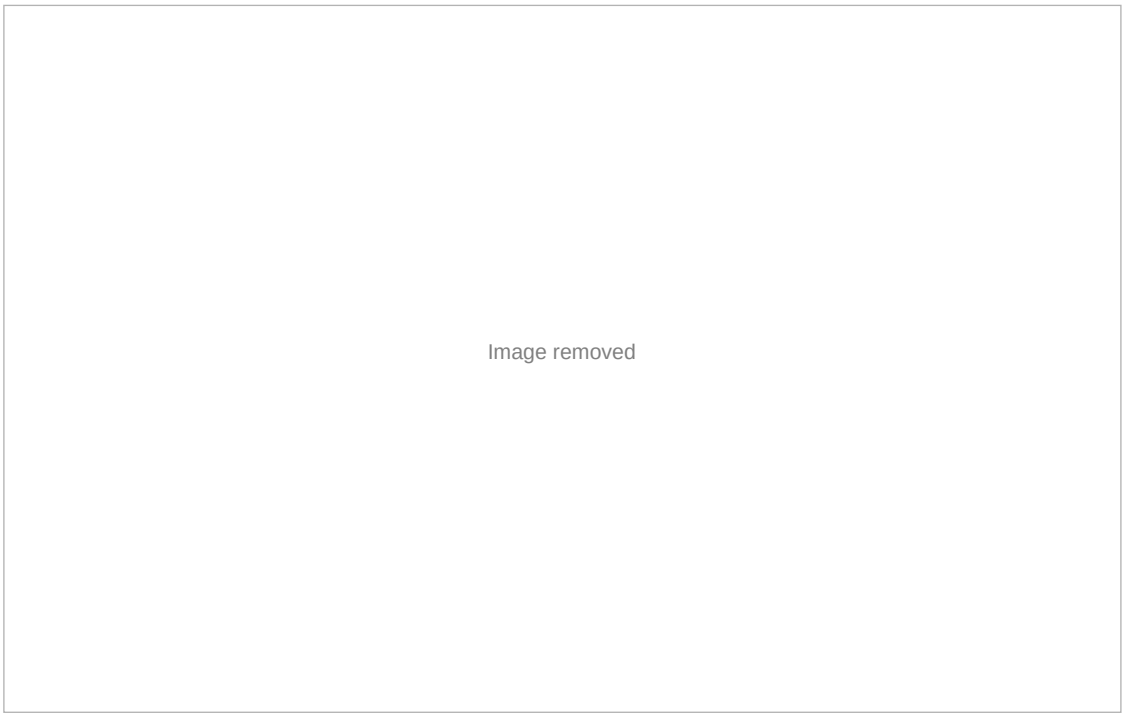


Figure 4-2: Scopus search results (Article Title field) for 'comics', 'graphic novel', 'comics AND education', and 'comics AND higher education', visualised by year, subject area, and country/territory. The data illustrate the interdisciplinary nature of CS research and its comparatively limited presence within educational research, particularly in HE (only 4 documents).

While this richness of perspectives is a strength, it renders the convergence on a single definition difficult without risking reductionism or exclusion, especially considering the numerous boundary cases and ideological pitfalls inherent in defining comics (Wolk, 2007; Cabero, 2021). This difficulty, as Delany (1999, p. 212) points out, stems from a fundamental paradox: while a discipline is defined by its object, often these disciplinary objects themselves resist definition. Accordingly, rather than seeking an illusory essence, this chapter treats comics as a *complex ecosystem* (Labio, 2011, p. 123)—a fluid system, not a monolithic category, whose epistemic potential resides precisely in its multifaceted nature. This perspective aligns

with viewing comics as 'a subversive medium that obeys no rules' (Mainardi, 2007) in pursuit of what Beaty (1999) terms *comics exceptionalism*. The approach adopted here will therefore prioritise integration over the exclusion of specific frameworks, echoing Gardner's (2006, p. 802) observation of the productive 'sin of *not choosing*' between apparent dichotomies in comics scholarship. Such refusal to impose reductive boundaries enables comics to function as epistemic ecosystems—fluid, hybrid structures capable of supporting diverse modes of reasoning and representation.

Building on the post-digital framework established in Chapter 3, this chapter examines comics as a medium uniquely positioned to meet the epistemic demands of contemporary HE. To navigate this complexity, the chapter is organised in two parts. **Part A** (sections 4.2–4.5) critically reviews key theoretical frameworks—the visual-verbal tension, the sequentiality/spatiality debate, layout interpretation models, and cognitive foundations—identifying both their contributions and the gaps they leave regarding the medium's knowledge-generating capacities. **Part B** (sections 4.6–4.9) proposes an original interpretative framework, reconceptualising comics as diagrammatic, cartographic, and interactive epistemic interfaces with implications for knowledge production in HE.

Part A: Theoretical Foundations and Critical Frameworks

4.2. The Challenge of Definition and the Visual-Verbal Nexus

Given the absence of an essentialist definition of comics, a pragmatic approach, drawing on Wittgenstein's (1953, §66, cited in Bambrough, 1961, p. 209) concept of family resemblances, suggests focusing on the similarities among its diverse forms. As Wittgenstein famously advised, 'Don't think, but look!'—an invitation to examine shared features rather than seek essentialist definitions. Operationally, comics can be defined as objects commonly recognised and intended to be 'read' as such (Mikkonen, 2017, p. 15).

A core aspect of the medium is the dynamic interplay between text and image, extending beyond physical coexistence to include interpretative patterns inherited from alphabetical reading, even in wordless comics. Historically, critical debate has oscillated between establishing a hierarchy and describing a more equal interaction (Faust, 1971; Harvey, 1994). The classification of comics as a 'language' exemplifies this. While some propose terms like 'visual language' (Barbieri, 1991; Varnum and Gibbons, 2001; Saraceni, 2003; Cohn, 2013b), many scholars resist this classification. Bramlett (2012, 2016, 2020) argues that describing comics as a language is inaccurate unless analysing language *within* them. He prefers the description of a 'visual semiotic system, relying on an incalculably rich set of visual and linguistic resources' (Bramlett, 2020, p. 33), a view which highlights the fundamental differences between iconic and symbolic signs and the irreducibility of comics to a lexicogrammatical system (Grennan, 2017). Others, like Rey (1982, pp. 57–58) question the act of 'reading' comics, suggesting it is closer to 'deciphering'.

It is important to note that even in wordless comics, the verbal dimension is not entirely absent, as visual perception can trigger internal 'verbalisation' (Mitchell, 2005, p. 397; Baetens, 2020, pp. 193–195), albeit approximate (Lefèvre, 2000). Conversely, writing in comics possesses graphic and visual valence; lettering, balloon and caption shape, position, and size contribute significantly to meaning beyond semantic content (Mitchell, 2014, p. 260). Spiegelman's 'One Row' (1983), illustrates this, where textual container shapes graphically represent narrative functions (Figure 4-3).

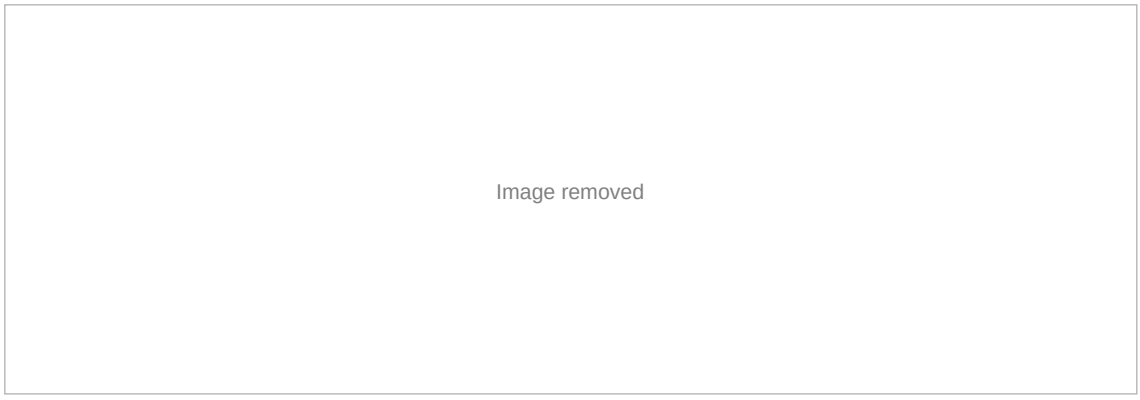


Figure 4-3: Art Spiegelman, 'One Row', from *RAW* vol. 1, no. 5 (1983). This self-reflexive comics uses the graphic shape of its textual containers to perform a meta-commentary on comics theory. The contrast between the speech balloon (representing immediate, subjective thought) and the rectangular caption (representing objective, reported prose) is used to explicitly debate and demonstrate their different narrative functions.

The visual-verbal tension, therefore, is not resolved into simple addition or a fixed hierarchy, but exists as a complex and dynamic interaction, a force field that the reader must interpret. As Hatfield (2005b, p. 36) suggests, in comics, meaning emerges from the negotiation of several 'tensions', primarily that between the visual and verbal codes. These codes can reinforce, complement, or conflict with each other, potentially creating distinct, even contradictory, 'narrators' (Lewis, 2010; Baetens, 2020). Whilst crucial for understanding meaning-making, analyses of this tension often stop short of exploring how this inherent semiotic heterogeneity might function specifically as an epistemic engine, facilitating distinct modes of thought or knowledge structuring beyond narrative conveyance. Resisting the reductionist temptation to apply purely linguistic models is the initial step towards understanding its specific functioning and its epistemic potential, which often thrives on this

fundamental semiotic heterogeneity, enabling comics to support complex, multimodal reasoning beyond verbal articulation.

4.3. Sequentiality, Spatiality, and the Active Reader

> Time is now seen more as a universal container, an indefinite medium, which a line is absolutely incapable of representing.
>
> (Henry, 1970, p. 92, quoted in; Hutton, 1990, p. 170, translation by the writer)
>
> Linearity itself is a problem when a scholar tries to linearise time processes in a sequence. Knowledge must always be constructed in each of its dimensions.
>
> (Ratcliff, 1999, p. 288)

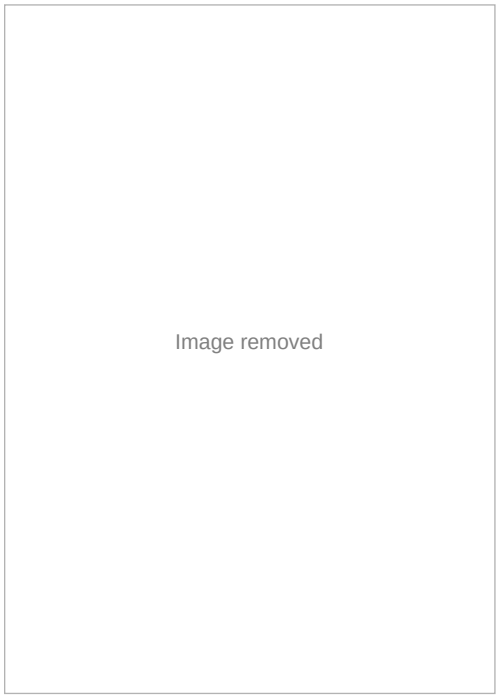


Figure 4-4: Page from *Dylan Dog* #1, 'L'alba dei morti viventi' (Tiziano Sclavi, writer; Angelo Stano, art, 1986, p. 6). The overlaid arrows illustrate the conventional Western 'Z-path' reading pattern (left-to-right, top-to-bottom), a model aligning comics with the linearity of traditional written texts.

The conventional emphasis on sequentiality as a primary characteristic of comics reflects a logocentric bias, aligning with Saussure's (1983 [1916]; see also, Hutton, 1990, p. 170) view of linearity as intrinsic to language. This perspective has historically framed comics as linear successions of panels, analogous to written or spoken chains. As the comics scholar Baetens (2020, p. 195) notes, 'after all, words form "strings"'.

The canonical models here are the sequential comic strip and the Z-Path (Figure 4-4), both aligning with conventional modes of reading written text. From early on, the unconventional nature of comics reading was sometimes supported by panel numbering (Witek, 2008, p. 150)—a

convention that persists, though increasingly rarely, in the form of directional arrows guiding the reader's path.

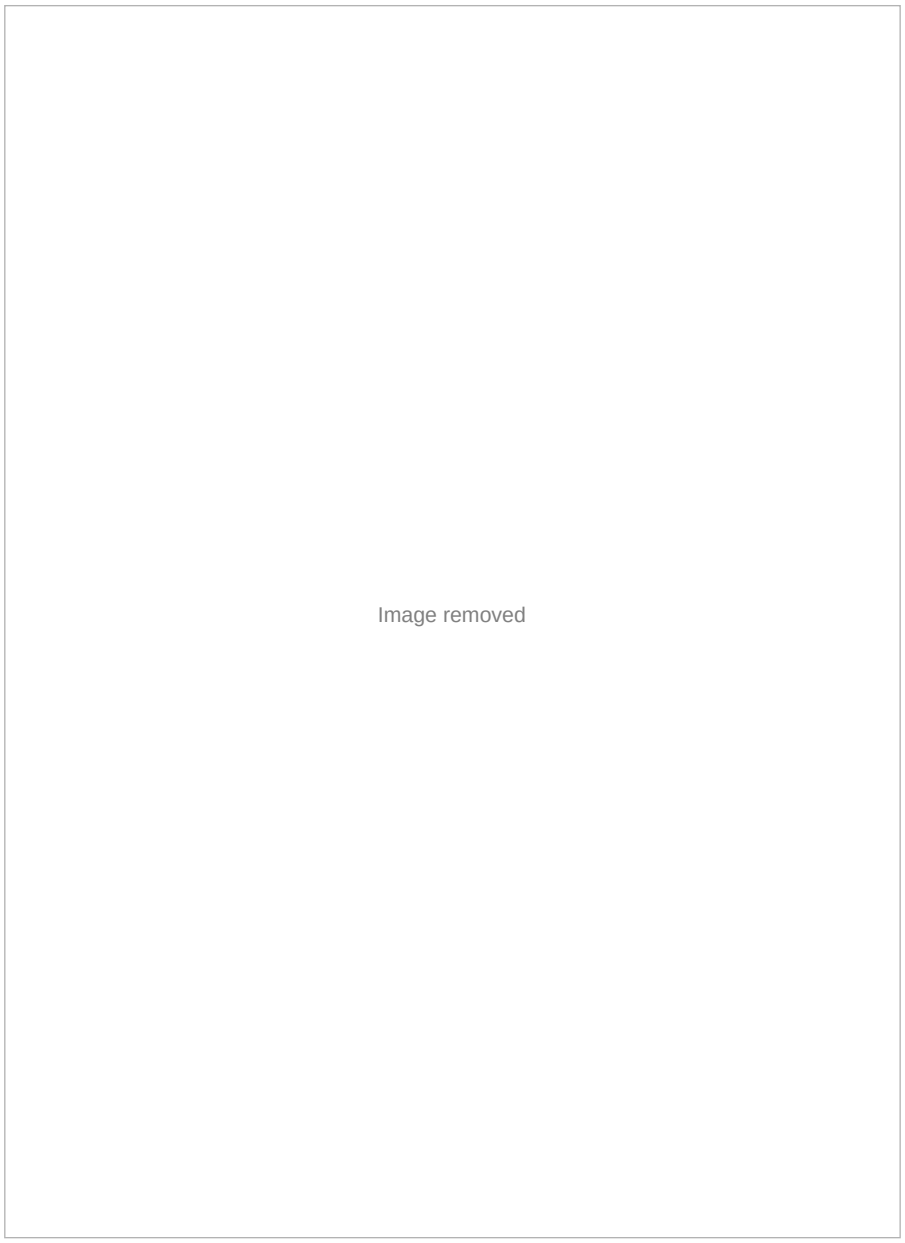


Figure 4-5: Pascal Jousselin, *Mr. Invincible* (2020, p. 5). This page demonstrates the protagonist's ability to interact across panel boundaries, physically violating conventional temporal sequences and spatial integrity of the comics page to alter narrative outcomes.

However, linearity—as also reported by the quotations in the exergue—is a mediated cultural artefact, shaped by non-linear cognition, physiological limits, and cultural practices. While contemporary linguistics acknowledges hierarchical and non-sequential structures in language

(Bolshakov and Gelbukh, 2004; Chomsky, 2013), written text remains culturally perceived as a fixed, linear product (Auer, 2009), embodying authority.

Comics, in contrast, leverage their inherent spatiality and multimodality to subvert this paradigm. Their coexisting panels, text, and images create a navigable space, enabling multidirectional interactions that challenge both linguistic linearity and the 'finished' artifice of writing. As Miodrag (2013, p. 13) observes, whilst all narrative forms can manipulate event sequences, only comics can 'override the linear progression of the text itself'.

The comics page offers itself to the gaze in its entirety, permitting a global, synchronic perception that complements and interacts with local, sequential reading (Genette, 1980, p. 34; Hatfield, 2005a, p. 48; Frezza, 2008, p. 44; Barbieri, 2012). This constitutes a unique meaning-making system integrating sequential and spatial arrangements (Dittmer and Latham, 2015) and allowing for multiple reading paths (Baetens, 2020, p. 195; Hatfield, 2005b, p. 53). This potential is exploited by authors who manipulate layout. For instance, in Pascal Jousselin's *Mister Invincible* (2020) (*Imbattable*, 2017; Figure 4-5), the protagonist, aware of the structure of the page, violates the temporal sequence by interacting across panel boundaries, for example by exchanging objects between distinct moments in the narrative or by alerting the self to a panel. Art Spiegelman's 'Day At The Circuits: I' (1973) presents an extreme case of multidirectional reading, reflecting cyclical themes through its recursive structure (Figure 4-6). Comics' spatial affordance—illustrated in previously introduced works like 'Big Tex' (Ware, 1996, Figure 1-5), *Alpha… Directions* (Harder, 2009, Figure 1-3), and *Here* (McGuire, 2014, Figure 1-4)—transforms reading into a configurative act. Spatial arrangement is not a passive container but an active element constructing meaning, temporality, and causality.

This capacity allows comics to integrate the traditionally separate arts of time and space (c.f. Lessing, 1767; Baetens, 2020, p. 194), potentially realising Benjamin's (1999) vision of breaking the 'barrier between writing and image'. Furthermore, as Gardner (2006, p. 802) suggests this spatial logic moves comics towards a navigable database organisation rather than purely linear narrative.

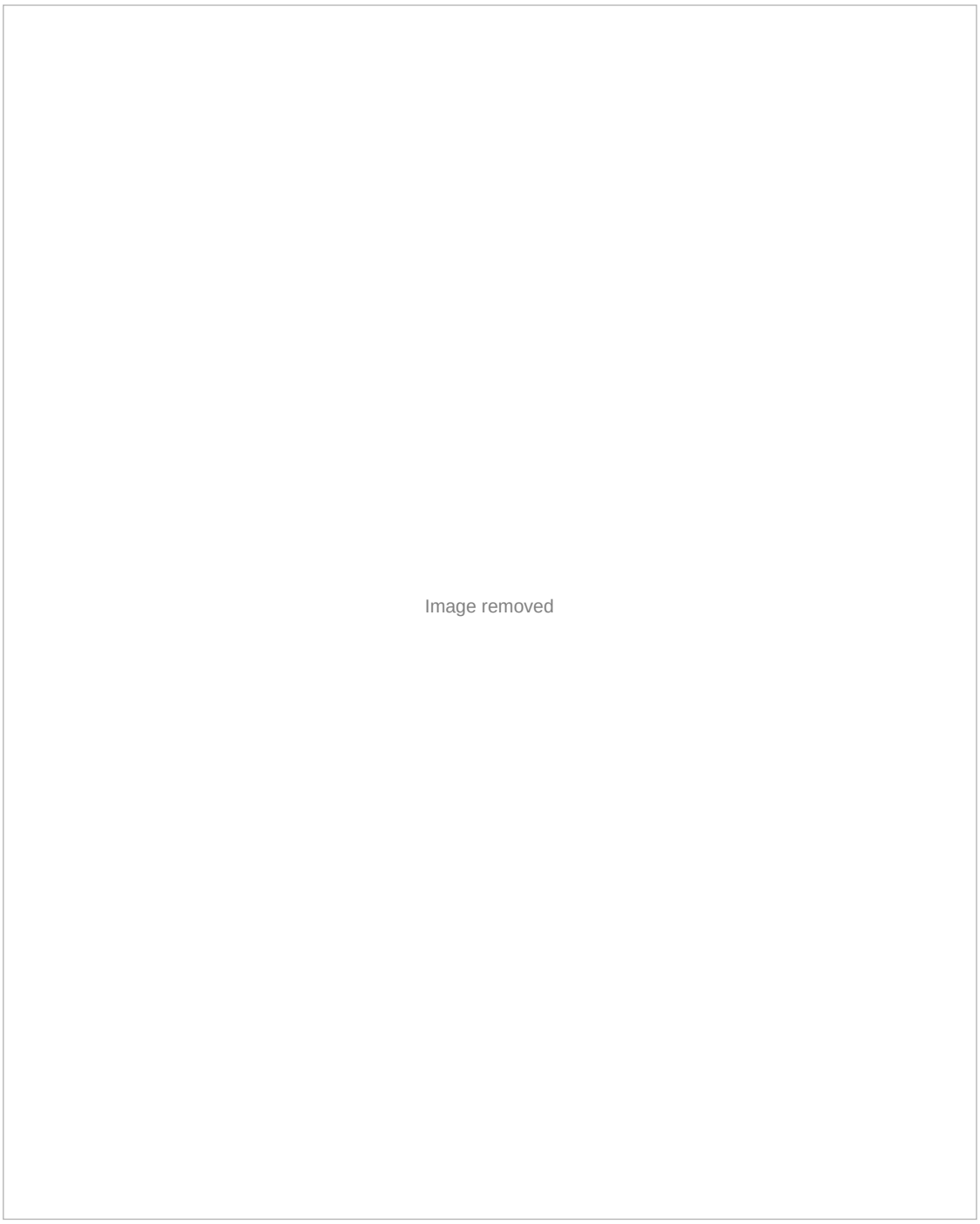


Figure 4-6: Art Spiegelman, 'Day at the Circuits: I' (1973). Back cover of *Arcade: The Comics Revue*, no. 2. This work is designed to be read along fifteen different paths, radically challenging comics' conventional linear progression. Its recursive structure and dark humour are employed to reflect the cyclical, self-destructive nature of depression and addiction, leveraging the page's spatial affordances for thematic resonance.

This intrinsic sequential/spatial duality demands and cultivates an active reader. Meaning is not merely transmitted but co-constructed through an interpretative process involving inference. Drawing on Eco's (1979) *interpretative cooperation* and Iser's (1974) 'gap filling', the reader actively completes the text. In comics, a quintessential multimodal medium, this role is amplified. Serafini (2012a), adapting Freebody and Luke (1990), describes the reader of multimodal texts as a reader-viewer assuming four roles: *Navigator* (choosing reading paths), *Interpreter* (integrating different codes), *Designer* (shaping their reading experience by combining semiotic resources), and *Interrogator* (critically analysing ideologies and contexts). Empirical studies (Jimenez and Meyer, 2016), confirm that expert comics reading involves sophisticated cognitive synthesis, often prioritising visual analysis before textual integration, challenging prejudices about the medium's simplicity.

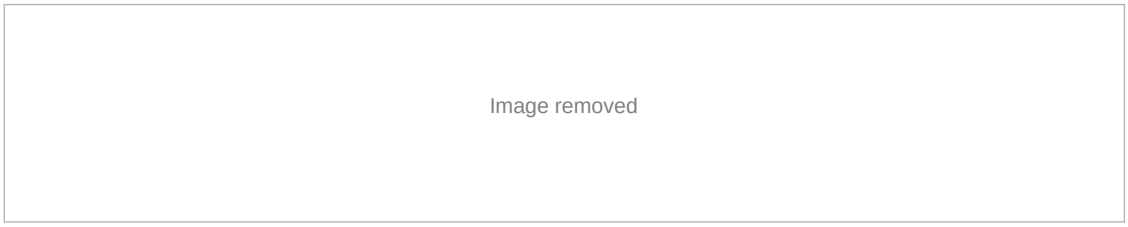


Figure 4-7: Segel and Heer's (2010, p. 1146) dichotomous model of narrative visualisation, contrasting *Author-Driven* linear approaches with *Reader-Driven* interactive experiences. This thesis critiques the application of the Author-Driven model to comics as overly reductive.

Thus, while the active reader negotiates sequence and space, existing reader-response models may not fully capture how this negotiation, particularly engagement with spatiality, constitutes an epistemic practice—a way of structuring thought and generating insight distinct from narrative gap-filling. This active, configurative potential is often underestimated. Segel and Heer's (2010) reductive categorisation of comics as *author-driven* and *linear* (Figure 4-7) is a case in point. Their view is rooted in the early formalism of McCloud (1993) and the data-centric minimalism of Tufte (2001), While their 'middle ground' concept (balancing authorial control and reader agency in narrative visualisations) (Segel and Heer, 2010, p. 1146) can be adapted to analyse comics' *multimodal interactivity*, comics radicalise this interplay through their inherent spatiality, transcending mere equilibrium to reconfigure narrative power dynamics. Such conceptual oversights risk stifling innovation in adjacent fields like DC

(see Chapter 5), underscoring the need to reimagine comics as dynamic, reader-configurable interfaces.

The active reader's engagement also manifests in navigating complex temporalities. Beyond Chatman's (1978, 1980) distinction between *story-time* (*fabula*) and *discourse-time* (*syuzhet*), Grennan and Hague (2018) introduce *user-time*: the reader's material interaction with the medium. Chris Ware's *Building Stories* (2012a), Figure 4-8–comprising 14 physically reorderable books enabling over 87 billion narrative paths—exemplifies this. Its fragmented design explicitly embeds reader agency into the text's materiality, allowing physical reconfiguration that transcends authorial intent (Grennan and Hague, 2018, p. 75).

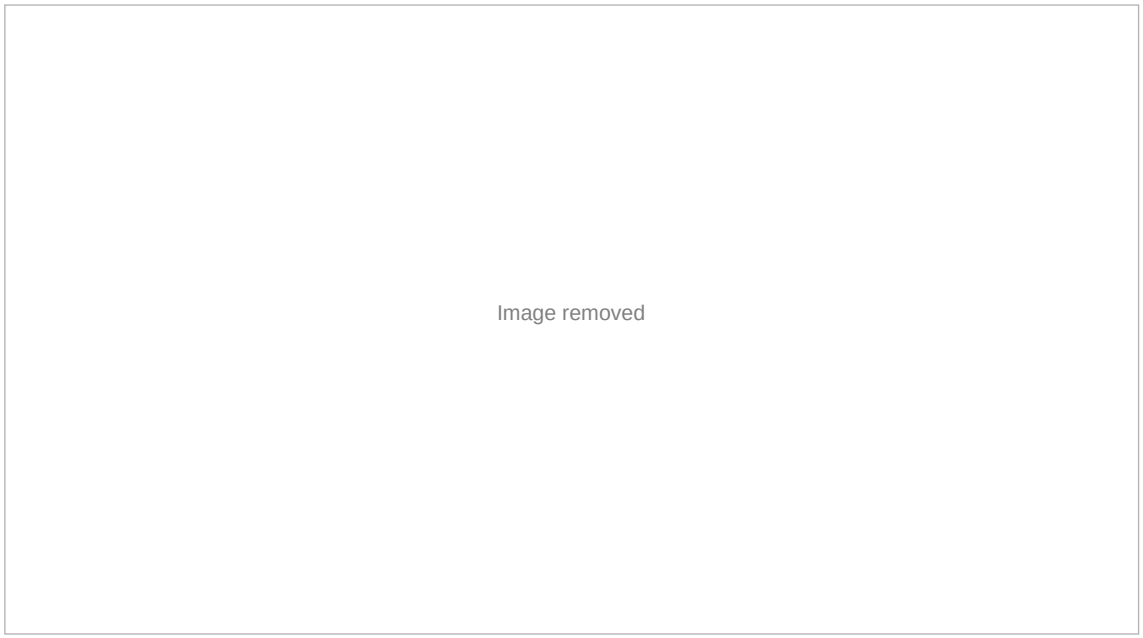


Figure 4-8: Chris Ware, *Building Stories* (2012a). This work, comprising fourteen physically discrete, reorderable printed elements, exemplifies the concept of 'user-time' by embedding reader agency directly into its material structure, thereby allowing for a multitude of narrative reconfigurations. Image source: *Lo Spazio Bianco*: https://www.lospaziobianco.it/building-stories-il-grande-romanzo-americano-a-fumetti-di-chris-ware/).

Watchmen (Moore and Gibbons, 1986–87), by contrast, demonstrates how a rigidly fixed grid can nonetheless generate non-linear temporal experience: Doctor Manhattan's simultaneous perception of past, present, and future mirrors the reader's navigation of a structurally constrained but interpretively open page (Baroni, 2016; Barnes, 2009, p. 58).

This active, configurative potential raises the broader question of interactivity in comics—a notoriously challenging concept in non-digital formats. Interactivity spans a 'spectrum' of forms (Evans, 2008, p. 200)—ranging, in Murray's (1997) terms, from superficial interaction to authentic agency—variably understood as a property of the system, medium, or user (Landay, 2023, pp. 243–244). Busi Rizzi (2024), drawing on game design frameworks (Ryan, 2006, 2011; Tekinbaş and Zimmerman, 2003), outlines a multilinear agency in comics encompassing narrative, interpretive, material, and social dimensions, from exploratory freedom to ontological agency. Complementing this, Ossa, Thon, and Wilde (2022), drawing on Actor-Network Theory (Latour, 2005), frame comics as dynamic assemblages or *dispositives* where agency is distributed among human and non-human, semiotic and material actors.

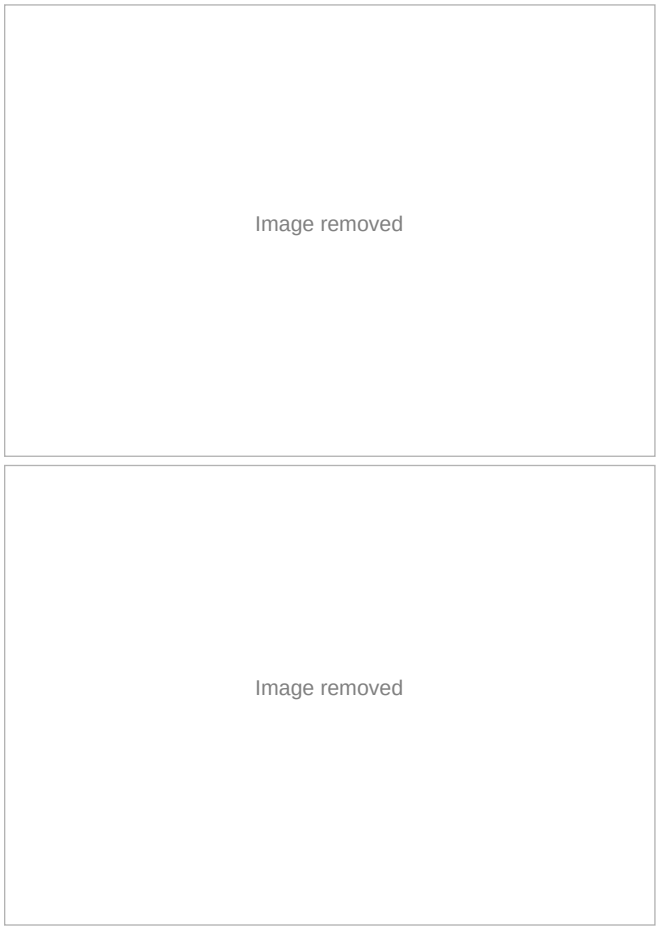


Figure 4-9: George Wylesol, *2120* (2022). These double-page spreads illustrate the work's engagement with conventions from interactive digital narratives. Readers are required to physically manipulate the comics and navigate branching paths to solve embedded puzzles, demonstrating material interactivity and distributed agency.

Non-sequential reading habits inherent to comics' spatiality—skipping pages or revisiting panels—transform potential drawbacks into interpretive opportunities; as Hassoun (2013) observes, spoilers in comics can enrich meaning by adding interpretive layers. George Wylesol's *2120* (2022) (Figure 4-12), exemplifies material agency: a paper-based comics dialoguing with point-and-click game conventions, requiring physical manipulation, branching-path navigation, and embedded puzzle-solving—interactivity manifesting materially beyond purely interpretive engagement.

These dimensions—explored further through the cybertext framework in Section 4.7—position comics as interfaces that, despite fixed materiality, demand active engagement across interpretive, navigational, and configurative registers, placing them on a spectrum of interactivity in dialogue with other ergodic media, and opening affordances directly relevant to multimodal knowledge design in HE.

4.4. From Strip to Page: Evolution of the Layout

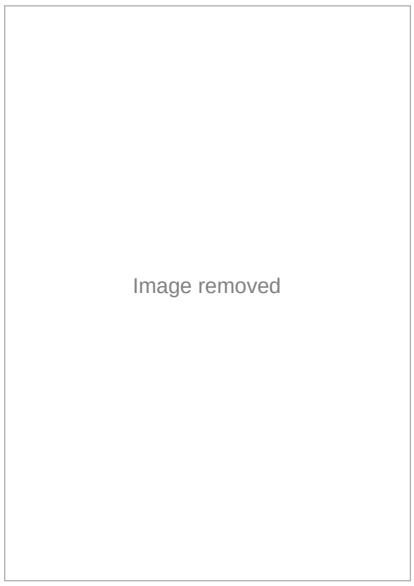


Figure 4-10: SNAC BD (*Syndicat des Auteurs de Bande Dessinée*) manifesto for the 2015 Angoulême Festival authors' demonstration. The empty layout alone is sufficient to evoke the comics' concept.

Considering the spatialised logic of comics, realised on the page—itself 'an object in its own right' (Polara, 2002, p. 68)—the *layout*, or the specific architecture arranging panels, text, and other elements within the page space, assumes central theoretical and practical importance. This *External Compositional Structure* (ECS) (Cohn, 2018b, p. 316) or *multiframe* (Groensteen [1999], 2007, p. 146), distinct from *Internal Compositional Structure* (ICS) within single panels (Cohn, 2018b, p. 317), functions not merely as a container or an organizer but as a '*communicative resource* in its own right' (Bateman et al., 2021, p. 210), epitomizing the medium itself (see Figure 4-10). Understanding its functions has direct implications for educational design, particularly in crafting comics-based learning materials that foster spatial reasoning and multimodal literacy.

Early structuralist analyses (e.g., Fresnault-Deruelle, 1976, distinguishing the strip's linear logic from the *planche*'s tabular logic) recognised layout as an architecture that 'reveals through enframing' (Priego and Wilkins, 2018). This function, comparable to the Heideggerian *Gestell* (framework or enframing) actively structures meaning and guides gaze and interpretation (cf. Priego and Wilkins, 2018; Wilkins and College, 2014). This complexity distinguishes the comics grid from the anti-narrative grid of modernist painting (Krauss, 1979); in comics, the grid participates in meaning-making. The page's composition orchestrates the tension between panel fragmentation and page unity, sequence and simultaneity (Sousanis, 2015a, p. 2)—a 'timelessness' where all images remain co-present to the viewer (Alaniz, 2004, p.

146).[21] Each page is a paradox: a rigid structure yet an open labyrinth, where the Z-path coexists with alternative explorations. The gutter, the interstitial space, is crucial: it is the site of readerly inference filling narrative gaps (McCloud, 1994 [1993]), but also a potential locus of semantic rupture or transformation challenging linear continuity (Van Lier, 1988), not a mere separator but a 'topological gulf' (Dittmer and Latham, 2015, p. 436), a threshold that simultaneously divides and connects, generating epistemic friction between fragmentation and coherence. Understanding this operational interface requires engaging with key theoretical frameworks where layout operates as the mechanism through which comics' theoretical hybridity becomes an operational machine.

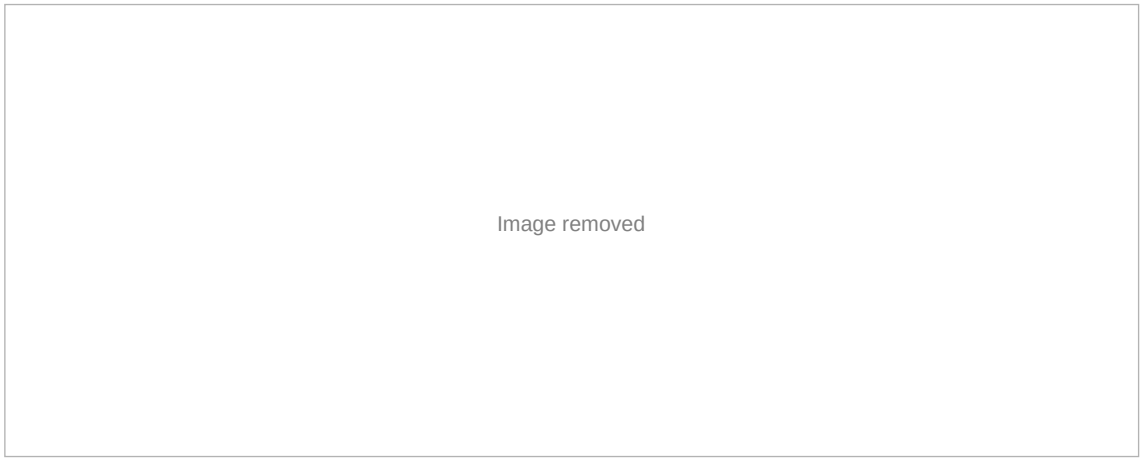


Figure 4-11: Peeters' (2007 [1998]) taxonomy of comics page layouts, illustrating four primary conceptions of the page based on the interaction between narrative and composition dominance and their degree of autonomy or interdependence. These categories—*Conventional*, *Rhetorical*, *Decorative*, and *Productive*—map different ways in which page design structures meaning and guides reader engagement. Source: https://imagetextjournal.com/four-conceptions-of-the-page/

Peeters (2007 [1998]) proposed a taxonomy of comics page layouts, identifying four principal uses: the *Conventional* (a regular grid), the *Rhetorical*, the *Decorative*, and the *Productive* (Figure 4-11). Groensteen (2007 [1999], pp. 93–102), building on Peeters, argued that uniform grids can be highly productive, not inherently neutral. However, Groensteen (2013, pp. 7–8 [2011]) also stressed the reader's pivotal cognitive engagement, cautioning against predicting reception solely from spatial analysis, and differentiated *discreet* (narrative-dominant) from *ostentatious*

[21] It should be remembered that, in addition to the plurality of connections between panels or other signifying units supported by the layout, there is the inherent polysemy of the images themselves.

(design-dominant) layouts (2013, pp. 43–47 [2011]). Chavanne (2015, 2010) proposed three compositional modes—*regular*, *semi-regular*, and *rhetorical*—plus *fragmentation* (panel splitting/merging).

Such models have been criticised for insufficient accommodation of hybrid or culturally specific forms (Rommens, 2000; Lefèvre, 2012), and for prioritising classification over readerly dynamics (Jess Cohn, 2007). Bateman et al. (2017, pp. 479–485, 2021, pp. 238–239) further suggest these approaches risk appearing artificial and insufficiently distinct, complicating their consistent application in comics page design, and lacking precision in corpus analysis (Pederson and Cohn, 2016). These limitations produced a fundamental schism, polarising between two paradigms (Bateman, 2014, pp. 96–97):

1. **The Cognitive-Sequential Paradigm**: Exemplified by Neil Cohn's (2013b, 2018b, 2024) Visual Narrative Grammar (VNG). VNG posits comics as a visual language with socio-cultural variations, where image sequences are processed via cognitive structures akin to linguistic syntax, assigning narrative roles to panels in a hierarchical sequence. Meaning primarily derives from this linear structure. The layout (ECS)—'one of the most overt features of comics' structure' (Pederson and Cohn, 2016, p. 7)—while interacting with content, is mainly a presentation interface separable from the primary narrative structure, with a preferential Z-path reading (Cohn, 2013a; Cohn and Campbell, 2015; Cohn, 2019, 2020, 2024). Critics argue this oversimplifies layout-content interplay, undervaluing holistic readings and emergent meanings from spatial arrangement (Bateman, 2014; Mikkonen and Lautenbacher, 2019). Mikkonen (2017, pp. 15, 39) emphasises the inherent variability and complexity of comics, noting their diverse structural organisations and the fact that 'very little seems to be needed for the presentation to suggest a meaning and, perhaps, a story', which makes applying a single, fixed grammar difficult. Others argue panel inversion generates new meanings, not meaninglessness (Campbell, 2013; Grennan, 2017), challenging the reduction of visual representation to a linguistic framework and its phenomenological specificity.

2. **The Spatial-Relational Paradigm:** Championed by Thierry Groensteen (2007 [1999], 2013 [2011]). Central is spatio-topia, i.e., 'the point of view that can be had on comics before thinking about any single comics, and starting from which it is possible to think about a new performance of the medium' (Groensteen, 2007, p. 23). The page is a fundamental network of spatial, topological relations structuring the narrative. *Arthrology* describes linear and translinear panel relationships: *restricted* (sequential, adjacent), *general* (non-adjacent, same page/hyperframe), and *tele* (across pages). These contribute to narrative recomposition via *breakdown* (*découpage*) and *braiding* (*tressage*), generating meaning across layers in a bricoleur-like process where readers actively reconstruct story time from discourse time. Criticism focuses on potential subordination of narrative dynamics to spatial articulation, possibly overlooking cognitive sequencing's role in narrative progression (Cohn, 2008).

While Cohn's corpus-based approach, grounded in cognitive neuroscience and linguistics (e.g., Pederson and Cohn, 2016; Cohn, 2024)—and Groensteen's framework (rooted in semiotics) differ, both recognise the dynamic interplay of visual/textual elements and the reader's active role in narrative meaning-making. Actual reading likely involves a dynamic interplay: parsing local sequences while simultaneously apprehending global spatial relationships. In practice, cognitive-sequential and spatial-relational approaches coexist: readers draw on both linear syntax and spatial inference when constructing meaning from the page.

Disagreeing with Cohn and extending Groensteen's concepts, Bateman and Wildfeuer (2014b, 2014a) offer a model operationalised via a detailed, open multilevel classification scheme for comics layout (Bateman et al., 2017), facilitating empirical analysis. The page is the minimum multimodal unit. Elements have rhetorical connections (cf. *Rhetorical Structure Theory* (Mann and Thompson, 1988); *Segmented Discourse Representation Theory* (Asher and Lascarides, 2003)) extended to multimodal objects. Comics (or *documents*) are collections of pages, regardless of format. Bateman's (2008) *GeM* (Genre and Multimodality) model posits multimodal documents comprise semiotic modes (text, image, layout), each with communicative affordances. The GeM model analyses a document as a '*multi-layered semiotic*

artefact', where 'each layer of the description of a page artefact tell[s] us something different about how the page is being constructed' (Bateman, 2008, p. 108). Visual organisations are described using categories like *tiling* (segmentation of the page canvas), *layering* (organisation in depth), *gridding*, and *panelling* (Bateman et al., 2017). Relations are hierarchical, not merely juxtaposed, with varying complexity (Bateman and Wildfeuer, 2014b), distinguishing layout structures like *lists*, regular *tables*, more flexible *vario-tables*, and complex *XY* layouts. Any element interacts continuously and non-linearly without needing a grammar. Notably, the authors argue that, regarding the visual narratives, the notion of grammar is problematic and overly rigid (Bateman and Wildfeuer, 2014b), and they claim that the same information can be captured in a *discourse*-based approach that dynamically updates meaningful information across juxtaposed images. This *discourse-based* approach is grounded in empirical methods, drawing on corpus linguistics and multimodality to analyse large datasets of comics pages (Bateman et al., 2021).

Comics' layout also exemplifies the interplay between narrative and non-narrative dimensions. Picado, Senna, and Schneider (2021) noted organising principles like visual syntax, thematic unity, and iconic solidarity enable coherence without traditional narrative progression, positioning comics as flexible tools representing complex ideas through structure and interpretive freedom. The shift from Cohn's VNG is from linguistic syntax to a more abstract, perception-led discourse level:

> perception reveals potential analytic units, among which discourse organization further refines and selects when placing these units into a communicatively motivated structure. This provides the raw material for the formation of discourse hypotheses in visual media (Bateman and Wildfeuer, 2014a, p. 196).

Hierarchies exist, with elements organised into clusters, but these are not rigid, allowing reader-viewers greater interpretive freedom (Bateman and Wildfeuer, 2014a, p. 190).[22] As Bateman (2014, p. 115) notes, once meaning generation is understood, it is not limited to

[22] Cohn (2018a, p. 14) argues that VNG does not rule out readers' potential to interpret a sequence differently or alter their perceptions as they read. In the case of ambiguity, this would result in the construction of a different sort of grammatical or semantic structure, or it would trigger an update procedure when a sequence is parsed in an unanticipated or improper manner, as 'just as garden-path sentences or other grammatical constructions require syntactic revision'.

narrative; comics' complex units can serve diverse genres. Consequently, the balance of linear and spatial principles in comics offers a model for flexible, multimodal learning resources.

Recent reflections describe comics reading as a sophisticated, multimodal, non-spontaneous process requiring specific 'literacy' and becoming more familiar with practice. Paraphrasing Geertz (1973, p. 5), analysing this network is 'not an experimental science in search of law but an interpretive one in search of meaning'. The distinct spatial possibilities and layout arrangements of the comics medium, unlike other visual narratives, warrant further exploration of its nature.

While this critical overview reveals rich theoretical approaches, it also highlights persistent tensions (notably between sequential and spatial paradigms) and less focus on the medium's specific knowledge-generating capacities. Acknowledging the foundational contributions of frameworks like Groensteen, Cohn, and Bateman and Wildfeuer to understanding layout's role in narrative and cognition, this review identifies a persistent gap: theorising how layouts function specifically as operative epistemic interfaces. The integrated framework in **Part B** will address this, focusing on the page's capacity to structure thought and generate knowledge.

The preceding discussion has highlighted comics' complex nature, the interplay of spatiality and sequence, and their intrinsic epistemic potential. Before developing **Part B**'s framework, a complementary perspective from cognitive science can enrich this understanding. *Schema theory*, particularly the concept of the *image schema*, offers a valuable lens—though not the sole nor main theoretical basis of this paper—for analysing how comics' spatial and structural affordances activate fundamental cognitive patterns in meaning-making. Examining these cognitive mechanisms provides an additional analytical layer.

4.5. Schemas and Comics: Cognitive Foundations for Navigating Visual Narratives

The process of reading comics is often described as a form of spatial and embodied navigation across the page, an activity engaging the reader cognitively and perceptually through its multimodal architecture and spatial design. This conceptualisation aligns with Groensteen's networked approach to comics layout and Bateman et al.'s (2017) multimodal classification scheme, yet departs from their predominantly structuralist orientations by explicitly grounding comics reading in embodied cognitive schemas.

Schema theory offers a valuable, if partial, lens for understanding this process. *Image schemas*[23]—not detailed mental pictures but recurring experiential patterns grounded in embodied interaction (Johnson, 1987)—arise from experiences common across cultures, structure information and scaffold thought (Dodge and Lakoff, 2005; Hedblom et al., 2015), and form foundational building blocks for more complex conceptual structures. They are organised wholes with internal meaning, fundamentally shaping how readers navigate spatial relationships across the page.

Building on this cognitive substrate, the theoretical framework proposed in this thesis shifts from single-schema models to a multi-schematic orchestration of meaning within the comics layout. While existing models often emphasise sequentiality, the layout is here interpreted as a complex cognitive structure dynamically combining multiple image schemas. These include, for example:

- CONTAINER schemata (structuring how panels and pages frame content hierarchically);

[23] The 'image' portion of the term 'image schema' refers not just to visual perception but to 'all types of sensory-perceptual experience' (Evans and Green, 2006, p. 179) — visual, auditory, haptic, and vestibular — creating mental 'images'

- PART–WHOLE and LINK schemata (guiding how readers connect local elements into coherent narrative wholes);
- BALANCE and CENTRE–PERIPHERY schemata (influencing composition, attention, and visual hierarchy).

In this account, the PATH schema, often associated with linear reading, is merely one among many interacting cognitive patterns. The comics grid thus becomes not a passive layout but an *active diagrammatic interface*—a spatial and conceptual tool for organising complex meaning across modalities, uniquely positioned to support multimodal literacy, exploratory engagement, and structural flexibility.

The generative potential of this panel-based cognitive architecture is confirmed by recent AI research: Akimoto's (2021) *Cogmic Space* draws on comics' panel structure to simulate embodied narrative experiences, while Hedblom et al.'s (2024) *Diagrammatic Image Schema Language* (DISL) uses panel sequences to model abstract conceptual relationships for cognitive linguistics and robotics—evidence that the comics interface operates as a genuinely productive epistemic structure beyond the humanities.

Although the specific vocabulary of schema theory will recede in the subsequent sections, its underlying principles—embodied structure, relational patterning, and the dynamic configuration of meaning through spatial layout—persist conceptually within the epistemic metaphors (cybertexts, diagram, meshwork) employed in **Part B**, providing the cognitive grounding for the *comics-fact* (elaborated in Section 4.8) and the reader's wayfaring across the page—and marking a methodological shift from analysing how comics organise meaning cognitively towards theorising how they enable the emergence of knowledge through their unique affordances. This perspective complements rather than replaces the paradigms examined in Section 4.4: where Groensteen's arthrology and Bateman et al.'s multimodal classification describe the structural logic of comics, image schemas explain why that logic is intuitively navigable—grounding spatial relations in embodied cognition rather than formal grammar.

Part B: Comics as Epistemic Interfaces

4.6. Introduction

Building on the theoretical foundations and identified tensions explored in **Part A**—including the interplay between sequential and spatial paradigms, insights from cognitive perspectives like schema theory on spatial interpretation, and the medium's underexplored epistemic dimensions—this second part transitions to propose an original interpretative framework. Rather than replacing existing models, it aims to integrate and extend valuable insights, including cognitive principles underlying spatial meaning-making, while opening new conceptual avenues focused on the medium's structural complexity and knowledge-producing potential. This theoretical lens enables educators to conceptualise comics not just as narrative tools but as epistemic platforms capable of scaffolding complex, multimodal learning experiences.

Drawing on the established understanding of comics' multimodal nature and the active reader's role, Part B argues that key features of the medium—its spatial organisation, semiotic hybridity, and configurative openness—function as crucial epistemic affordances. Comics are thus conceptualised not merely as narrative vehicles, but as dynamic interfaces for thinking, exploring, and structuring knowledge. This moves the analysis from cognitive organisation towards a theory of knowledge emergence. Adopting the transdisciplinary and bricoleur approach outlined in Chapter 2, this model intentionally combines insights from philosophy, semiotics, cognitive science, and educational theory to articulate a composite understanding of the medium's epistemic function.

The framework is developed through three interconnected lenses, employing distinct guiding metaphors:

- Understanding comics as dynamic, configurable systems (extending *cybertext* and *database* analogies).

- Identifying their core structural function as diagrammatic, giving rise to specific meaning-events termed *comics-facts* (through a synthesis of Peircean and Deleuzian thought).
- Grasping their operational nature as navigable cartographic interfaces, illuminated by Ingold's concept of the *meshwork*. Finally, cognitive and educational perspectives are explicitly reintegrated to underscore this framework's practical relevance for complex multimodal learning environments, particularly in HE.

4.7. Interactivity: Comics as Cybertexts and Database Narratives?

This section explores comics through the lens of interactivity, building on Part A's foundations regarding the medium's definitional fluidity, the sequential/spatial tension, and its semiotic hybridity. Comics, rather than being categorically 'passive' or 'non-digital', invite engagement that is interpretative, navigational, and configurative. This perspective revisits the idea of comics as *epistemic ecosystems*: not fixed sequences, but dynamic interfaces negotiated through active reader participation. For educators, understanding this interactivity is key to designing learning experiences that encourage active knowledge construction rather than passive reception.

Espen Aarseth's (1997) concept of *cybertext* offers a compelling framework. Cybertexts are media requiring *ergodic effort*—non-trivial work from the reader—to be traversed. This effort includes choosing, exploring, and reassembling, not just decoding. Aarseth (1997, p. 4) distinguishes two experiential modalities: the *passenger on a train* (fixed path) and the *player* (navigating a labyrinth with choice and uncertainty). Drawing on Eco's (1984, pp. 80–81) labyrinth typology—*unicursal* (single-path), *multicursal* (maze-like), and *rhizomatic* (network-like)—Aarseth favours the maze over the rhizome for meaningful interactivity, deeming the latter too unconstrained.[24] While Aarseth dismissed the rhizome, Eco (2014, pp. 53–54 [2007]), later reconceptualised the network as a dynamic knowledge system requiring continual user reorientation, a shift resonating with complex media like comics.

Print comics, though not digital cybertexts, often exhibit a reading phenomenology mirroring the *player* model. Complex works particularly require readers to choose navigational paths, establish inter-panel connections, backtrack, and engage in recursive synthesis. Comics

[24] In his theory, Aarseth's exclusion of the network might stem from his literary-oriented perspective. Although Hayles (2007a) originally refers to digital media, she critiques cybertext theories for their lack of medium-specificity, warning against applying traditional literary frameworks without considering the unique characteristics of each medium.

thus support a *material interactivity* independent of code, relying on spatial and representational architecture.

Lev Manovich (1999) *database narrative* concept further sharpens this view. Unlike linear narratives, database narratives present a logic of unordered, often co-present elements—collections, not sequences. In the digital age, they reflect information's interconnected, fragmented nature, operating via 'dual processes of selection and combination' (Kinder, 2003, p. 349) that expose chosen structures' arbitrariness while preserving a persistent 'possibility space'. Comics pages frequently embody this: the layout offers a *paradigm* (a *database* of available signs—panels, fragments, icons), while the act of reading produces a *syntagm*—a narrative or conceptual path constructed through spatial inference and semiotic association (c.f. Manovich, 1999, p. 89). Manovich saw the *database* and narrative as 'natural 'enemies' (1999, p. 85), but Hayles (2007b) posits a symbiosis: *databases* supply content and structural possibility; narratives provide contextualisation and temporal logic. Comics often stage this dynamic: a *database's* structured openness with narrative's interpretive trajectory.

Moreover, Gardner (2006) and Chute (2011, pp. 108–110) argue, comics enact an *archival aesthetics*. They visualise simultaneity, mnemonic connections, and relationality through spatial juxtaposition rather than sequential development. These 'analogue databases' enable a reader to *configure* meaning rather than merely *consume* it.

Shaun Tan's *The Arrival* (2007) clearly illustrates this *database* logic (Figure 4-12). Its opening page (left) presents a grid of symbolically charged objects (a visual *database* of departure items: a folded bird, a child's drawing, a pot, a clock, a suitcase, family photographs, etc.), open to multilinear exploration. The subsequent page (right) selects one item—a photograph—depicting its careful wrapping through a clear sequence (a linear narrative *syntagm*). This transition demonstrates how comics shift from *a field of potential relations* (the

database) to *a specific narrative trajectory* (the *syntagm*), holding *structural possibility* and *narrative actualisation* in productive tension and fostering genuine multilinear engagement.

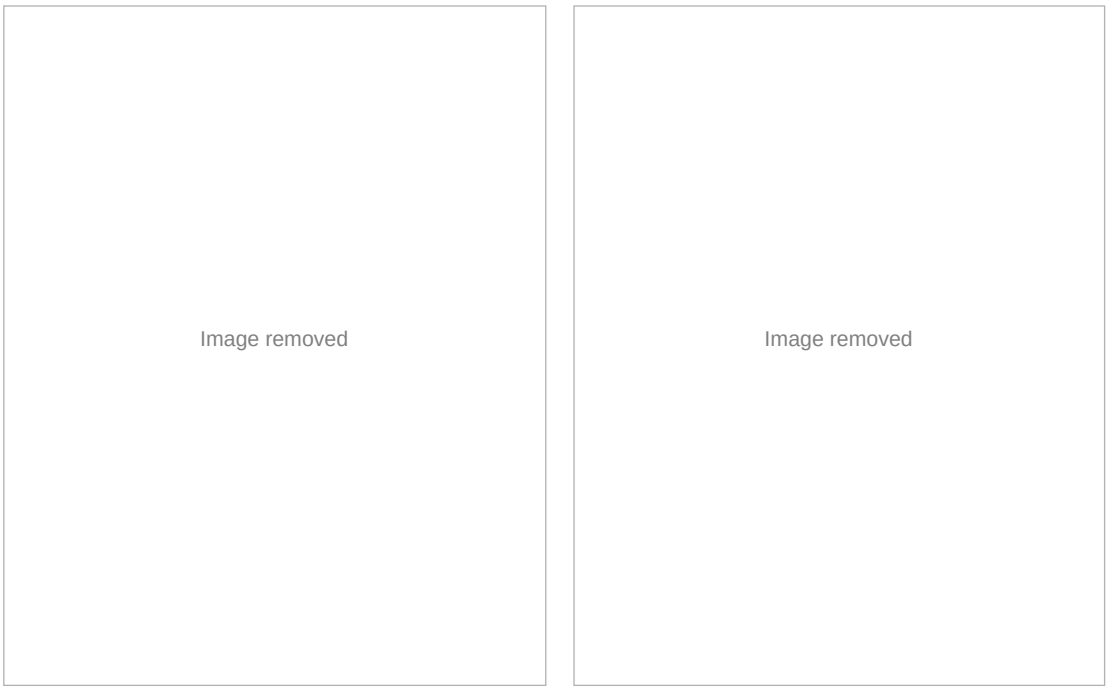


Figure 4-12: *The Arrival* (Tan, 2007, pp. 5-6). The first page displays a grid of symbolically charged objects, forming a visual database open to multilinear exploration. The following page selects one item—a photograph—and shows its careful wrapping in a linear narrative sequence. This shift illustrates how comics move from a field of potential meanings to a specific narrative path.

Importantly, the medium of comics structurally sustains enduring multilinearity—a concept distinguished from mere nonlinearity by Hadler and Irrgang (2014). While multimedia narratives often simulate interactivity via deterministic 'final cuts' (Simons, 2008), or create the illusion of choice through predetermined pathways (Murray, 1997; Ryan, 2001), comics avoid this superficial interactivity by enabling meaning to emerge through an ongoing interplay of sequence and spatial configuration—both intra- and extra-panels. This sustains multiple interpretive trajectories without collapsing them into single resolutions.

Hadler and Irrgang (2014) argue this multilinearity stems from how visual narratives operate: viewing images never follows a fixed order, but generates ad hoc connections through the viewer's gaze (2014, pp. 73–74). Comics institutionalise this through their page

architecture, solving what Poster (2011, p. xiv) identifies as the core challenge of nonlinear writing: guiding readers meaningfully through disordered content.

This capacity relies on the cooperation between representational content and spatial structure. Multilinearity in comics depends not only on layout or topology (Groensteen, 2007 [1999]), but also on how individual panel content—its symbolic, narrative, or iconic load—interacts. This duality, theorised as *iconic solidarity* (Groensteen, 2007 [1999]) is elaborated by Cate (2010), who stresses meaning emerges from both spatial arrangements and their visual-textual contents. Bateman and Wildfeuer (2014b, 2014a) frame this interaction as multimodal rhetoric: a discourse space where layout and representation guide attention, shape inference, and foster interpretation. This recursive engagement—moving between local detail and global configuration—is deeply cognitive. The comics page becomes a site of *topological reasoning*: meaning is built, often non-linearly, through an inferential process that is as much visual as conceptual. This interactive, interpretive activity prepares the ground for understanding comics as inferential machines. Readers must synthesise not only the spatial logic of the layout but also the semantic resonances among representational contents—images, motifs, themes—that cut across page divisions and narrative segments.

The framework elaborated here sets the stage for the next sections, where comics are reconceptualised as diagrammatic and cartographic interfaces. It also anticipates the application of Ingold's (2007) notion of *meshwork*—to be explored further in Section 4.9—as a metaphor for understanding comics not as linear paths to be followed, but as dynamic, entangled environments to be navigated. In such environments, readers do not merely decode meaning; they inhabit it, tracing and retracing lines of relation across structure and representation. Much like explorers in a complex terrain, they must continuously adjust their perception—balancing local detail with evolving hypotheses about the overall configuration of the work. This model not only redefines comics as spatial epistemic environments but also anticipates a diagrammatic turn, where navigation, inference, and meaning-making converge into a unified cognitive experience.

4.8. The *Comics-Fact*: Epistemic Diagrams and Meaning Generation in Comics

> We talk about comics being a mixture of image and text, but it really seems to me that a part of the way comics works is in this sort of diagrammatic space. You have a pictorial space, which follows certain pictorial norms, and then you have the text part of comics, which follows the syntactical structure of text and language. What comics does is it has this particular way of diagramming those things together using the panel unit and the word balloon as symbols for certain things [...] I realized the thing that interested me in comics is the way all of that stuff is diagrammed on the page and the way that you read it.
>
> Kevin Huizenga, interviewed by Kiel Phegley (2007).

Building on the prior discussion of comics as cybertexts and database narratives—where interactivity and non-linear engagement are central—this section shifts focus to their specific epistemic function. Recognising that even writing, when articulated spatially, can behave diagrammatically through *synsemic* arrangements where signs coalesce to transcend linear paradigms (Lussu, 2007; Perondi and Romei, 2010; Franchi, 2011; Perondi, 2012; Digregorio, 2020) comics, with their inherent visuo-spatial nature, function as epistemic diagrams. These diagrams subvert traditional text-image hierarchies by embedding meaning directly within their spatial organisation. This functional and structural affinity, noted in scholarship highlighting shared reliance on spatial arrangement and visual inference (cf. Cates, 2010; Tosti, 2021), underpins the introduction of the *comics-fact*.

The comics-fact is defined here as an emergent epistemic moment—an instance of insight, affective resonance, or conceptual connection—generated through the reader's active

engagement with the comics' spatial organisation (layout) and multimodal elements. It arises at the intersection of Peircean-style structured inference from the page's diagrammatic layout and the virtual, Deleuzian potential for unforeseen connections and affective intensities triggered by the composition. In this dynamic interaction, the reader co-constructs meaning. This capacity for generating unique epistemic events is central to understanding comics' educational potential, particularly in fostering critical thinking and complex meaning-making. The comics-fact, then, is not a property of content but a function of the medium's form: an epistemic moment generated by the encounter between spatial reasoning and aesthetic emergence.

As previously illustrated with Shaun Tan's *The Arrival* (Figure 4-12), the comics page can function as a visual database. The opening page, with its grid of symbolically charged objects, offers a field of potential relations and interpretive possibilities, a 'possibility space' (cf. Manovich, 1999). The transition to the subsequent page, which selects and sequentialises one element into a narrative action, exemplifies the shift from this paradigmatic database to a syntagmatic narrative. This tension between the co-present spatial structure (database) and the diachronic act of reading (narrative construction) is highly productive in generating meaning. Comics' combinatorial potential as a database can thus be channelled through sequentialisation, which can also be multi-ordered. Chris Ware's *New Yorker* cover 'Still Life' (Figure 4-13)[25] further exemplifies this.

[25] Ware's cover visually dialogues with the special *New Yorker* issue April 15th, 2020, offering a 'fractal portrait' (Mouly, 2020) of a single day in New York City during the coronavirus pandemic. The issue comprises multiple snapshots from writers and contributors depicting isolated moments across the city, resonating with Ware's spatial, fragmented depiction of urban solitude under lockdown.

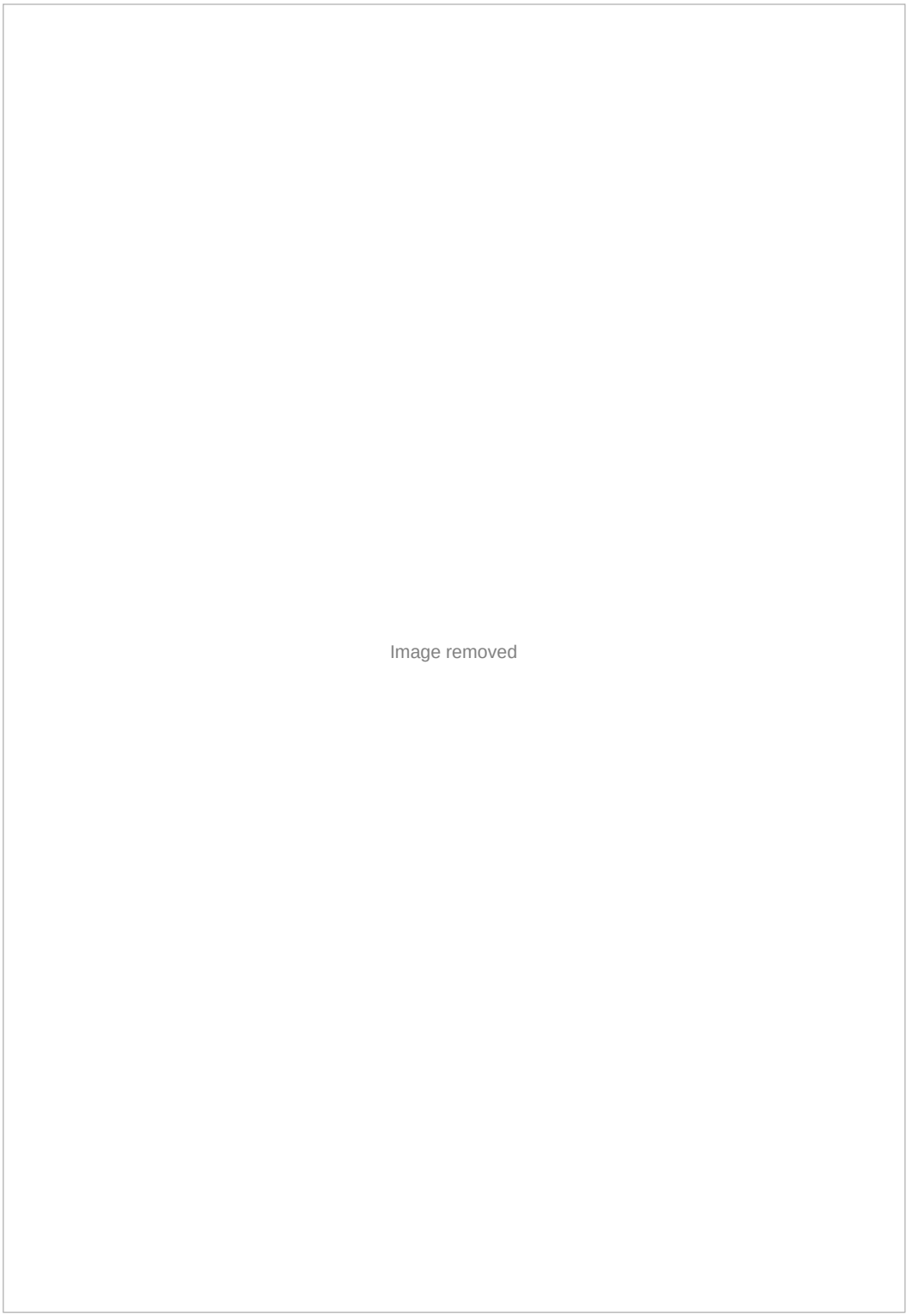


Figure 4-13: Chris Ware's *The New Yorker* cover, 'Still Life' (April 15th, 2020), depicting fragmented urban experiences during lockdown. The spatially complex layout invites multilinear reading, emphasising synchronic perception over linear narrative progression.

This structured yet open composition depicts isolated urban lockdown experiences, initially resembling a database of images. Like database narratives offering multiple exploratory pathways, this layout encourages multilinear, speculative reading through spatial relationships, recalling Manovich's (1999, pp. 96–98) analysis of Vertov's *Man with a Movie Camera*. However, unlike Vertov's temporal montage, Ware's spatial arrangement of simultaneous panels invites a multilinear, speculative reading: rather than following a fixed temporal order, readers map relationships and draw inferences through spatial juxtaposition. While a Z-path reading might suggest the passage of a day, the layout privileges synchronic perception. The varied panel sizes, colour use, and diverse elements enhance cognitive mapping, potentially producing an immediate affective response of fragmented simultaneity. Ware's cover thus demonstrates how spatial layouts can generate thought distinct from linear narrative structures.

Other artists employ similar strategies. Bianca Bagnarelli's illustration for Davis's (2014) article I Couldn't Turn My Abortion Into Art (Figure 4-14) uses a nine-panel structure inviting non-sequential, centrifugal reading; a dominant central panel acts as a conceptual anchor, facilitating visual synthesis of the protagonist's inner conflict by relating peripheral panels to the core, while centrifugal visual energy spatially conveys turmoil (see also Tosti, 2021).

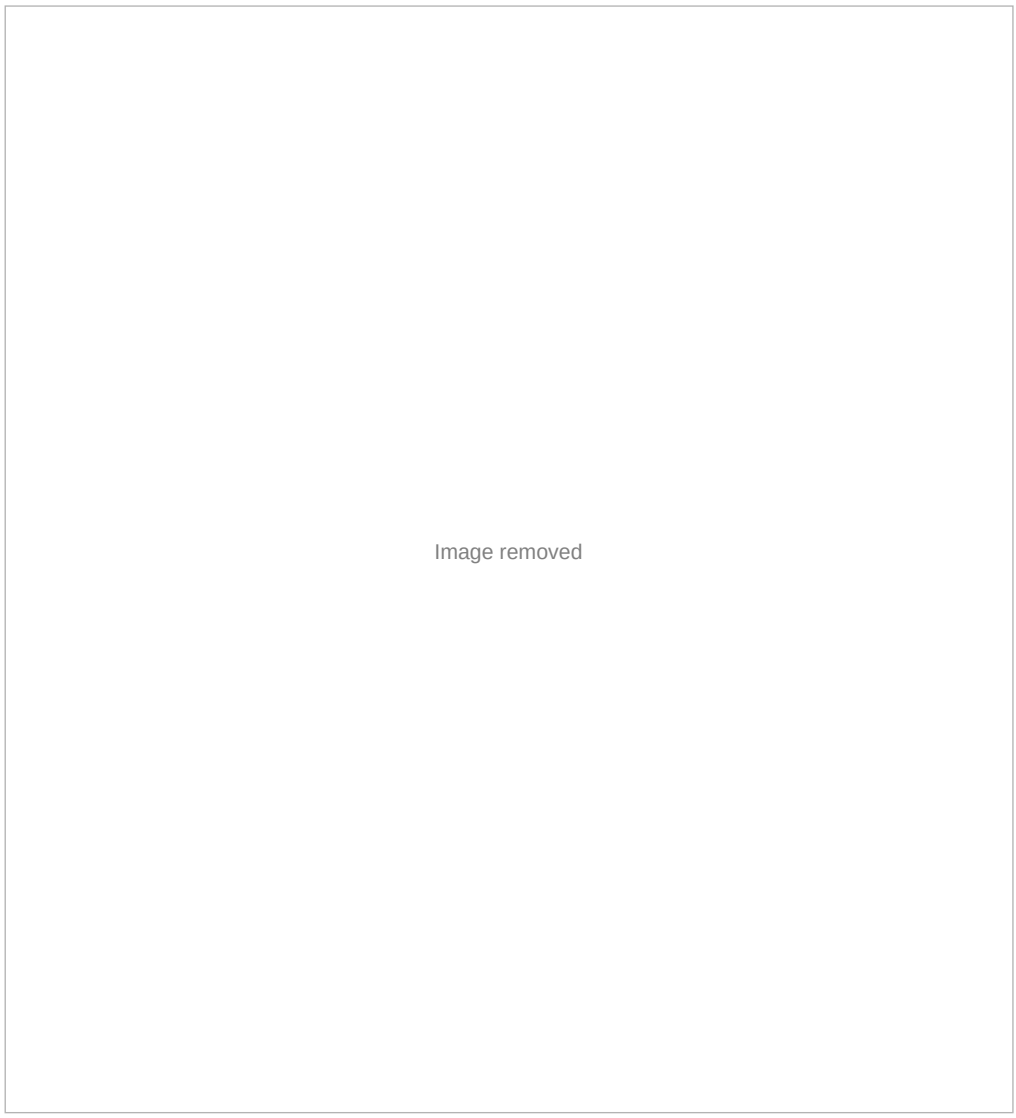


Figure 4-14: Illustration by Bianca Bagnarelli for Davis's article 'I Couldn't Turn My Abortion Into Art' (2014). The nine-panel layout features a dominant central panel anchoring a centrifugal visual structure, conveying the protagonist's emotional turmoil

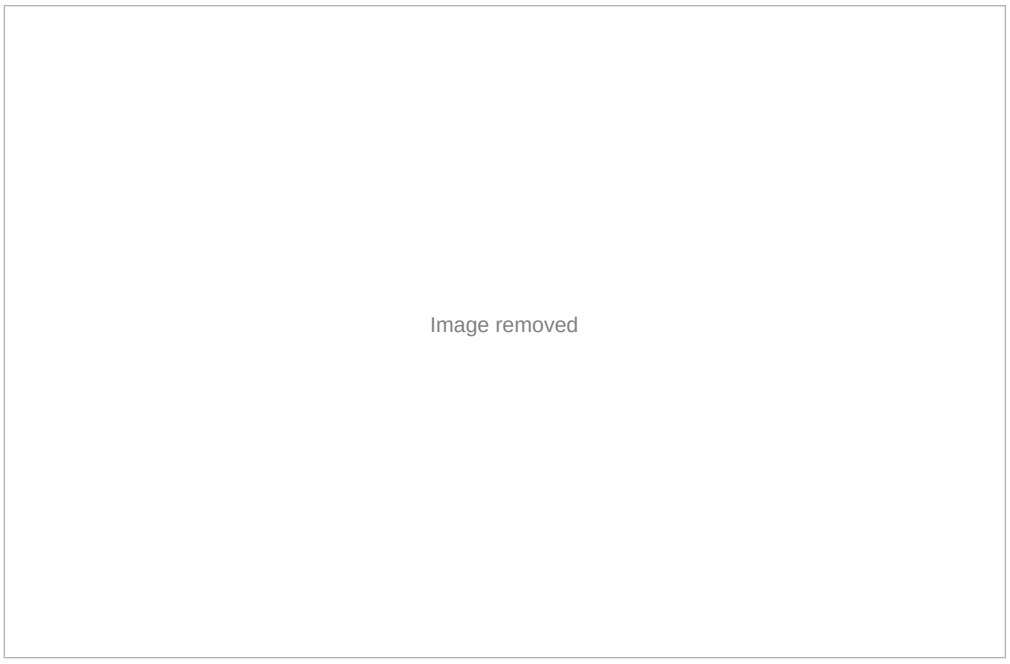


Figure 4-15: Double-page spread from *The Arrival* (Tan, 2007, pp. 1–2), showing portraits of immigrants arranged as an archive. Their spatial, semantic, and chromatic interplay fosters a sense of interconnectedness, framed by the comics' dual context of medium and narrative continuity.

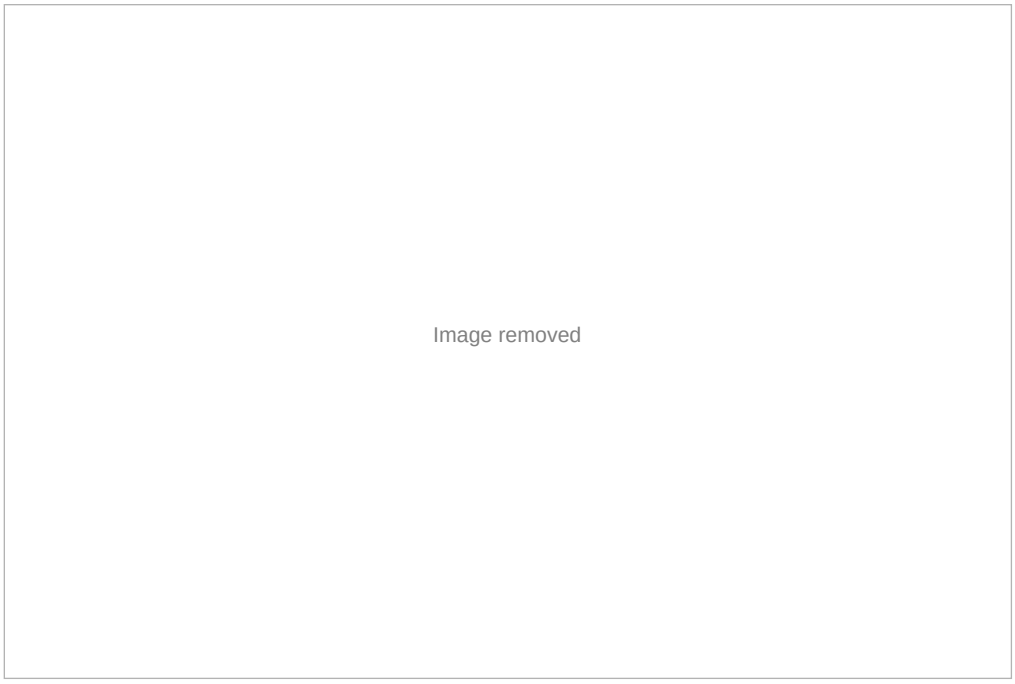


Figure 4-16: Double-page spread from *The Arrival* (Tan, 2007, pp. 17–18), depicting a 'cloud catalogue' of atmospheric and abstract shapes. Presented decontextualised, it evokes an archival collection while inviting semantic and spatial connections within the comics' narrative framework.

Returning to *The Arrival*, its double-page spreads of immigrants' faces (Figure 4-15) and a 'cloud catalogue' (Figure 4-16), if decontextualised, might seem mere archives. However, they are perceived as interconnected—spatially, semantically, and chromatically—due to their co-presence and the comics' dual context: the medium itself and the surrounding pages.

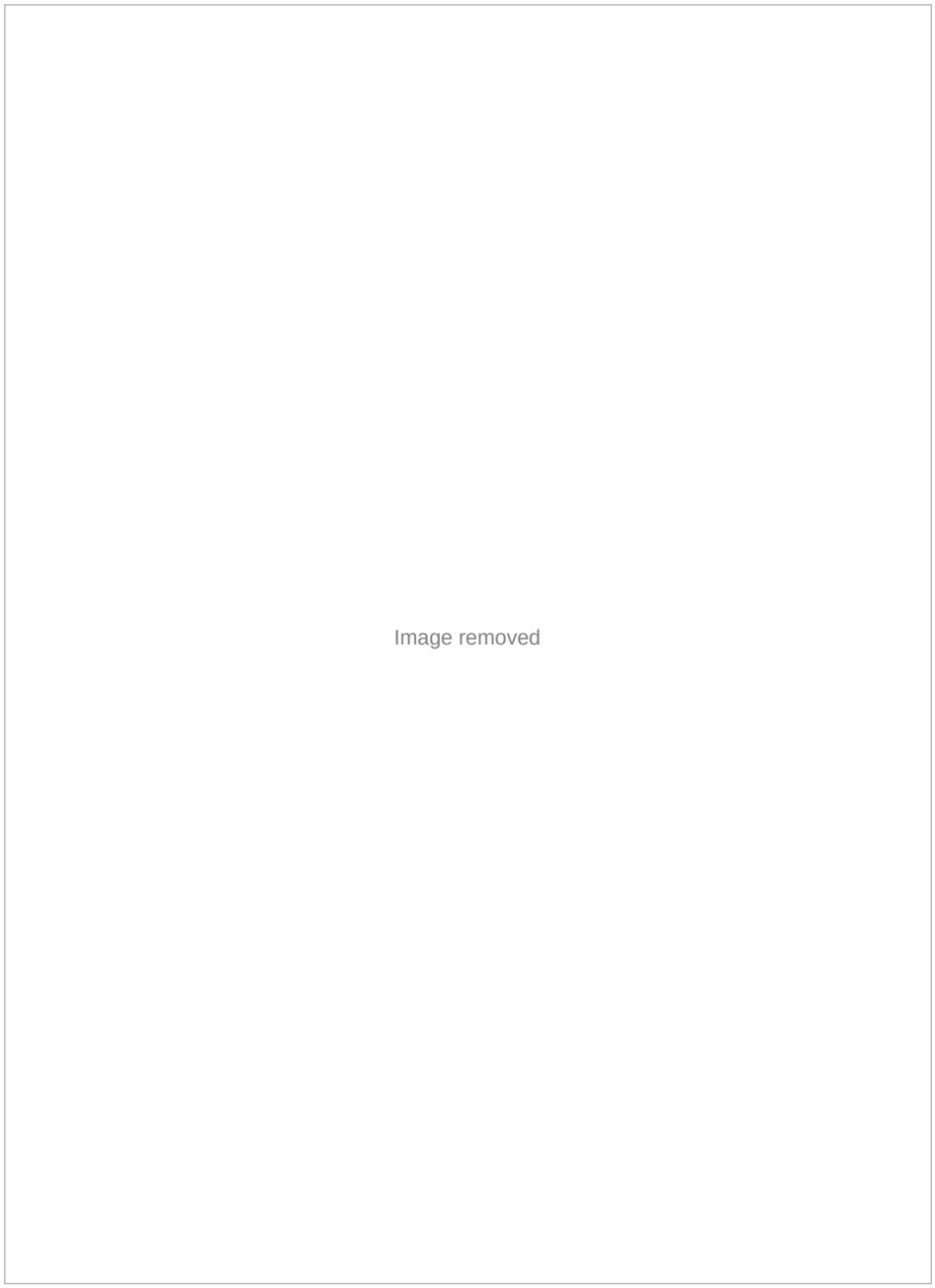


Figure 4-17: Charles Burns, *The Hive* (2012, p. 27). A series of images drawn from art history, homogenised stylistically to create a cohesive visual field, inviting comparative and thematic interpretation.



Figure 4-18: Charles Burns, *The Hive* (2012, p. 28). The images from the previous page are revealed as part of a collected album.

Similarly, Charles Burns in *The Hive* (2012) assembles art history images, homogenised by his graphic style (Figure 4-17), later revealed as collected in an album in a more mimetic style (Figure 4-18). Their spatial co-presence promotes comparative interpretation over sequence. The layout invites readers to infer relationships before narrative context is provided. This comparison, substituting for narrative unfolding, shows how the page structures thought non-sequentially. The resultant understanding is an emergent meaning, distinct from linear reveal, positioning the work between an archival dimension and one where spatial reasoning complements narration.

These examples highlight layouts functioning diagrammatically, structuring thought beyond mere representation. Yet, as Bateman (2014, p. 107) notes when discussing Groensteen's (2007 [1999]) spatio-topia in relation to diagrams, while formal similarities exist in the 'meaningful division of space', the specific meanings comics generate may differ from those in technical diagrams. Bateman cautions against assuming identical meanings, urging a nuanced view. This perspective underscores the need to explore the theoretical underpinnings of comics' unique diagrammatic capacities.

To establish this theoretical basis, this section draws upon Peircean semiotics, Deleuzian philosophy, and contemporary visual epistemologies. The aim is to demonstrate comics' capacity to function as a visual instrument for active thinking, reasoning, and speculative hypothesis generation—an active role in theorising itself (cf. Pradies et al., 2023). Cognitively, a diagrammatic representation is 'a data structure in which information is indexed by two-dimensional location', differing significantly from '*sentential* representations

[that] are sequential, like the propositions in a text' (Larkin and Simon, 1987, pp. 65, 68). Fundamentally, diagrams are cognitive tools externalising thought and visually mapping relationships to facilitate inference and discovery (Krämer and Ljungberg, 2016; Tversky, 2000). Comics and diagrams share an ability to balance structural fixity with interpretative openness, functioning as cognitive interfaces for non-linear exploration that challenge logocentric paradigms. This alternative reasoning mode, originating with Venn diagrams (1880), as a 'graphical *alternative* to sentential and algebraic forms to represent logical relations' (Hoffmann, 2011, p. 189), finds a robust framework in Peirce.

Peirce's theory offers a compelling lens for understanding comics' capacity to mediate between text and image, structure and inference. For Peirce, a diagram is an 'Icon of a set of rationally related objects', representing not only correlates but also 'the relations between them' (NEM IV, 316–317, 1906; Carter, 2020, p. 260). It operates as a hybrid sign integrating icons, indices, and symbols (Nöth, 2024), comparable to comics' own sign system (Cates, 2010). This aligns with Peircean theorematic reasoning, where deductive certainty arises from 'ingenious experiments'—systematically manipulating diagrams to uncover latent inferences (CP 2.267; Shin, 1997, p. 23), actively generating new insights (Swedberg, 2016; Digregorio, 2020). Pietarinen (2016, pp. 129–133) further suggests that diagrams, within a shared 'universe of discourse', support error detection and revision through spatial experimentation and intuition, challenging linear logic via their topological nature (Pietarinen, 2011, pp. 275–277). Comics often demand such reasoning; understanding arises from actively manipulating visual relationships. This resonates with Peircean analyses framing comics as spatial matrices (Magnussen, 2000; Caldwell, 2012). Applied to comics, this implies that the reader, through observing and mentally experimenting with the diagrammatic relationships on the page (such as layout and panel juxtapositions), can actively discover latent inferences and meanings not immediately apparent but 'embodied' within the structure itself.

While Peirce emphasises inferential power, Deleuze, at times in collaboration with Guattari, reimagines the diagram as a pre-representational field of emergence, an ontogenetic force shaping thought. Rejecting internal/external dualism, Deleuze defines diagrams as non-representational 'abstract machines' (Deleuze and Guattari, 2001, p. 141), operating as 'pure

Matter-function', devoid of form or substance and 'not yet 'semiotically' formed' (Deleuze and Guattari, 2001, p. 141; see also Zdebik, 2012, pp. 14–15; Vellodi, 2014, p. 86). This ontological approach diverges from Peirce's epistemology: Deleuzian diagrams are 'agents of construction' (Vellodi, 2014, p. 80) that actively 'bring into being that which does not yet exist' (Deleuze, 2001, p. 147). They construct reality through immanent syntheses and modulations of difference (Vellodi, 2014, pp. 84–87), mapping virtual possibilities before actualisation (Vellodi, 2014, p. 80). As Deleuze (2003, p. 159) states, 'the essential point about the diagram is that it is made in order for something to *emerge* from it, and if nothing emerges from it, it fails'. De Landa's (1997, pp. 58–59) thermodynamic analogy illustrates this: the Carnot cycle diagram abstracts energy flow logic—applicable across diverse systems—from specific instantiations, mapping 'possibilities prior to their appearance' (Zdebik, 2012, p. 1). This 'abstract function' (Zdebik, 2012, p. 4) links 'two incongruous systems together' through functional, not formal, unity (Deleuze, 2006, p. 38), facilitating transdisciplinary creative processes (Burrows et al., 2025, p. 7). Within the context of comics, therefore, the layout and composition can operate as such abstract machines, not merely representing, but actively generating novel connections, affective intensities, or fields of virtual possibility that the reader is invited to explore and actualise.

Harder's *Alpha…Directions* (2015) (further explored in Section 7.7) compellingly illustrates the Deleuzian diagram. This monumental work synthesises radically diverse elements—physics, art history, cosmology, mythology—within the same visual and conceptual space. Its complex layouts function as *abstract machines*, generating emergent meanings and unforeseen connections through juxtaposition and recontextualisation, rather than relying on a purely descriptive or narrative approach. *Alpha* thus operates as a dynamic epistemic framework, mapping virtual possibilities and embodying the diagram's power to link incongruous systems and construct knowledge relationally. Thus, unlike Peirce (diagrams as tools for logical truth), Deleuze positions diagrams as 'maps of pure relations'—dynamic assemblages independent of material instantiation (Vellodi, 2014, p. 80), although this non-representational entity requires embodiment (map, architectural drawing) (Zdebik, 2012, p.

23). This dual character—dynamic generators of meaning through spatial relations and materially instantiated constructs—can begin to position comics as epistemic diagrams.

Integrating these perspectives requires acknowledging their distinct orientations: Peirce focuses on structured, logical inference, whilst Deleuze views the diagram as a generative field producing novelty and affect. These dimensions likely interact in comics reading. The Peircean layout structure may provide constraints for reasoning, while the Deleuzian potential in compositional materiality and juxtapositions allows emergent insights and affective intensities beyond logical deduction. The comics-fact, therefore, arises from this interplay—a moment where structured inference meets generative emergence within the specific affordances of the comics page.

Abstract comics—potentially lacking characters, narration, or even figurativeness (Groensteen, 2013, p. 9)—illuminate comics' diagrammatic nature in its purest form. Where narrative is absent, the visual and spatial framework becomes the primary site of interpretation (Picado et al., 2021, p. 105; Baetens, 2011), and although total de-narrativisation is rare—juxtaposition often triggers narrativisation (Magnussen, 2000, p. 106; Mikkonen, 2017, p. 39)—the tendency highlights a narrative/anti-narrative coexistence requiring active reader initiative (Baetens, 2011, p. 104; Groensteen, 2013, p. 19). In these cases, the Deleuzian dimension becomes explicit: layout operates through what Deleuze terms 'metabolic variability' (cf. Deleuze, 2003, p. xiv), the gutter fracturing linearity and generating meaning beyond figuration. Recalling Van Lier's (1988) blanc nul—the interpanel space as 'cancellation of all continuities'—the gutter operates simultaneously as Van Lier's threshold, Peirce's diagrammatic scaffold (inferential tool), and Deleuze's zone of virtuality (potential field), aligning with differential ontology and grounding the comics-fact in the medium's material structure itself.

Although Peirce and Deleuze offer divergent views (logical inference vs. generating novelty), comics engage both dimensions. Their interplay of material fixity and interpretive openness facilitates structured reasoning and affective emergence. These dual potential grounds the concept of the *comics-fact*.

Within this theoretical framework, the comics-fact is introduced not as a static entity but as a *dynamic, emergent epistemic event*. It arises from the reader's active interaction with the comics' spatial organisation (layout) and its interpretative openness. It manifests where Peircean theorematic reasoning (guided by spatial relationships) intersects with the Deleuzian virtual potentials and intensities generated by the composition. Facilitated by the page's material structure (panels, gutters, design), this interaction produces insights, affective responses, or moments of understanding often exceeding or paralleling linear narrative decoding. Akin to Deleuze's *pictorial fact* (2003, p. 160), the comics-fact highlights comics' transformative potential as an active epistemic process. Layout and gutter function as sites where meaning emerges dynamically, enabling speculative reasoning within a controlled, yet potentially chaotic, 'multi-order delirium' (cf. Section 1.1).

Whilst acknowledging foundational frameworks emphasising the spatial system (e.g., Groensteen's *spatio-topia* and *arthrology*) or cognitive sequencing (e.g., Cohn's VNG), the comics-fact proposed here offers a distinct focus. Rather than concentrating primarily on the underlying structure or the grammatical processing, it conceptualises the specific *epistemic event* arising from the reader's interaction with the page—an event where, as previously defined, Peircean inference derived from spatial structure intersects with Deleuzean virtual emergence. It foregrounds this dynamic *outcome of engagement*, bridging logical potential and affective resonance uniquely actualised within the medium's specific affordances.

This conceptualisation of the comics-fact as the specific outcome of interaction with the comics interface can be further illuminated by connecting it to the concepts of *operative iconicity* and *medial seeing-with* discussed in Section 3.3. If, as argued, the comics interface possesses an operative iconicity (functioning as a diagrammatic tool), it enables a particular mode of perception, a medial seeing-with—a seeing *through* the formal and structural qualities of the visual artefact (Alloa, 2021a). The comics-fact, therefore, emerges as the distinct epistemic result—the insight, resonance, or connection—specific to this medium. It is generated precisely through this *seeing-with* at the moment when structured inference derived from the diagrammatic layout (Peirce) encounters the diagram's generative potential: its Deleuzian capacity, operating as an abstract machine, to map fields of *becoming* and directly

produce *sensation* or affective intensity, rather than simply representing existing relations. Recognising the broader applicability of Deleuze's diagrammatic principles beyond their original articulation through painting (as explored, for instance, in relation to literature by Conley (2017)) lends further support to identifying this specific comics-fact as distinct from, though conceptually related to, Deleuze's *pictorial fact*.

A page from *Big Numbers* (Moore and Sienkiewicz, 1990) (Figure 4-19) illustrates the comics-fact across three strata:

1. **Sensory Prefiguration**: A whirlpool-like compression of bodies acts as a sensory detonator, coalescing into a Deleuzian *Figure* before narrative parsing.
2. **Symbolic Recognition**: Crushed postures and diverging trajectories may later be read metaphorically (e.g., familial strife), but this symbolism emerges from, rather than precedes, the diagram's asignifying forces.
3. **Sequential Narrative**: Reading panels reconstructs a linear story, yet this narrative is already destabilised by the diagram's privileging of rhythmic dissonance over causality.[26]

[26] This is further compounded by interaction with the text which, although potentially linearising, is also fragmented and spatialised by the layout.

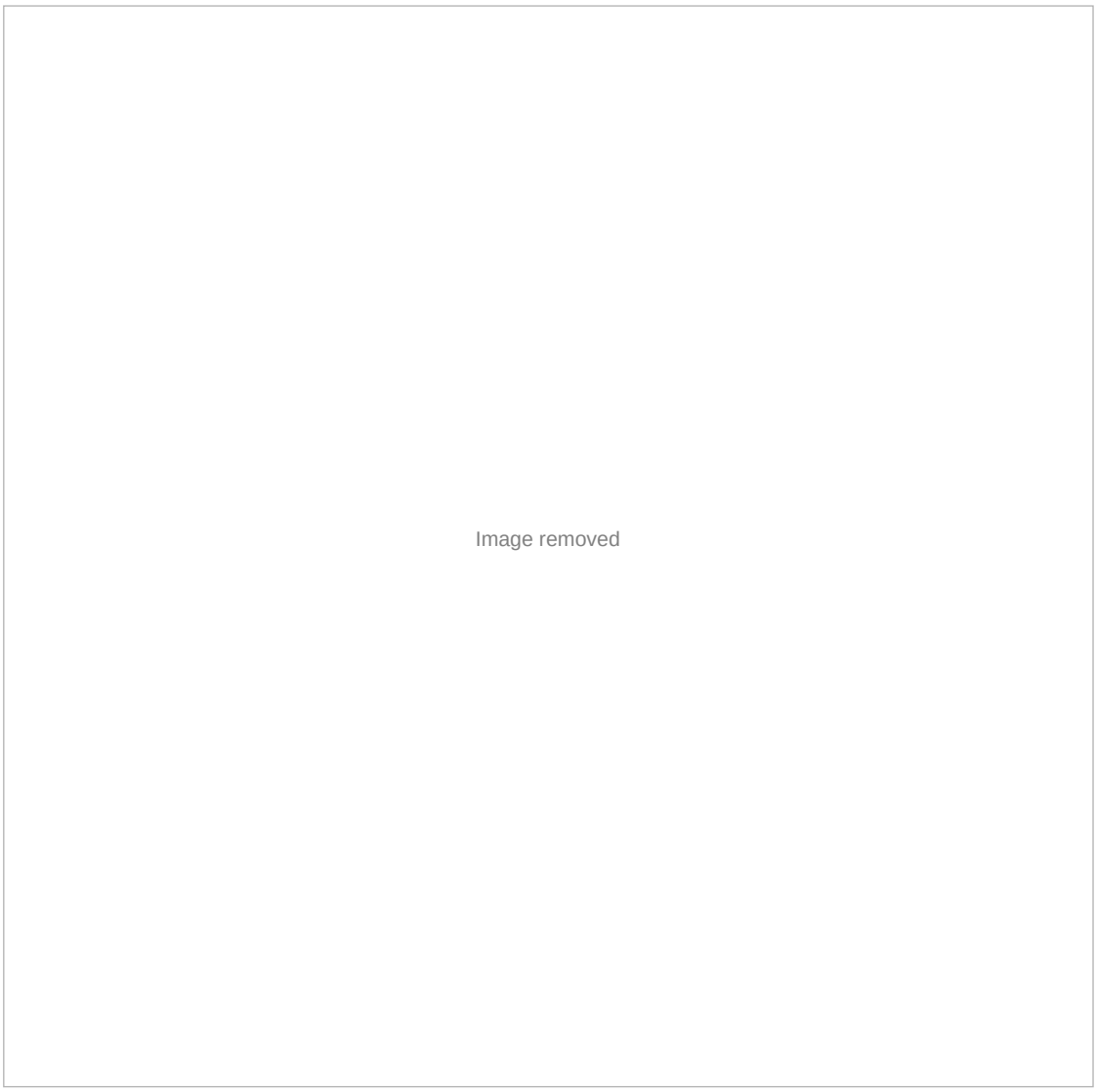


Figure 4-19: *Big Numbers*, vol. 2, p. 7 (Alan Moore, writer; Bill Sienkiewicz, art, 1990). A dense sixteen-panel composition combining spatial fragmentation with rhythmic dissonance. The page stages entangled trajectories, layered focal planes, and verbal overlays, encouraging the reader's inferential engagement through conflicting visual and narrative cues.

This stratification distinguishes comics from Bacon's paintings (which purge narrative to liberate the *Figure*) and potentially from sequential grammar models: comics stage collisions between diagrammatic intensity and narrative. This framework positions layout as a polyphonic matrix—a 'plane of consistency' (Deleuze and Guattari, 2001)—where sensory, symbolic, and narrative registers interact non-hierarchically. The comics-fact emerges as an epistemic surplus from this productive tension. The reader/viewer oscillates between Peircean deduction via spatial experimentation and Deleuzean emergence of affect and virtuality.

Chris Ware's multilinear works epitomise this. Described as *rhizomatic* (e.g., Banita, 2010; Haddad, 2016; Tirino and Paola, 2018), they subvert linear storytelling via recursive structures and associative visual syntax. Functioning as Deleuzian abstract machines, they transform readers into participants generating nonlinear meaning through diagrammatic 'graphic semantics' (Cates, 2010, p. 99)—visual matrices balancing legibility and fluidity. In works like *ACME Novelty Library* and *Building Stories*, marginal elements often 'substantially alter the emotional tenor' (Cates, 2010, p. 90), prompting spatial reassembly of meaning. This tension materialises the comics-fact. As Haddad (2016) notes, Ware's explicit diagrammatic nature generates non-sense disrupting temporality. Similar effects occur in rigid grids like 'Big Tex" (Figure 1-5), where sparse cues encourage free scanning (Miodrag, 2013, p. 143), leading to an impossible attempt at recomposition/reconcilation but also generating excess meaning. This aligns with Osborn's (2005) Deleuze-inflected view of diagrams as abstract machines generating navigable 'trails', with the gutter as a key site for active reader construction. The result is an orchestrated interplay where the comics-fact manifests in colliding micro-forces generating pre-linguistic intensity. Ware's design mimics memory's non-hierarchical flow, bridging comics, diagrams, and information design (Bartual, 2012, p. 57; Cates, 2010, p. 96).

In summary, this section has outlined how comics function as diagrammatic media, supporting both Peircean inferential reasoning and Deleuzian difference production. This dual lineage allows reconceptualising comics as epistemic interfaces externalising thought. The introduction of the comics-fact as an emergent event supports this claim, offering a concept for theorising knowledge configuration in comics. This reconceptualisation prepares for the next section's exploration of comics' affinity with cartographic models.

4.9. Cartographic Interfaces: Navigating Comics as Cognitive Maps

> So what happens when we take that fact and put it at the heart of what we're doing—as writers and as readers? What happens when we focus on geographical narrative—the construction of a place—rather than temporal narrative—the construction of a series of events? When we replace plot with landscape as the central organizing element? And when, instead of going on a journey through time, we set out to create and explore a space?
>
> Dylan Horrocks, 2004

An extreme and provocative example of this spatial reconfiguration is offered by Matt Madden's *Map* (Figure 4-20), which transforms a comics sequence into a cartographic diagram. Viewing the comics page as a 'landscape' to be explored, as Horrocks (2004) suggests, positions it as a cartographic interface. This perspective, shifting from McCloud's (1993) equation of SPACE=TIME to what Horrocks (2004; 2010 [1998]) frames as SPACE=SPACE (see also Figure 4-21 and Figure 4-23), foregrounds comics as fundamentally spatial tools for world-building and exploration, where page structure becomes a primary organising principle.

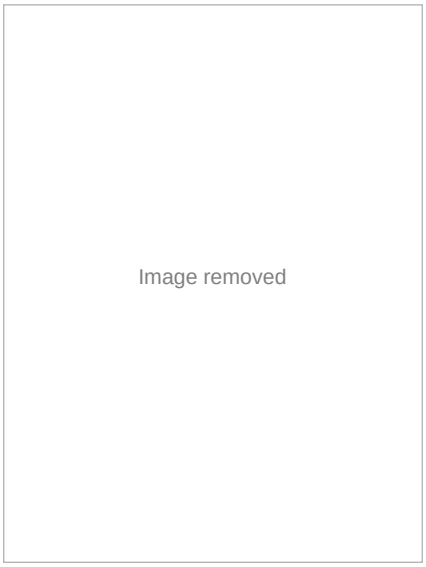


Figure 4-20: Matt Madden, 'Map', from *99 Ways to Tell a Story: Exercises in Style* (2005, p. 95). This cartographic reimagining of a basic comics sequence spatialises narrative action as a visual itinerary, transforming the layout into a map of movement, orientation, and relational zones.

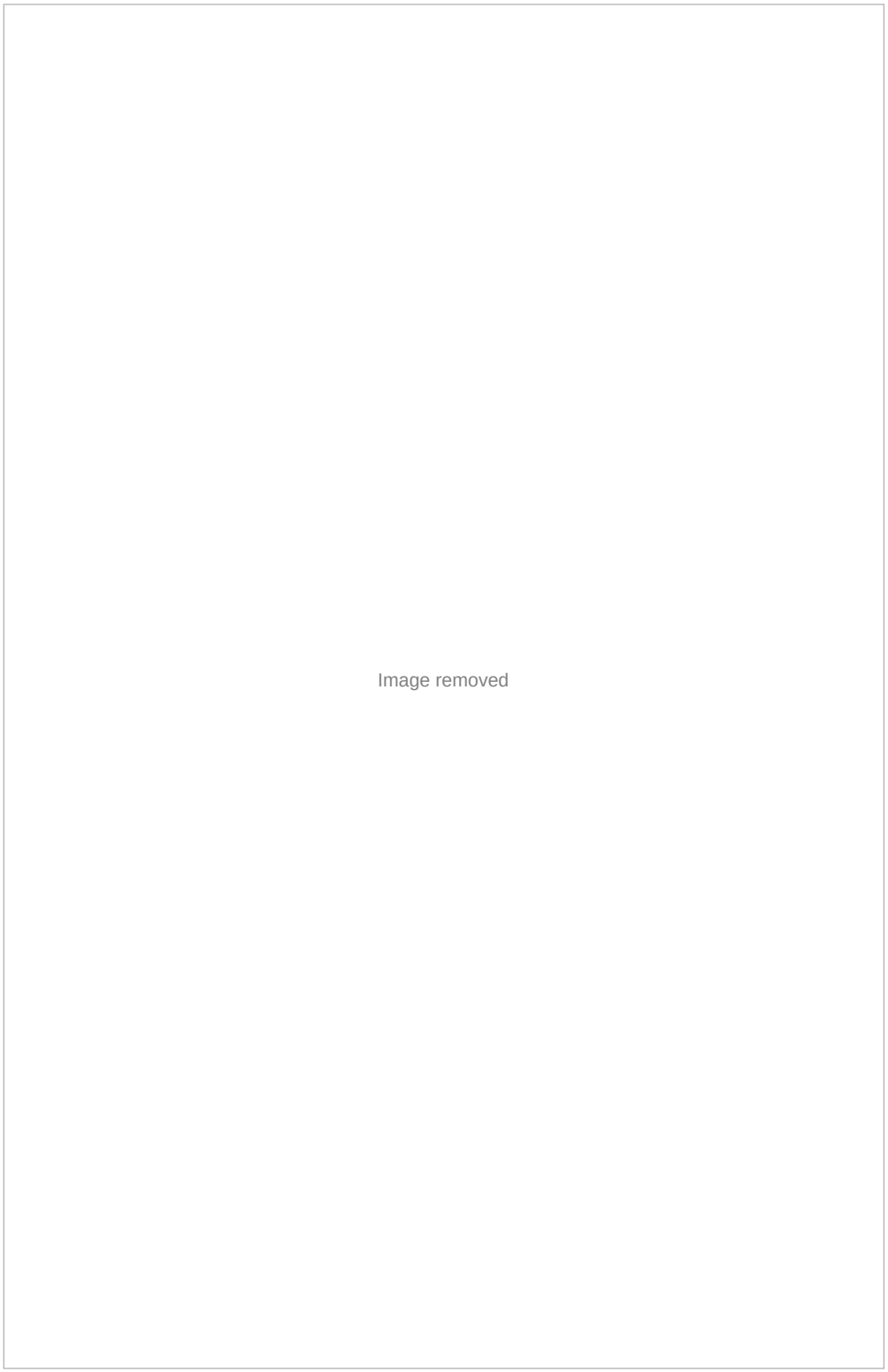


Figure 4-21: Dylan Horrocks, *Hicksville*, p. 84 (2010 [1998]). Cartoonist Emil Kópen introduces the idea of comics as a form of map-making, framing the medium in explicitly cartographic terms.

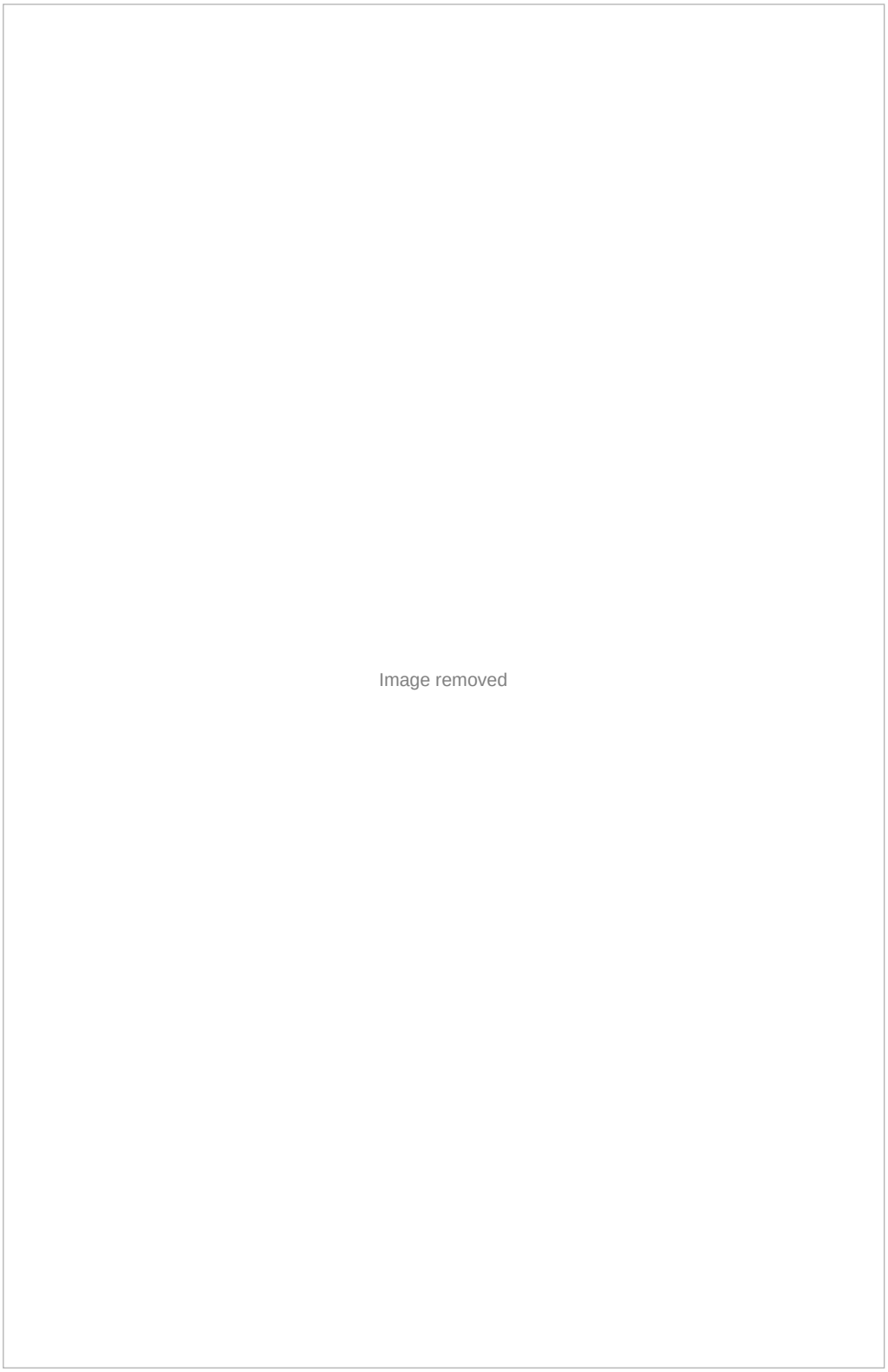


Figure 4-22: Dylan Horrocks, *Hicksville*, p. 85 (2010 [1998]). Continuation of Kópen's conversation, deepening the analogy between comics and maps through reflection on language, text, and image.

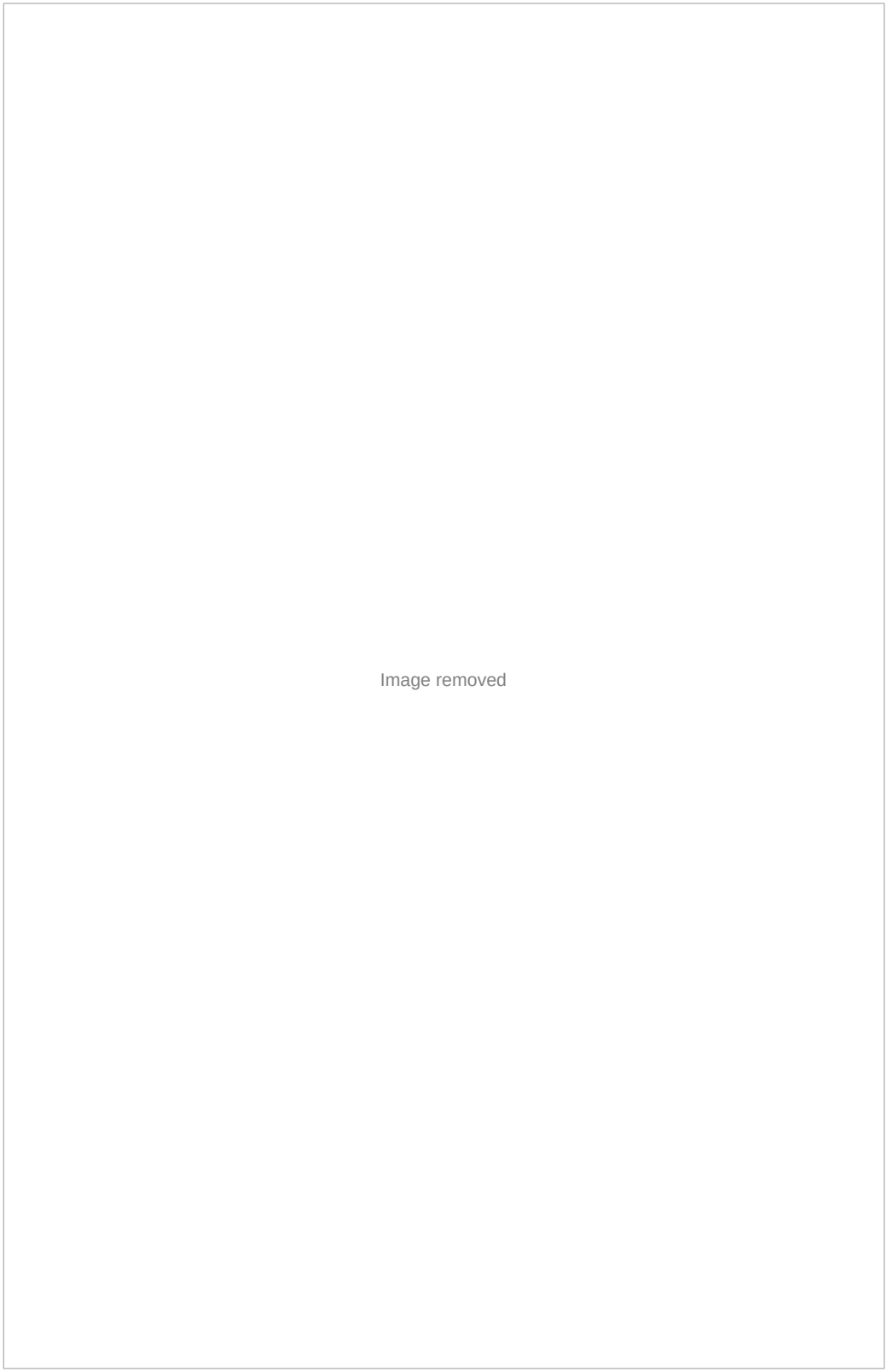


Figure 4-23: Dylan Horrocks, *Hicksville*, p. 86 (2010 [1998]). Kópen distinguishes between spatial and temporal maps, reframing storytelling as the articulation of spatial relationships that persist beyond narrative sequence.

This cartographic reading aligns with interdisciplinary research on the convergences between comics, mapping practices, and post-representational cartography (cf. Peterle, 2015, 2018, 2019; Tosti, 2019). Building on this, Ingold's concept of the *meshwork* is employed here to model the reader's navigation within this interface and link it to the generation of comics-facts.

Maps are a specific subset of diagrams, sharing structural affinities rooted in spatial arrangements and symbolic conventions (Winn, 1991). Their epistemic value lies in representing spatial relationships to enable orientation, pathfinding, discovery of connections, and a relational understanding of a territory (Tversky, 2000, p. 78). Specifically, maps are 'analog diagrams' mediating perception and reality construction through spatial-semiotic negotiation (Ljungberg, 2016, p. 141). Just as maps visualise relationships using second-order logic—focusing on abstract concepts like proximity or hierarchy (Pietarinen, 2016, p. 132)—comics structure meaning relationally.

Comics inherently share these cartographic affordances. Both media select and arrange spatial and temporal fragments according to their aims (Langran, 1992, p. 28; Dittmer, 2010, p. 222), organise multimodal information within a relational spatial layout, require active reader navigation, and allow visualisation of complex relationships in non-linear ways, creating a distinctive 'chronotopography' (Troiani, 2016). This extends beyond literal maps within comics (cf. Peterle, 2019, p. 3) to the structural logic of the page. Certain layouts explicitly highlight a topographical quality. The 'polyptych', where a continuous background is divided into panels, resembles a grid-segmented map, inviting topographical navigation (see, for example, Figure 0-3, Figure 1-5; the top portion of Figure 1-6 also demonstrates aspects of this; Figure 4-19; and Figure 4-24).

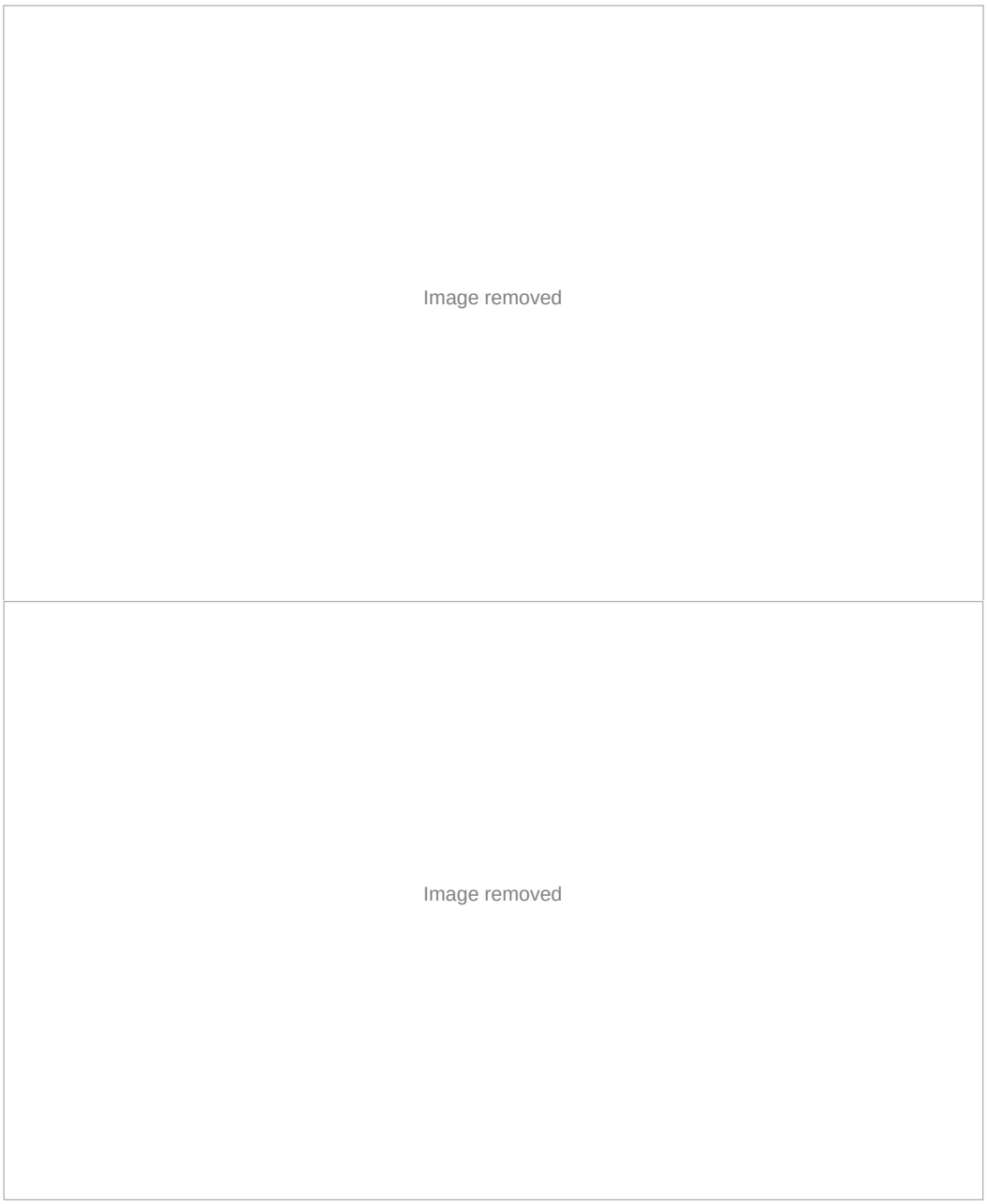


Figure 4-24: Patrick McEown, *No Escape* (1999), pp. 1–4. Extract from a ten-page polyptych designed as a continuous spatial strip. The layout divides a coherent background into panels, inviting topographical reading across a mapped environment.

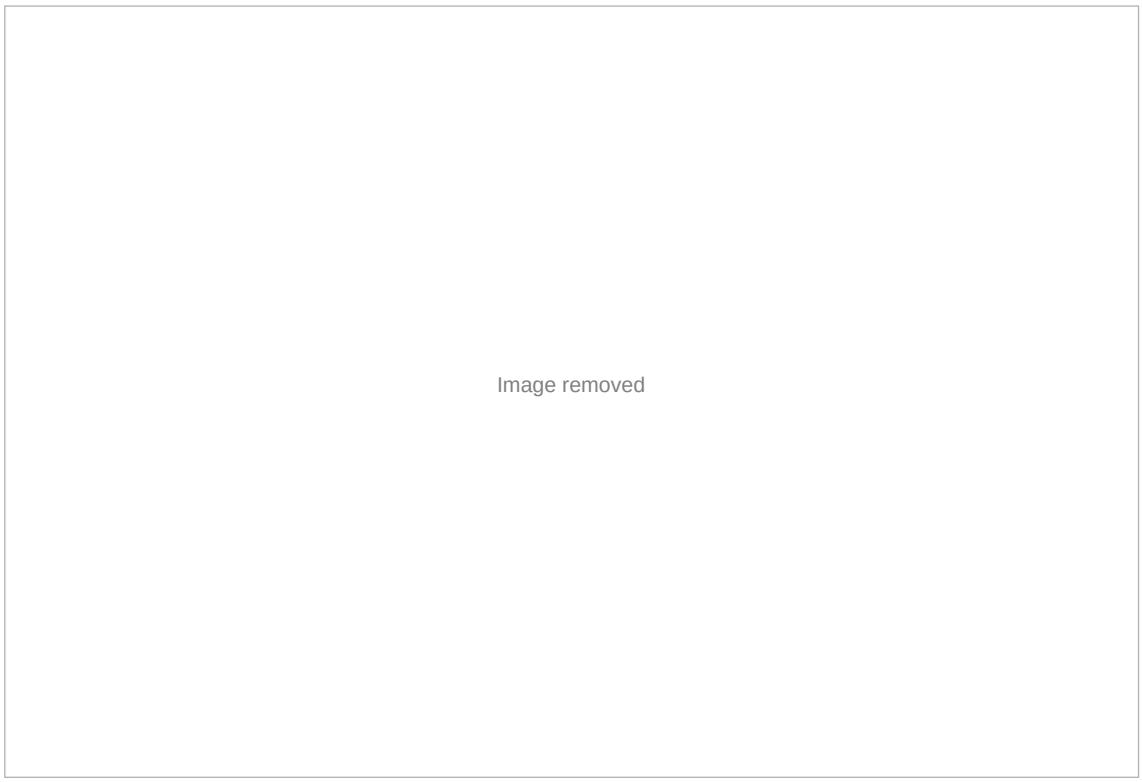


Figure 4-25: Gianni De Luca, 'Romeo e Giulietta'. *Il Giornalino*, no. 44, 7 November 1976, pp. 10–11. This double-page spread exemplifies the technique later known as the De Luca effect: characters are repeated across a continuous background, tracing spatial and temporal progression without traditional panel divisions.

Another example is the *De Luca effect* (Gravett, 2009), where characters are repeated within the same continuous background, moving through space and time with minimal panel borders (see Figure 4-25), inviting topographical navigation of the reader's gaze. Crucially, the division into 'scenes' is not always explicit. As in medieval painting (Tosti, 2016, pp. 43–53), architectural elements (columns, arches) or the repetition of human figures can implicitly define narrative compartments, even in the absence of panel borders. As Català (2012) notes, this spatial logic diverges from the mimetic-photographic-narrative tradition (Renaissance painting to cinema), aligning with a pre-Renaissance, anti-Aristotelian lineage defined by simultaneity and multiplicity. Crucially, comics' cartographic nature persists even in conventional, segmented layouts, which function as navigable 'territories.'

Comics possess a plurivectorial spatial 'grammar' comparable to map navigation, while post-representational theories frame maps themselves as dynamically performed by users. This parallel foregrounds the comics reader as an actively embodied participant in 'mapping–and

orientation–practice' (Peterle, 2015, pp. 71–72) (see Figure 4-26), exploring the page's 'map', establishing connections, backtracking, and reassessing routes and landmarks (panels, motifs) as they construct meaning (Dittmer and Latham, 2015, p. 435).

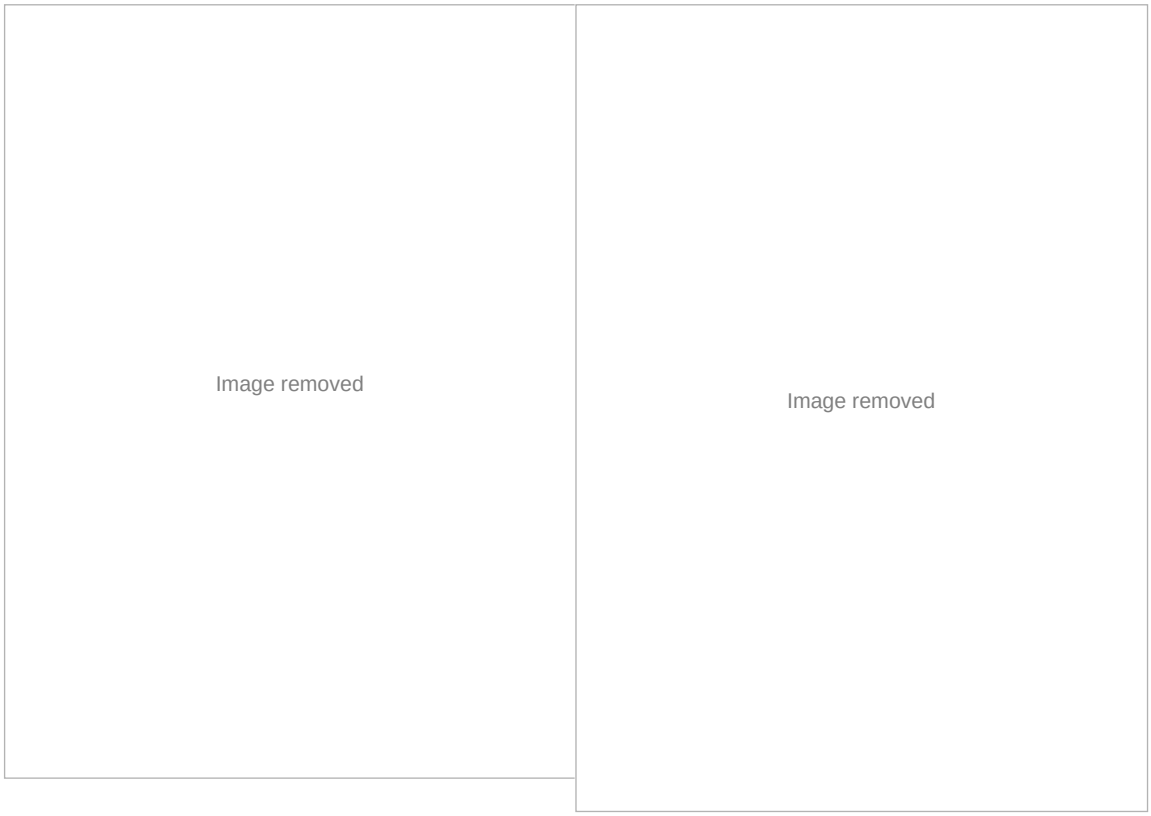


Figure 4-26 Peterle, 'For a Carto-Criticism ~~of~~ in Comics Form', pp. 4 and 5 (in Peterle, 2019). This two-page sequence conceptualises comics reading as spatial navigation. It frames the act of reading as a mapping practice, aligning the reader's interpretive movement with embodied orientation.

The boundary between maps and comics thus blurs; maps embrace narrative potentials, and comics function as *narrative maps* shaping spatial imaginaries. This convergence reflects a deep linguistic and conceptual exchange, allowing cartography to be rethought through comics and comics to be experienced as 'cartographic events' (Peterle, 2018, p. 23). Thus, McCloud's SPACE=TIME equation—where space is primarily experienced through sequential temporality (Wolk, 2007, p. 134)—is complemented by the notion SPACE=SPACE, framing comics as cartographic constructs engaged in worldbuilding. Comics, consequently, constitute a spatial cartography, functioning as epistemic interfaces whose narrative potential transcends conventional linear frameworks.

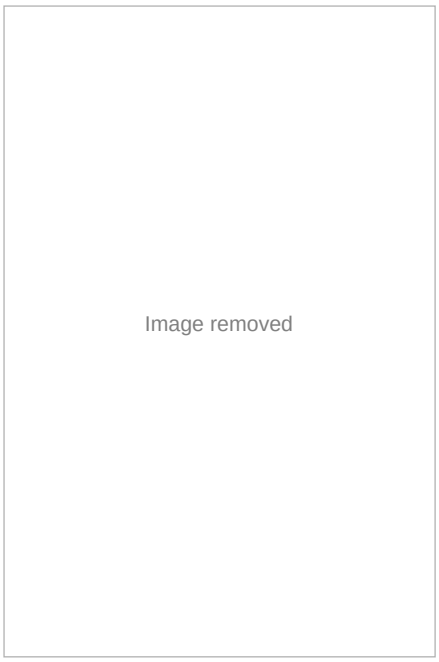


Figure 4-27: Tim Ingold, diagram of a meshwork (top) and a network (bottom), from *Lines* (2007, p. 82). The meshwork depicts entangled, processual lines of movement, while the network shows static connections between fixed points.

This spatiality enables a topological coexistence of temporalities on the page. Echoing Deleuze's (1988, pp. 36, 44) *superimposed maps*—sites of temporal collisions and spatial palimpsests—comics structure time as relational layers. This inherent potential for temporal coexistence aligns with philosophical challenges to linear temporal perception (Rucker, 1977, 1984). Comics' spatial structure facilitates the topological coexistence of past, present, and future nested within the page's architecture as relational nodes, aligning with *Eternalism*, the philosophical view that past, present, and future coexist in a four-dimensional *Block Universe* (*cf.* Mozersky, 2011; Savitt, 2011; Slavov, 2020).

Each panel, within this framework, functions as an event deriving meaning primarily from its position in the page's lattice—a spatial logic mirroring Rovelli's (2019) relational time, where multiple temporalities coexist as nodes rather than points on a linear arrow. Works like *Alpha… Directions* (Harder, 2015) and *One Soul* (Fawkes, 2011) exemplify this: epochs and parallel lives unfold simultaneously across the page, resisting reduction to a single sequential progression.

While cybertexts, database theory, diagrams, and cartography effectively capture comics' spatial structure and relational potential, describing the reader's dynamic navigation of these interfaces benefits from Tim Ingold's (2007, pp. 72–103, 2011, pp. 63–94, 2017) metaphor of the *meshwork*. This concept aptly captures the reader's path-making through an environment structured by sequential constraints (Cohn), relational networks (Groensteen), and multimodal content interplay (Bateman). Offering nuances beyond network or rhizome, the meshwork shifts focus from static nodes to immanent, living processes unfolding along generative pathways (cf. Ingold, 2007, 2011) (see Figure 4-27). It emphasises a dynamic,

continuous *entanglement* of *interwoven lines* (movement, growth, relationship) in constant motion, creating continual differentiation (cf. Ingold, 2017). Ingold contrasts the static model of points connected by lines with the meshwork's characteristic activity: not *transport*—efficient travel between fixed points—but *wayfaring*—exploratory movement through a landscape, learning and orienting oneself by tracing a path in the process itself (Ingold, 2007, p. 84). Importantly, the meshwork's order emerges from the continuous interweaving of lines, a dynamic system of connections rather than pre-existing structural frameworks (cf. Ingold, 2007, 2011, 2015, 2017).

Applied to comics, the meshwork metaphor vividly captures reader engagement: not merely jumping between panel-nodes, but actively tracing paths through the spatial and temporal entanglement of images, text, gutters, and visual cues—a cognitive and perceptual 'wayfaring' across the page-landscape. This contrasts with the linear transport Ingold associates with traditional text reading. Comics wayfaring is exploratory, involving discovery, deviations, retracings, and returns, allowing readers to co-create their reading path by interacting with the meshwork's potential lines (cf. Ingold, 2007). The layout becomes a dynamic field, and meaning emerges *along* these interwoven paths, simultaneously guided by the structure and created by the reader's navigation. Crucially, wayfaring in comics is not just spatial navigation; it is an active, temporal process of meaning-making, where the reader synthesises past, present, and anticipated moments into an understanding that evolves *during* the act of reading through tracing and re-tracing connections.

It is through this active navigation—this wayfaring across the page's cartographic interface—that the comics-fact (defined in Section 4.8) emerges. The comics-fact manifests at the nexus of the relatively fixed spatial structure (the page's 'map') and the reader's dynamic, interpretive journey (wayfaring). This interaction generates insights, connections, and affective resonances transcending mere linear decoding, an epistemic event produced by the encounter between medium affordances and the reader-explorer's cognitive agency.

During wayfaring, the comics-fact arises from the synthesis of two simultaneous mental processes:

1. **Interpreting the Spatial Structure (Peircean):** The reader actively makes sense of visible relationships, questioning panel connections and grid functions, attempting to understand the 'grammar' of the encountered structure.
2. **Grasping Emerging Connections (Deleuzian):** Through exploratory movement, the reader stumbles upon unexpected connections, emotional resonances, or new ideas arising directly from the arrangement of elements in the traversed 'landscape', often beyond simple linear narrative.

The comics-fact, therefore, is the unique cognitive and affective result—a particular realisation or sensation—when these two activities (logical analysis of structure and discovery of hidden potentials) converge, facilitated by the comics interface. This interpretative framework, rooted in the reader's engagement with the page's complex spatiality (cognitively processed via multi-schematic orchestration involving image schemata like containment, balance, and path), holds significant implications for understanding cognitive processes in comics reading and for leveraging their educational potential, particularly for complex multimodal communication.

4.10. Conclusions: Comics as a Mediator between Arborescent and Rhizomatic Models in Post-Digital Educational Frameworks

This chapter has moved beyond the definitional complexities examined in 4.2, focusing on comics' often-overlooked epistemic potential, particularly in contrast to the predominantly illustrative or supportive function commonly assigned to current ECs, which frequently adhere to verbal and linear models (Chapter 1).

Part A provided a critical overview of established theoretical frameworks, synthesising key debates on the medium's constituent tensions (visual/verbal, sequential/spatial) and reviewing dominant models for layout interpretation. This review highlighted the richness of existing studies while underscoring the need for a framework that holistically integrates the medium's diverse possibilities for knowledge generation, specifically concerning their implementation in HE.

Part B subsequently developed such an original interpretative framework, positing comics as active epistemic interfaces. It argued that comics fundamentally function as diagrams, possessing a unique dual capacity rooted in Peirce's concept of theorematic reasoning (inferential potential) and Deleuze's notion of the diagram as a generative machine (emergent potential). This interplay, mediated by the reader's active engagement with the spatially organised multimodal structure, gives rise to specific epistemic events termed comics-facts. This diagrammatic function was further articulated through the conception of comics as cartographic interfaces—complex meaning-landscapes whose navigation is best understood via Ingold's metaphor of the meshwork, emphasising active, multilinear exploration and aiming to transcend the still pervasive 'aggressively linguistic' cognitive paradigm (Stafford, 1996, p. 7).

This conceptualisation of comics as active, diagrammatic, cartographic interfaces—navigated as meshworks involving both intra- and extra-panel wayfaring—aligns directly with the post-digital educational frameworks examined in Chapter 3. Connectivism's network

navigation, edusemiotics' relational meaning-making, and rhizomatic learning's decentralised knowledge structures (Section 3.6) each find in the comics meshwork a concrete operational model, one that balances exploratory freedom with guiding structure in ways that address some of RL's known operationalisation challenges.

Comics, as argued, can mediate these tensions. They inherently combine arborescent structuring (via sequentiality, spatial framing, hierarchical grammar, multimodal layering) with affordances for rhizomatic exploration (multilinearity, configurative reading), exemplifying the duality between rhizome lines and points of arborescence (Best and Kellner, 1991, p. 102, analysing Deleuze and Guattari). This non-rigid opposition is reinforced by Gregoriou (2008, p. 244) who notes arborescent knots within rhizomes and vice versa, conceptualising the rhizome as a dynamic process. Comics operate as dynamic systems where panels or clusters function as nodes, while the page or series unfolds as a larger, fluid yet structured mesh of interconnections. As Kinchin and Gravett (2020, p. 6) suggest in their discussion of concept maps, the lack of structure in the rhizome is evident primarily at its *gross morphology*. At the micro level, even rhizomes reveal structure. Consequently, a comics, like concept maps, can be considered as 'a section of the rhizome at the "vascular level", considering that 'concept maps [or comics] can themselves be seen as figures cut from or sliced through a more complex rhizomatic multiplicity as a cross section' (Harris, 2016, p. 230). Building on this argument, it can be asserted that groups of panels within a comics represent sections of a larger rhizome (e.g., the page or issue), which are part of an even broader rhizomatic system (e.g., the series, the medium itself).

The multi-schematic orchestration of the grid—deploying CONTAINER, PATH, BALANCE, and CENTRE-PERIPHERY schemas simultaneously (Section 4.5)—provides the cognitive scaffolding enabling the active navigation from which the comics-fact emerges.

This capacity allows comics to overcome the fragmentation often seen in other *Multiple External Representations* (MERs) (to be discussed in Chapter 5). Crucially, navigating this complex visual and cognitive structure—decoding multimodal signs, inferring meaning across gutters, tracing spatial relationships—directly cultivates visual literacy competencies (interpretation, analysis, synthesis, spatial reasoning) essential for the post-digital age (see

Chapter 3). Ingold's meshwork, privileging entanglement, movement, and wayfaring over static nodes, aptly captures this reader experience—a cognitive mapping within a resilient system (Ingold, 2015), resonating with Hayles's (2016, 2017) *cognitive assemblages* which foreground embodied interaction across material interfaces. Furthermore, comics' capacity to spatialise time aligns with challenges to linear temporal perception (cf. Rucker, 1977, 1984; Rovelli, 2019), facilitating a topological coexistence of temporalities.

This hybrid epistemic structure of comics as meshworks addresses the need for pedagogical tools integrating structure and creativity. Their navigability can mitigate RL's challenge of perceived chaos, the grid offering implicit metrics. Comics support diagrammatic reasoning, functioning as both abstract machines and 'lazy machines' (Eco, 1979) stimulating inference through the interplay of local reading and global looking. As in Eco's model for visual texts, comics are complex systems prompting pattern recognition and multilinear interpretation (Polidoro, 2017).

Proposing comics as ECtC outlines a zone of feasible innovation (Rogan, 2007, p. 441): strategically integrating arborescent scaffolding and meshwork exploration. This demands pedagogical balance—moderating semiotic density and maintaining coherence, whilst encouraging student exploration. As Ruitenberg (2007, pp. 17–18), notes, rhizomatic structures, difficult for linear texts, lend themselves to cartographic expression; comics offer this spatialisation of multiplicity. Such affordances suit post-digital knowledge ecologies, synthesising linearity with exploratory logic. The reading purpose, as Chute (2016) notes for documentary comics, orients engagement towards a *reading out*—as opposed to ordinary reading—that leaves 'the burden of inference to the reader' (Chatman, 1978), their effectiveness depending on pedagogical framing that fosters 'bold imagination and praxis' (Lee, 2008, p. 921). These insights inform wider debates in visual communication and multimodal learning. Indeed, such structural principles appear to have influenced interface design and internet aesthetics, positioning comics as paradigmatic of a 'new everyday aesthetic' (Wright, 2014; Herd, 2014). In this sense, comics function not only as forms of storytelling or epistemic tools, but also potentially as templates for structuring experience within contemporary visual culture.

In conclusion, this chapter has positioned comics as sophisticated cognitive and epistemic devices equipped for post-digital learning complexities. If reasoning itself is inherently diagrammatic, with diagrams actively performing reasoning (cf. Drucker, 2014, p. 115, on Peirce), a reconsideration of data visualisation and data comics is necessary. Building upon this framework, Chapter 5 will situate comics within the broader landscape of visual knowledge work in HE, examining External Representations (ERs) and MERs, their benefits, and limitations (cognitive load, fragmentation). It will then critique current data visualisation practices, including nascent *data comics* often constrained by linear models. Drawing on comics' potential as navigable meshworks, diagrammatic tools, and cartographic interfaces, Chapter 5 will explore how ECtC can offer innovative representational strategies, engaging with concepts like data humanism, knowledge cartography, and posthuman perspectives on visualisation. Ultimately, it aims to demonstrate how comics' unique affordances can be applied in visual knowledge communication and pedagogy, providing a robust basis for the conceptual prototypes presented later.

5. Situating ECtC: Comics as Epistemic Tools Beyond Data Comics and Visualisation

5.1. Introduction: Setting the Stage—From Comics Theory to Epistemic Visualisation

> Visual displays are more than a simple matter of supplying pictorial illustrations for scientific texts. They are essential to how scientific objects and orderly relationships are revealed and made analysable.
>
> Lynch, 1988, pp. 201–202

Lynch's insight frames this chapter's epistemological focus: visual artefacts function as active instruments in articulating knowledge, not mere textual adjuncts. Building on the theoretical scaffolding established in Chapters 1-4, this chapter marks a critical shift from the structural and semiotic principles of comics as spatially organised epistemic interfaces towards their operationalisation within existing visual representation and visual pedagogy frameworks. Key terms used throughout this chapter—including *epistemic potential*, *post-minimal visualisation*, *beyond clarity*, and *productive ambiguity*—are defined in the Key Terminology section (1.5) and developed at the points indicated therein.

The preceding chapter reconceptualised comics beyond their narrative vocation; here, the medium is positioned within the broader constellation of *External Representations* (ERs), *Multiple External Representations* (MERs), and *Data Visualisations* (DVs)—not merely as entertainment or linear storytelling tools, but as multimodal, spatialised, and potentially non-linear devices for structuring and generating knowledge. In doing so, it serves as a conceptual and methodological bridge between the thesis's analytical first part and the speculative design of the *Educational Comics to Come* (ECtC) detailed in Chapters 6 and 7.

The discussion turns first to ERs and MERs, exploring their pedagogical significance and documented limitations—particularly fragmentation, cognitive overload, and linear bias—arguing that the integrative affordances of the comics medium can, at least partially, address

these issues. The discussion then turns to DV, examining the dominant minimalist paradigm that has shaped its aesthetics and epistemology. By unpacking tensions between clarity and complexity, objectivity and subjectivity, abstraction and figuration, this chapter situates comics within ongoing debates on visualisation's epistemic and affective dimensions, especially in light of calls for human-centred, speculative, and multimodal visual practices. Against this background, *Data Comics* (DC) are analysed as a transitional format whose current implementations are often limited by linearity, anthropocentrism, and stylistic minimalism, thereby underutilising the medium's epistemic affordances. Finally, the chapter explores new frontiers in visualisation theory—from diagrammatic reasoning to knowledge cartography and posthuman epistemologies—to frame comics as promising candidates for representing distributed, multi-scalar, and non-linear phenomena, laying the groundwork for Chapters 6 and 7, which articulate and prototype the ECtC as speculative, epistemic, and pedagogical tools for the post-digital age.

5.2. Visual Representation and Knowledge Structuring

5.2.1. Multiple Representations and Cognitive Complexity

Building on the visual and epistemic reframing from previous chapters, this section addresses how knowledge is structured, externalised, and made cognitively tractable through representational artefacts, focusing on *External Representations* (ERs) and *Multiple External Representations* (MERs).

ERs are cognitive artefacts—physical or digital—that render real-world phenomena tangible, manipulable, and available for thought, imagination, and action (Hutchins, 1999, pp. 126–127; Kirsh, 2010, p. 452; Pande, 2021, p. 464), including paintings, diagrams, maps, photographs, and visual-verbal hybrids (Mustaqim and Zahar, 2022), though no universally accepted classification exists (Ainsworth, 2006, p. 190). MERs deploy multiple ERs, simultaneously or progressively, to depict the same phenomenon, supporting richer mental models by linking concepts across different levels—phenomenological, submicroscopic, symbolic (Ainsworth, 2006; Kozma, 2003; Gilbert and Treagust, 2009)—and enhancing abstraction, transfer, and problem-solving (Seufert, 2003; Goldstone and Son, 2005; Mayer, 2021; Lindner et al., 2017; Ott et al., 2018).

However, ERs, and MERs particularly, pose substantial cognitive challenges. Their effectiveness depends on learners' *representational competencies*: the ability to select, interpret, transform, and integrate visual and symbolic representations (Kozma and Russell, 1997; Kozma, 2003; Wu and Puntambekar, 2012). This entails 'knowledge about how visual representations depict information about the content' (Rau, 2017, p. 717). Representational competence and conceptual knowledge can co-develop under appropriate instructional conditions and are positively correlated (Edelsbrunner et al., 2023; Edelsbrunner and Hofer, 2023). Without these competencies, students might face the 'representation dilemma' (Rau, 2017).

Lemke (1998; 2004) argues that managing different representations and texts is fundamental to scientific literacy, as 'scientific concepts are articulated *across* [...] the media of representation' (Lemke, 1998, p. 248) and scientific literacy requires translating 'back and

forth among verbal accounts, mathematical expressions and calculations, schematic diagrams, abstract graphs, and hands-on activities' (Lemke, 2004, p. 41). This translational fluency is constitutive of conceptual understanding in many domains.

The benefits of MERs are not without costs. MERs can significantly increase cognitive load, as learners must process multiple interdependent elements, often with unclear relationships or within complex systems (Sweller, 1994; Ainsworth, 2006; Stieff et al., 2011; Pande and Chandrasekharan, 2017; Junior et al., 2022).

Moreover, the effectiveness of MERs depends on presentation mode: sequential formats support *concreteness fading*, allowing learners to progress from concrete to abstract forms, while simultaneous presentation fosters analogical reasoning and structural alignment (Goldstone and Son, 2005; Baddeley, 2012; Fyfe and Nathan, 2019). In both cases, pedagogical scaffolding is essential to manage cognitive load and support representational competence across contexts (Rau, 2020).

These representational and cognitive challenges frame the context in which comics will be examined—not simply as narrative forms, but as potentially integrative visual tools capable of mitigating the limitations of traditional MERs. To fully assess this potential, comics are here situated within the epistemological foundations of data visualisation.

5.2.2. Data Visualisations: Defining the Field

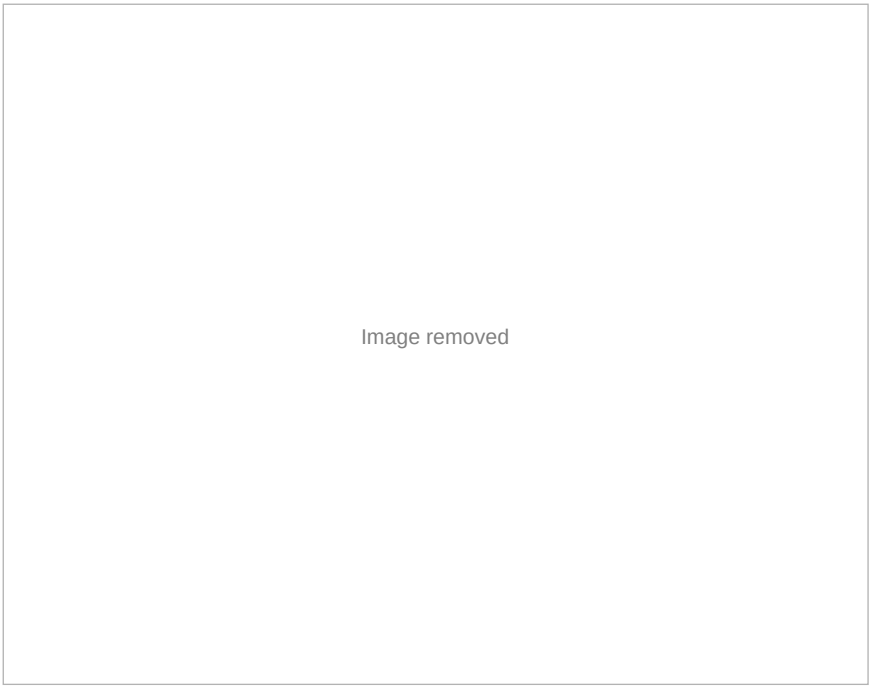


Figure 5-1: 'A Periodic Table of Visualization Methods', developed by Lengler and Eppler (2007), exemplifies the definitional fluidity of the field by mapping a wide range of visual formats across six categories. Interactive version available at: https://www.visual-literacy.org/periodic_table/periodic_table.html (Accessed 13 April 2025).

Building on ERs and MERs, this subsection explores Data Visualisation (DV), a central yet conceptually unstable area in visual knowledge representation. While ERs cover a broad range of cognitive artefacts, DV requires scrutiny due to its increasing pervasiveness and definitional ambiguities (Beer and Burrows, 2013, p. 62). Visualisations generally function within the Data-Information-Knowledge (DIK) continuum, serving as 'means to achieve purposes' (Masud et al., 2010, p. 445) by facilitating analysis, communication, and problem-solving for diverse audiences (Brodlie, 1992, p. 37; Masud et al., 2010, p. 446). DV can surface patterns and anomalies defying prior hypotheses: 'with visualization it jumps right out at you and says, "This is bizarre"' (Bill Stensrud, quoted in Bollier, 2010, p. 11). Yet, visualisations can also evoke an 'unknowability' characteristic of the sublime in the age of big data (McCosker and Wilken, 2014, p. 159).

The term *data visualisation* can refer to a research discipline, a computational process, a communicative artefact, or the resulting image (van Wijk, 2005, p. 79). This definitional fluidity reflects its hybrid, interdisciplinary nature, exemplified by the 'periodic table of visualisation methods' (Lengler and Eppler, 2007), which maps—although not exhaustively—several techniques and formats (see Figure 5-1).

Here, DV is understood broadly, including quantitative visualisations (e.g., charts, dashboards) and qualitative formats (e.g., infographics, conceptual diagrams). These span a continuum from exploratory tools for analysis to expressive devices for communication (Kosara, 2007; Masud et al., 2010, p. 447; Azzam et al., 2013, pp. 7–9; Gray et al., 2016, p. 228; Riche et al., 2018, p. 7; Midway, 2020, p. 2; Few, 2014). Although terminology is contested (Kennedy et al., 2016, pp. 715–716), Cairo (2013, p. xvi) views infographics and DV on a continuum where '**graphics, charts, and maps aren't just tools to be seen, but to be read and scrutinized**' (2013, p. xx). Kosara (2007) also suggests artistic and pragmatic visualisations can be reconciled.

This debate understates the epistemic and cultural dimensions involved. Although often presented as 'objective,'—especially in their more minimal and ascetic manifestations—or as transparent mediator (e.g., Bertin, 1983 [1967]; Tufte, 2007 [1983], 1997), DVs are never a 'neutral window onto data' (Kennedy et al., 2016, p. 719): they are constructed artefacts, relying on shared codes, established conventions, with specific limitations and biases. Data itself is not raw or neutral, but a human-made artefact shaped by collection context, instruments, and socio-political factors, its interpretation subjective and dependent on ideological filters (Woodward, 1989; McAllister, 1997; Lupi, 2017; Cairo, 2019). As Lupi (2017) asserts, '"data-driven" doesn't mean "unmistakably true"—and it never did"'. Data-phenomena reasoning is goal-relative; what constitutes a 'phenomenon' (vs. noise) depends on researchers' interests and frameworks (Woodward, 1989; Glymou, 2000, p. 30). Consequently, visualisations are situated interpretations. DV often introduces interpretative layers, with demands for clarity coexisting with aesthetic and narrative ambitions. DV's hybrid nature is an epistemic feature, operating at the intersection of data, aesthetics, and meaning-making.

5.2.3. Evaluation: What Makes a Visualisation 'Good'?

Evaluating DV effectiveness is complex, as dimensions such as speed, accuracy, engagement, memorability, and insight generation are often in tension, and context-dependent—a visualisation for expert analysis may be ineffective for general communication (Lam et al., 2012; Munzner, 2014; van Wijk, 2005, p. 82). While task performance is quantifiable, the epistemic value of a visualisation—its capacity to support discovery and meaning-making—is less easily captured; current methods assess perceptual accuracy but fall short in evaluating knowledge gained (North, 2006, pp. 6–7; Saraiya et al., 2005, p. 443; Burns et al., 2020, p. 1; Adar and Lee, 2021, p. 948).

Further challenges remain. Aesthetic appeal is a double-edged sword: rich visuals draw attention (de Haan et al., 2018) but may reduce retention compared to text (Du et al., 2019; Won, 2019). Interactive features can hinder understanding for users with low prior knowledge (Boy et al., 2015; Lee and Kim, 2016; Link et al., 2021), with static, self-paced formats sometimes yielding better results (Tversky, 2001; Tversky et al., 2013). Layout and data density also affect performance, though not always predictably (Ryan, 2016; Majooni et al., 2018).

Narrative visualisations add complexity. While increasing engagement (Wang et al., 2016), distinguishing between 'good visualisation' and 'good narration' is critical, as the two do not always align—particularly when both are expected to contribute to meaning-making (Holmes, 2014, p. 5). Brigham (2016, p. 216) further argues that narrative visualisations should not only convey information but also suggest possible courses of action. These additional expectations further complicate evaluation.

Moreover, user interpretation remains a largely uncontrolled variable. Cultural background, familiarity with conventions, and levels of visual literacy all mediate the reception and usefulness of a visualisation (Harley, 1989; Hullman and Diakopoulos, 2011; Franconeri et al., 2021). Generalising Harley's (1989, p. 3) suggestion, users must often learn to 'read between the lines of the map—"in the margins of the text"', interpreting not only what is shown but what is omitted.

Ultimately, as van Wijk (2005, p. 85) observes, DV's 'goodness' is always contingent on task, audience, and purpose: visualisations function as situated communicative acts (Kosslyn, 2006, p. 30; Dörk et al., 2013, p. 2013; Burns et al., 2020; Qin et al., 2020, p. 94).

5.2.4. From Practice to Theory: Pragmatism, Aesthetics, and the Myth of Objectivity

DV is strongly influenced by practice and 'rules of thumb', sometimes explicitly rejecting academic theorisation. Design principles are rarely codified but emerge from experience, taste, and iterative refinement (Kimball, 2013, p. 4): attempts to systematise these (Kimball, 2013) have resulted in thematic clusters such as likeness, composition, architecture, *Gestalt*, grouping, and spatiality (Figure 5-2), that do not exhaust the practice. Indeed, designers often rely on experience, data-driven improvisation, and even drawing as a reasoning tool (Berger, 2005, p. 43; Kantrowitz, 2022; Parsons, 2022, pp. 665–672) while many designers favour intuition and aesthetics over rigid rules (Lima, 2013). This preference reflects a well-known gap between formal design research and everyday practice (Parsons, 2022, p. 665), further underscored by the fact that influential authors in the field, such as Edward Tufte and Alberto Cairo, have maintained limited or indirect connections to traditional academia.

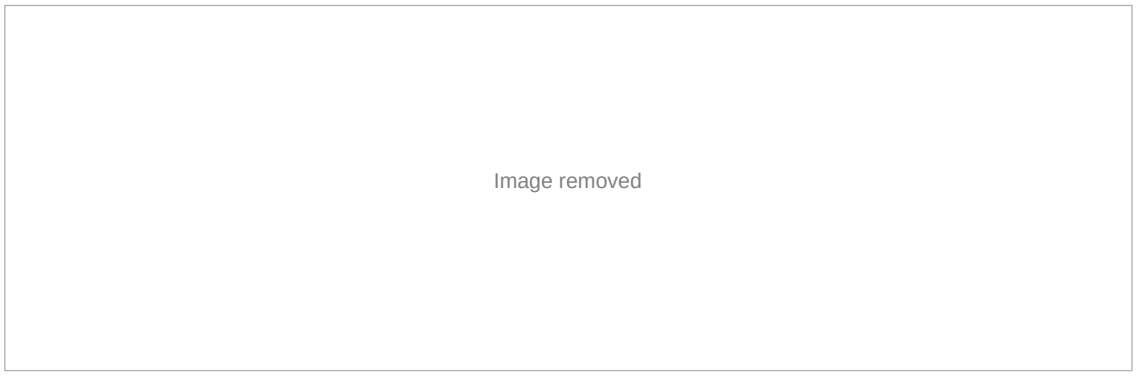


Figure 5-2: Design principles categorised by thematic clusters, illustrating the range of concepts often invoked in data visualisation practice. Source: Kimball (2013, p. 27).

Nevertheless, attempts to 'scientise' DV have been influential. Minimalist principles, formalised by Bertin (1983 [1967]) and Tufte (2007 [1983]), prioritise clarity through monosemic signs and the elimination of visual 'noise.' Bertin's semiology distinguishes rational graphics (unambiguous) from figurative art (subjective), positioning the former as the sole valid tool for knowledge production (Bertin, 1967, p. 2; Rod, 2001, p. 9). Tufte (2007 [1983], p.

51), states, 'graphical excellence requires telling the truth about data', achieved by maximising the data-ink ratio. Figurative representations are dismissed as distractions that invite polysemic interpretations (Floch, 1990, p. 14; Burgio, 2019, pp. 148–149). In other words, between *abstract DV*—which shows the relationships between data—and *figurative representations*—which form resembles the form of the represented object—the theoretical/practical approach of Bertin and Tufte excludes the latter altogether (Byrne et al., 2019).

This stance, however, is both ideologically loaded and empirically contested**.** Tufte's arguments often resemble 'aphorisms and epigrams' rather than rigorous theory, leaving practitioners disoriented when applying his principles to real-world data (Cairo, 2013, pp. 64–65). Studies show the data-ink ratio (proportion of ink for essential data vs. total ink) neither guarantees clarity nor memorability; embellishments like figurative icons can enhance comprehension without sacrificing accuracy (Bateman et al., 2010; Li and Moacdieh, 2014; McGurgan et al., 2021, pp. 192–193). This aligns with theoretical arguments suggesting that iconic representations, by resembling what they stand for, are inherently more intuitive and less cognitively demanding than purely abstract symbols (Kramer, 2024). As Cairo (2013, pp. 65–66) argues, 'resources considered by Tufte to be non-data ink [...] might not be junk at all. Far from obstacles to understanding, they may *enhance* understanding'.

In practice, figurative and narrative elements historically play critical epistemic roles. For example:

- Northway's 1953 sociograms, revised with stylised faces, improved both readability and interpretive depth (Lima, 2013, pp. 77–79).
- Keller and Keller (1993, p. 11) demonstrated that replacing abstract temperature grids with images of physical circuit components (e.g., resistors, transistors) shifted focus from 'relative values to meaning', enabling novices to contextualise thermal data and experts to evaluate operational impacts.
- Ware (2012b, p. 20) notes that figurative icons excel in pedagogical contexts, where intuitive comprehension outweighs analytical precision.

Furthermore, the analytical approach is not the only path to understanding: while images may lack the precision of numbers or words, accuracy does not equate to truth. As Drucker (2014, p. 118) notes in her reading of Fludd's *Meteorology* (1626), its scientific imprecision is offset by its imaginative richness (Figure 5-3).

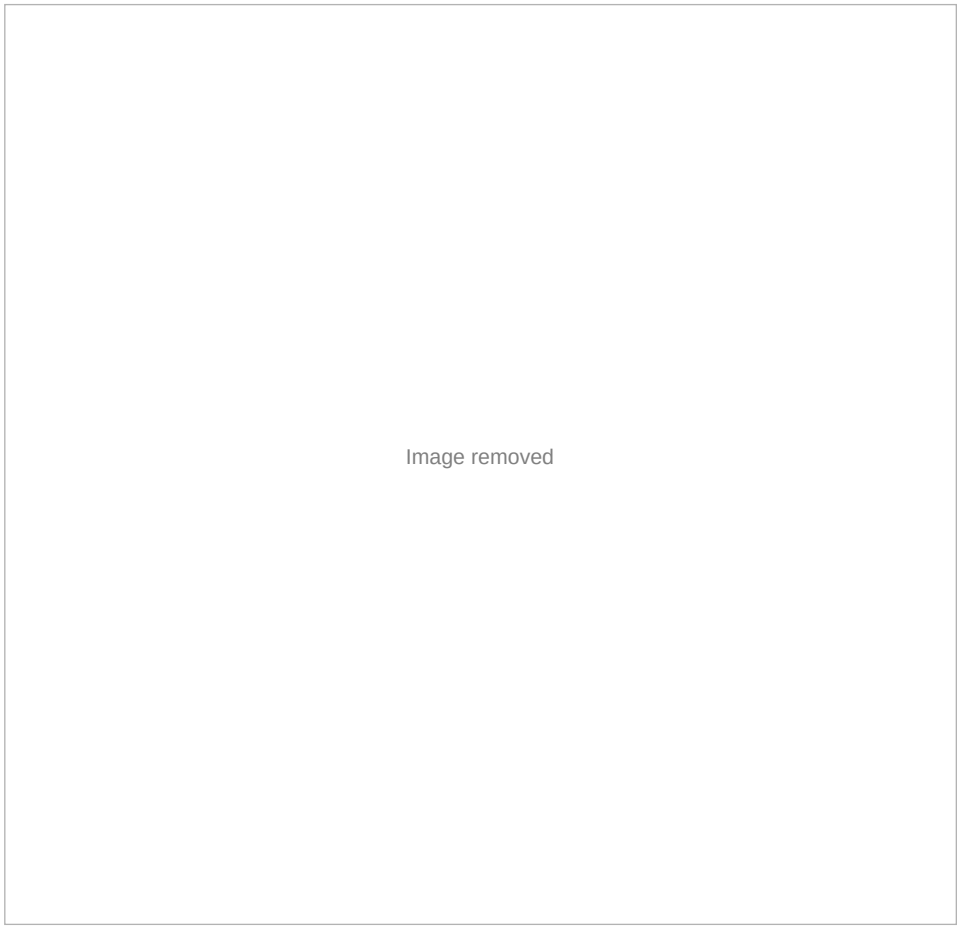


Figure 5-3: Robert Fludd, *Philosophia sacra et vere christiana seu meteorologica cosmica* (Frankfurt: T. de Bry, 1626). This meteorological chart exemplifies how imaginative and figurative visual strategies historically served epistemic purposes, even when lacking scientific precision. Source: https://www.reiss-sohn.de/en/lots/9454-A202–549/ (Accessed 13 April 2025).

The minimalist dogma also perpetuates data objectivity myths. Minimalist aesthetics (clean layouts, geometric forms) are deployed to signal neutrality, even while encoding cultural/political assumptions (Kennedy et al., 2016, pp. 719–723). Because DVs work well in representing 'wholly contained worlds' and less in representing uncertainty and lack of data (D'Ignazio, 2015), visualisations are often perceived and accepted as *facts*, 'because they are generalized, scientific and seem to present an expert, neutral point of view' which pretends to

generate the illusion of seeing the world 'from the perspective of no person, no body' (D'Ignazio, 2015). This illusion of objectivity echoes Haraway's (1988, p. 581) concept of a divine eye seeing 'everything from nowhere'. This fantasy of 'mapping the unmappable' (King, 2000) or achieving 'total knowledge' (McCosker and Wilken, 2014, p. 162), shapes DV as a techno-epistemological mirage, driven by the desire for a higher, *total* understanding of the world.

This approach aligns with a first DV wave, which, consistent with a 'less-is-more' ethos, emphasised minimalism, clarity, and the suppression of visual noise, while a second wave embraces interpretive richness and aesthetic complexity, recognising that embellishment can aid comprehension. Ciuccarelli and Elli (2019, p. 302) link this evolution to two waves of digital humanities: the first quantitative and formal, the second qualitative, emotional, and speculative. This second wave is what this thesis terms *post-minimal visualisation*: an approach that does not reject clarity as a value but refuses its status as the sole epistemic criterion, embracing instead informational density, figurative representation, aesthetic complexity, and productive ambiguity as legitimate—and in some contexts epistemically superior—tools for structuring knowledge. It is within this emerging paradigm that the claims for comics as a model for humanistic visualisation, developed in the following section, find their most natural theoretical grounding. Indeed, as Ciuccarelli and Elli note, encoding data does not guarantee understanding; supporting interpretive reasoning is essential. This shift is echoed by the rise of *data humanism* (Lupi, 2017) and feminist critique (D'Ignazio, 2015; D'Ignazio and Klein, 2016; D'Ignazio and Bhargava, 2020), which support the post-minimal move by questioning 'impersonal' technical approaches, embracing slowness and information density, and using non-linear narratives to reveal interconnectedness. Lupi (2017), for example, advocates for deliberately personal, even handcrafted approaches to data—treating the act of visualisation as a form of reflection that restores individuality to data subjects and resists the depersonalising effects of automated chart generation. This human-centred perspective reframes DV from simple information transmission towards creating rich, layered, and critically-aware meaning-making experiences. In a post-digital media ecology, as Manovich (2013) and Lima (2013) argue, visualisations must evolve beyond reductive clarity to enable spatial, exploratory, and

interpretive forms of reasoning. Furthermore, to meet contemporary demands, they must also embrace aesthetic diversity, narrative openness, and slower, more reflective modes of meaning-making.

5.3. Comics as a Model for ‘Humanistic’ and Post-Minimal Visualisation

5.3.1. Introduction: Beyond Clarity, Towards Interpretive Richness

This section critiques how Tufte's framework, and similar minimalist approaches, indirectly shape the reception of comics in DV contexts and argues for comics' potential as a richer, more humanistic model, especially in the context of the second wave of DV. The phrase *beyond clarity*, used as an orienting concept throughout this section, does not imply a rejection of legibility or communicative precision. It refers, rather, to a critical position that refuses to treat clarity as the primary or sufficient measure of visualisation's epistemic value. As argued in Section 5.2.4, the minimalist tradition has historically equated clarity with objectivity and authority, marginalising representational modes—including comics—that embrace figuration, polysemy, or interpretive openness. To move beyond clarity is to recognise that, for complex, multi-layered, or contested phenomena, interpretive richness can be epistemically more powerful than univocal readability: it activates inference, sustains engagement, and makes visible what monosemic signs suppress.

While Edward Tufte does not directly analyse comics in his published works, his views on visual clarity and credibility indirectly shape how comics have been received in the context of DV. Responding to a reader on his blog, Tufte (n.d.) acknowledged that a 'cartoon style' might explain things, he suggested it would 'compromise the credibility' of serious scientific evidence, thereby relegating comics to explanation rather than investigation and reinforcing a binary between figurative styles and those deemed appropriate for scientific authority. This view is echoed even by Tufte's critics, like Cairo (2013, pp. 65–66), who, while opposing the data-ink ratio, cautioned against 'cramming charts with cartoons and illustrations'.

Concerning DC, Segel and Heer (2010), influential in this field, reference Tufte's (2007 [1983]) *Visual Display of Quantitative Information*, specifically his analysis of 'Life Cycle of a Beetle Through a Year' (Figure 5-4), which Tufte himself identifies as a 'space-time-story graphic' rather than explicitly as comics (Tufte, 2007 [1983], p. 43). This example, however, much like their broader treatment of comics, enacts a rhetorical closure, guiding users through

a linear narrative without exploring visual interpretation or polysemy, thus influencing comics' classification as primarily author-driven (see Section 4.3).

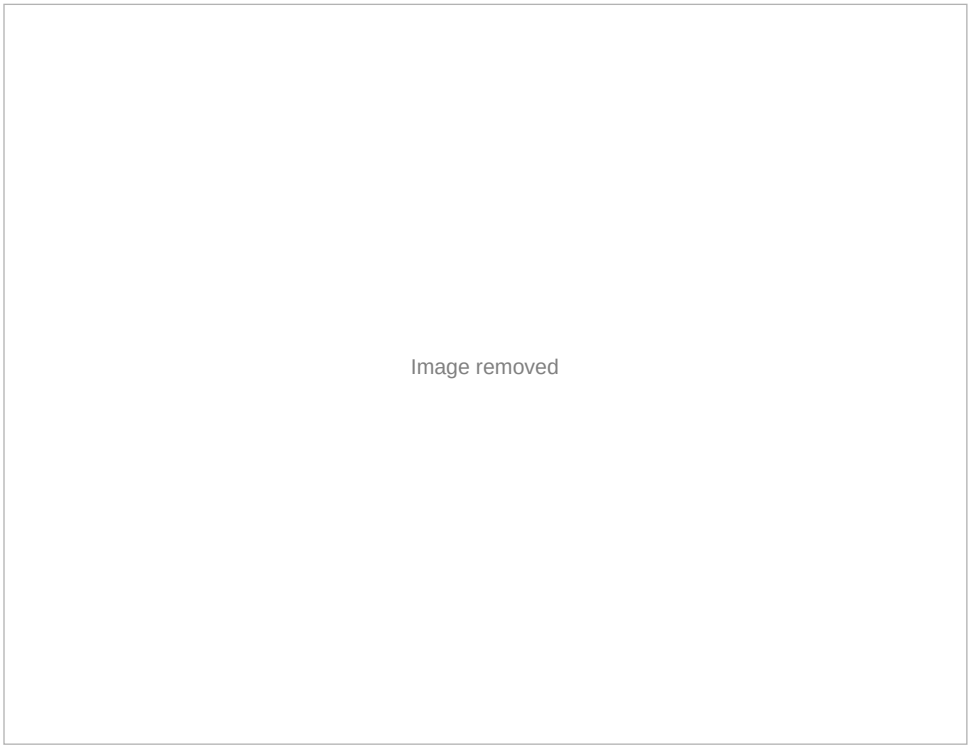


Figure 5-4: 'Life Cycle of a Beetle Through a Year', from Edward Tufte's *The Visual Display of Quantitative Information* (2007 [1983], p. 43). Tufte describes this as a 'space-time-story graphic' that combines vertical spatial and horizontal temporal axes in a closed, linear narrative form.

A comparable minimalist logic runs through the theoretical work of Scott McCloud on comics—most explicitly when he affirms that (Figure 5-5):

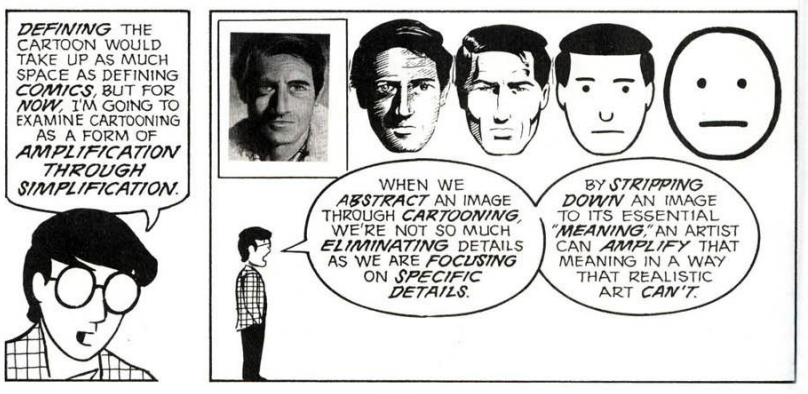


Figure 5-5: Excerpt from *Understanding Comics* (McCloud, 1994 [1993], p. 30), illustrating the principle of 'amplification through simplification'.

Consequently (Figure 5-6):

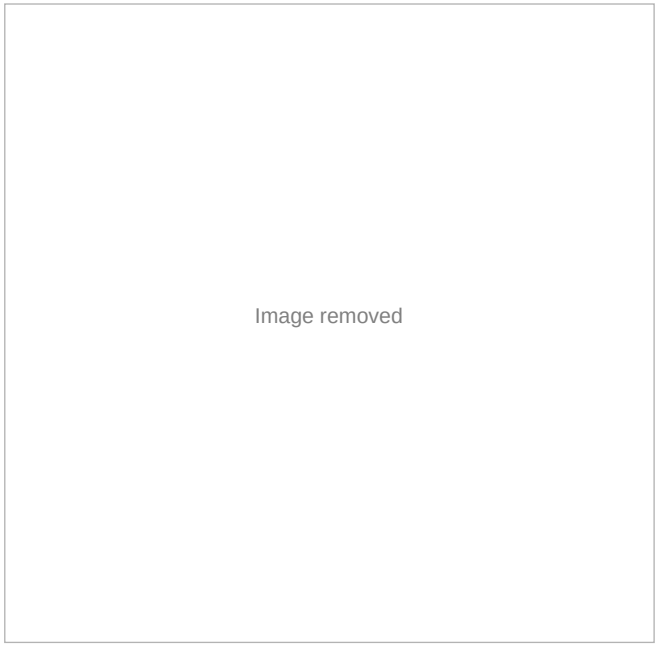


Figure 5-6: Excerpt from *Understanding Comics* (McCloud, 1994 [1993], p. 36), contrasting simplified and realistic styles to question visual credibility.

Like Tufte's works, McCloud's are anecdotal. So, when the author asks his readers 'Would you have **listened** to me if I looked like **this**??' (McCloud, 1994 [1993], p. 36) the answer is uncertain, to say the least, and depends more on personal inclinations, cultural and geographical influences, prior knowledge and other subjective factors (e.g., what and how much data/information is needed and why) than on an immovable truth. As with DV, there is no fixed 'rule' in comics and, although minimal, synthetic and 'subtractive' styles are part of the medium's repertoire, they are not the only ones.

This section, therefore, building upon the reconceptualisation of comics in Chapter 4, analyses how the medium's inherent representational strategies offer a model for richer, more complex, humanistic, and emotionally resonant visual communication, moving beyond minimalist dictates. It examines how comics' handling of figurativeness, ambiguity, multimodal integration, and subjectivity contributes to their unique positioning within the DV sphere.

5.3.2. Figuration as Epistemic Strategy



Figure 5-7: Shane Simmons, *The Long and Unlearned Life of Roland Gethers*, from *Longshot Comics* series (2018 [1993], p. 7). Extract from a minimalist, mock-epic comics that follows a Welsh coal miner through 89 years of British history (1860–1949). Composed of 3,840 identical panels where all characters are rendered as dots, the work leverages narrative breakdown and the instrumental pause of the panel gap to create humour and pathos from its radically abstract visual form.

A key element distinguishing comics from minimalist DV, which often favours abstraction, is their *intrinsic predilection for figurativity*. Although abstract, non-narrative (as seen in Section 4.8), or almost non-figurative comics exist such as Shane Simmons's *Longshot Comics* (2018 [1993]) (Figure 5-7), comics remain a predominantly figurative medium. When translated from entertainment to education, analysis, or exploration—thus entering DV's orbit—their representational orientation is a fundamental epistemic resource, not mere 'embellishment', aligning with the broader epistemic role of images.

As discussed in Chapter 4, figurative images in comics function relationally, producing meaning through spatial and sequential connections with other elements, much like components of a diagrammatic system leveraging simultaneous and spatial presentation (Krämer, 2017). This relational structure enables comics to represent not just isolated events, but the interconnectedness of lived experience from multiple perspectives, capturing gestures, environments, emotions, and temporal layers as parts of a meaningful whole—such as in Ware's memorial labyrinths—or the intricacy of complex cosmological and conceptual phenomena, as in the multi-scalar mappings of *Alpha…Directions*.

Within this framework, representational images play central epistemic roles. First, by depicting embodied interactions and affective cues, they foster empathy and emotional resonance, establishing a human connection often absent in abstract systems and providing contextual anchoring, aligning with human-centred visualisation. Second, figurative representation acts as a cognitive bridge; grounding abstract ideas in recognisable forms facilitates access to complex concepts, resonating with the value of iconicity where *showing* supports intuitive and situated *understanding*, rather than merely *symbolising* or *illustrating*. This function exemplifies what Krämer (2017) terms *operative iconicity*—the capacity of images to act as active cognitive instruments rather than passive representations, doing epistemic work through their visual form (see Section 3.3). In comics, this principle is embedded in the medium's structure: layout, panel configuration, and spatial arrangement are not neutral containers but active operators that organise the reader's cognitive engagement, enabling the kind of *seeing-with* elaborated by Alloa (2021a).

Finally, figurative imagery conveys contextual thickness—embedding data or ideas within rich visual environments that include spatial, emotional, and epistemic cues. In this sense, such images perform a function akin to what Clifford Geertz (1973, pp. 3–30) famously termed *thick description*: they do not simply depict events or concepts but situate them within a culturally and experientially meaningful frame, enabling multi-layered interpretation. Moreover, adopting a more detailed figurative style, beyond merely conveying 'thickness', can offer additional layers of information that are not necessarily ancillary. Such detail might help to capture the broader context of analysed phenomena, visualise correlations between context and 'raw' data, or even account for degrees of uncertainty and incompleteness, thus making broader sense of the data itself.

Importantly, this capacity to visualise interconnectedness extends beyond narrative or personal domains. Comics' relational visual logic also allows them to represent complex systems and abstract structures, much like established diagrammatic or notational systems that harness spatial arrangement to manage complexity. In this way, representational comics offer not only emotional engagement, but also an alternative visualisation form for exploring relationality across domains—bridging the gap between the experiential and the analytical.

5.3.3. Embracing Interpretive Ambiguity

In sharp contrast to DV minimalism's pursuit of univocal clarity, comics are fertile ground for *productive ambiguity* and interpretive complexity, a characteristic aligning with the pedagogical value of uncertainty (see Section 3.5). This interpretive richness stems from the inherent polysemy of the figurative image (allowing inference within the image itself), the complex verbal-visual interactions (see Section 4.2), and the active reader's role in filling narrative and spatial gaps.

Productive ambiguity, as used here, is a technical concept distinguishing deliberate interpretive openness from mere vagueness or imprecision. A representation is productively ambiguous when its resistance to a single, fixed reading is not a failure of design but a feature: it activates the reader's inferential engagement, sustains multiple legitimate interpretations, and generates meaning through what is left open rather than what is explicitly stated. This is distinct from confusion or incoherence. Productive ambiguity is controlled, structured, and epistemically motivated—it places the burden of inference on the reader in a way that deepens rather than obstructs understanding.

This interpretive openness, far from being an obstacle, stimulates critical thinking and active exploration. Moreover, the potential visual and graphical density of comics (cf. Wolk, 2007, p. 129; and Rabkin, 2009, p. 37) allows for representing complexity without necessarily oversimplifying, offering a model for visual communication that invites deep engagement rather than mere decoding.

5.3.4. Multimodality and Layered Meaning

Comics' *intrinsic and sophisticated multimodal integration* further positions them as a model for richer visualisation. Unlike forms that merely juxtapose text and image, comics natively fuse verbal, iconic, and spatial codes into an interdependent system (Chapter 4, particularly Sections 4.2, 4.3, and 4.4), often produced by the 'same hand behind both text and image' (Tufte, n.d.), ensuring visual coherence. This integration can extend to diverse graphical materials, creating mixed-media artefacts (Pedri, 2017) as exemplified by *Le Photographe* (Guibert and Lefèvre, 2003), which blends drawing and photography to create a layered narrative alternating between subjective rendering and documentary record (Figure 5-8).

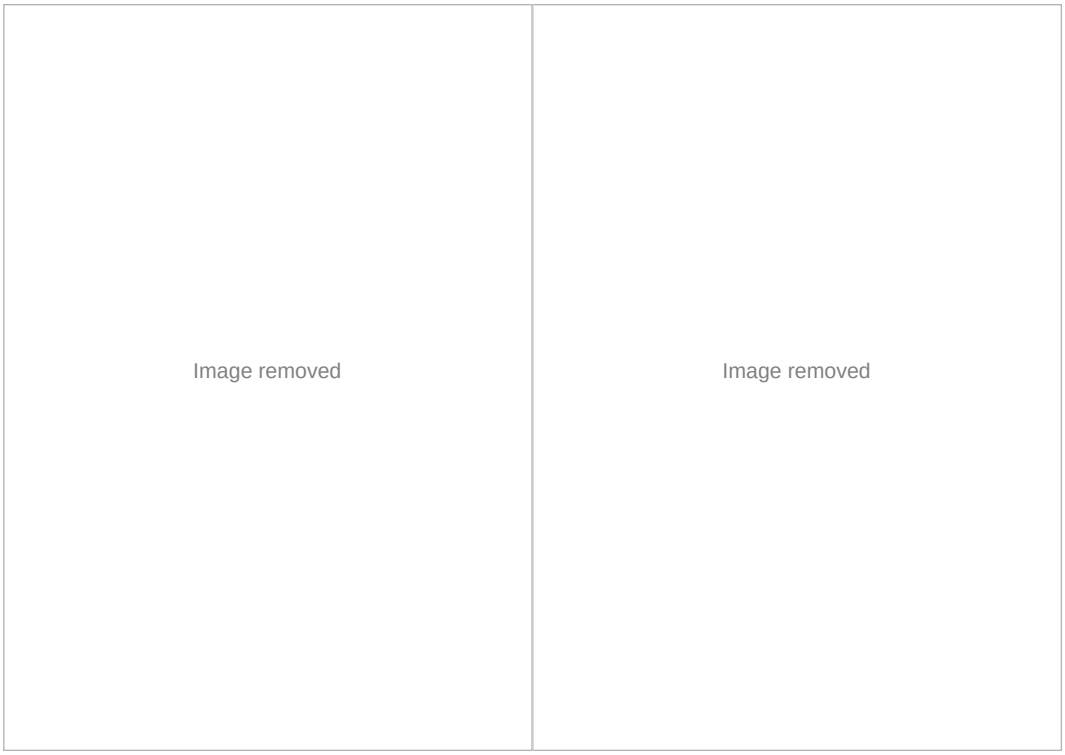


Figure 5-8: *Le Photographe* (Emmanuel Guibert, writer/artist; Didier Lefèvre, photographer, 2003, pp. 22–23). Double-page spread combining illustrated panels and original black-and-white photographs to document a *Médecins Sans Frontières* mission in 1980s Afghanistan. The work exemplifies comics' potential for layered multimodal storytelling that integrates subjective rendering with documentary realism.

As discussed, meaning in comics emerges not from the simple sum of parts, but from the complex and dynamic interaction between these different codes, orchestrated by the spatial

arrangement (layout). This synergy allows for the creation of multiple layers of reading and meaning, engaging the reader with narrative, visual detail, compositional structure, and thematic resonances simultaneously, thereby requiring and cultivating multimodal literacy competencies. It is precisely from this layered and multimodal interaction—the synthesis across textual, visual, and spatial dimensions—that the comics-fact can arise as a distinct moment of insight or affective resonance. Consequently, comics can manage dense and complex information through this integrated structure without necessarily sacrificing engagement, aligning with demands for less reductive and 'denser' visualisation approaches such as *data humanism*, discussed in Section 5.2.4. In summary, the native multimodal integration of comics offers a powerful example of how different communicative codes can work together synergistically to create interpretive depth, providing a robust model for overcoming the text-image dichotomy often limiting other forms of visual communication.

5.3.5. Subjectivity, Point of View, and Manifest Artificiality

Comics' foregrounding of subjectivity and constructedness inherently challenges DV minimalism's 'myth of objectivity'. While minimalist DV feigns neutrality, comics rarely hide their constructed nature, shifting from 'image-as-presentation to image-as-process' (Daston and Galison, 2021, pp. 382–383). In fact, they are a 'conspicuously artificial form', eschewing an aesthetic of transparency (Chute, 2016, p. 17).

This emphasis on constructedness extends to formal aspects. Visual choices—line, texture, composition, colour, layout—act as interpretive filters, shaping perception and emotion, articulating point of view, and foregrounding representation's situated nature. This 'epistemic honesty' becomes a resource, inviting critical awareness about representation and promoting visual literacy, aligning with demands for ethical, reflective visualisation practices. Unlike neutral presentations that risk alienating audiences (Carrada, 2006, p. 30), comics' management of subjectivity is integral to their communicative power.

Graphic style in comics operates as more than aesthetic preference. Carney (2008, p. 195) terms this *graphication*: the author's distinctive visual imprint—line quality, spatial density, degree of abstraction, chromatic register—which functions as what Lefèvre (2011, p. 31) calls a 'visual ontology', a structuring lens through which all depicted content is filtered and interpreted. Graphication is not decorative but epistemic: it shapes what the reader perceives as significant, how emotional distance or proximity is calibrated, and what degree of stylisation signals reliability or subjectivity. As such, it is a complex, polyphonic filter modulating interpretation at every level of the page. While some suggest style's significance lies more in the conceptual problems an image addresses and the experimental solutions it facilitates than in inherent qualities (Tore, 2007), stylistic choices are not indifferent. Furthermore, comics' intrinsic *polygraphy* (Smolderen, 2014; Grennan, 2023)—hosting different styles within one work—allows representation of diverse viewpoints or emotional states, underlining constructedness and differentiating comics from DV's usual uniformity. Artists like Spiegelman, Tezuka, Mack, and Mattotti combine styles and layouts referentially or for

dramatic or humorous effect. A particularly clear example is Asterios Polyp (Mazzucchelli, 2009), which uses distinct graphic styles and colour schemes for different characters to visually encode their divergent subjectivities (Figure 5-9). This demonstrates graphication functioning as an epistemic operator: graphic style structures the representation of situated, heterogeneous knowledge—precisely the kind of honesty ECtC must sustain to function as credible tools in HE.

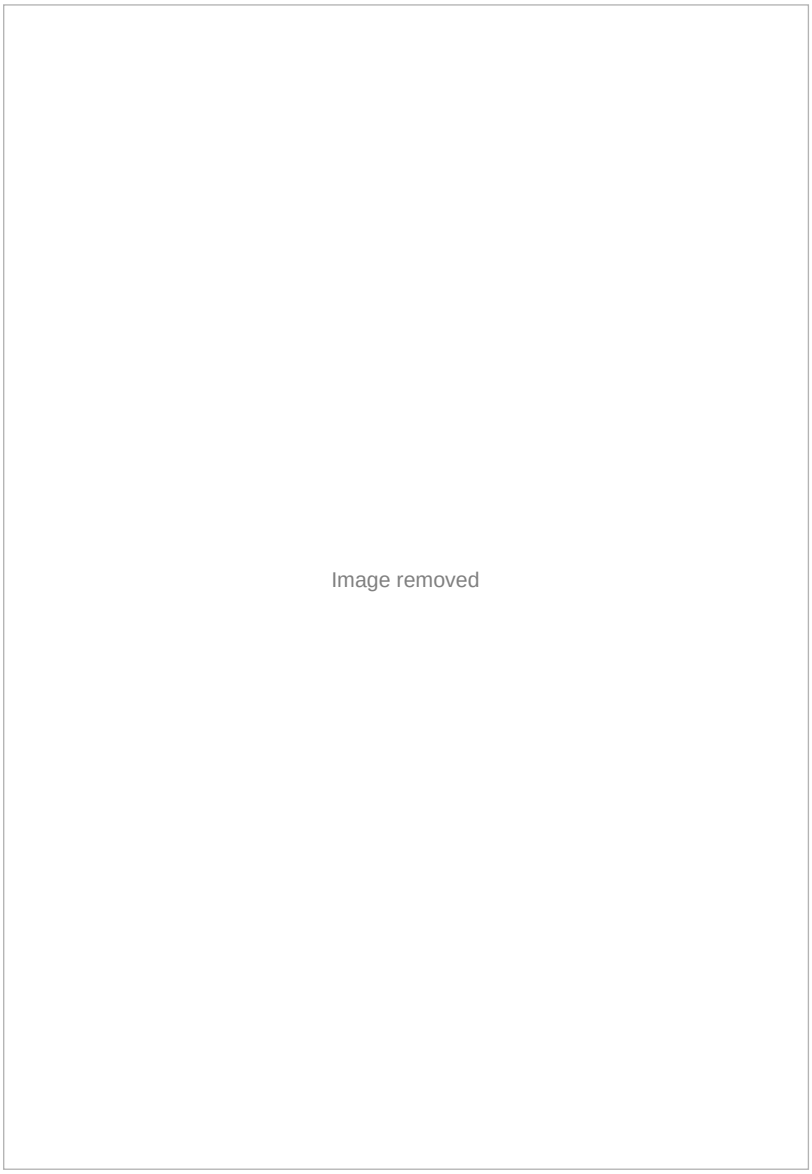


Figure 5-9: *Asterios Polyp* (Mazzucchelli, 2009). Extract showing the use of contrasting graphic styles and colour schemes to visually differentiate characters' viewpoints and personalities.

Comics also employ specific visual techniques for subjectivity. In *Daredevil* (Waid and Martin, 2011), inset panels on a polyptych page visualise the amplified sensory perceptions of the protagonist, a blind superhero with heightened senses; these small, focused panes function like inset maps, magnifying and highlighting Daredevil's specific auditory, olfactory, and tactile perceptions, marking a difference between habitual perception and the amplified senses of the blind superhero (Figure 5-10). This technique directly addresses the thesis's research question on epistemic uniqueness: the inset-panel structure represents simultaneously the standard and the augmented, a multi-scalar configuration that minimalist DV—constrained to a single representational register—cannot achieve.

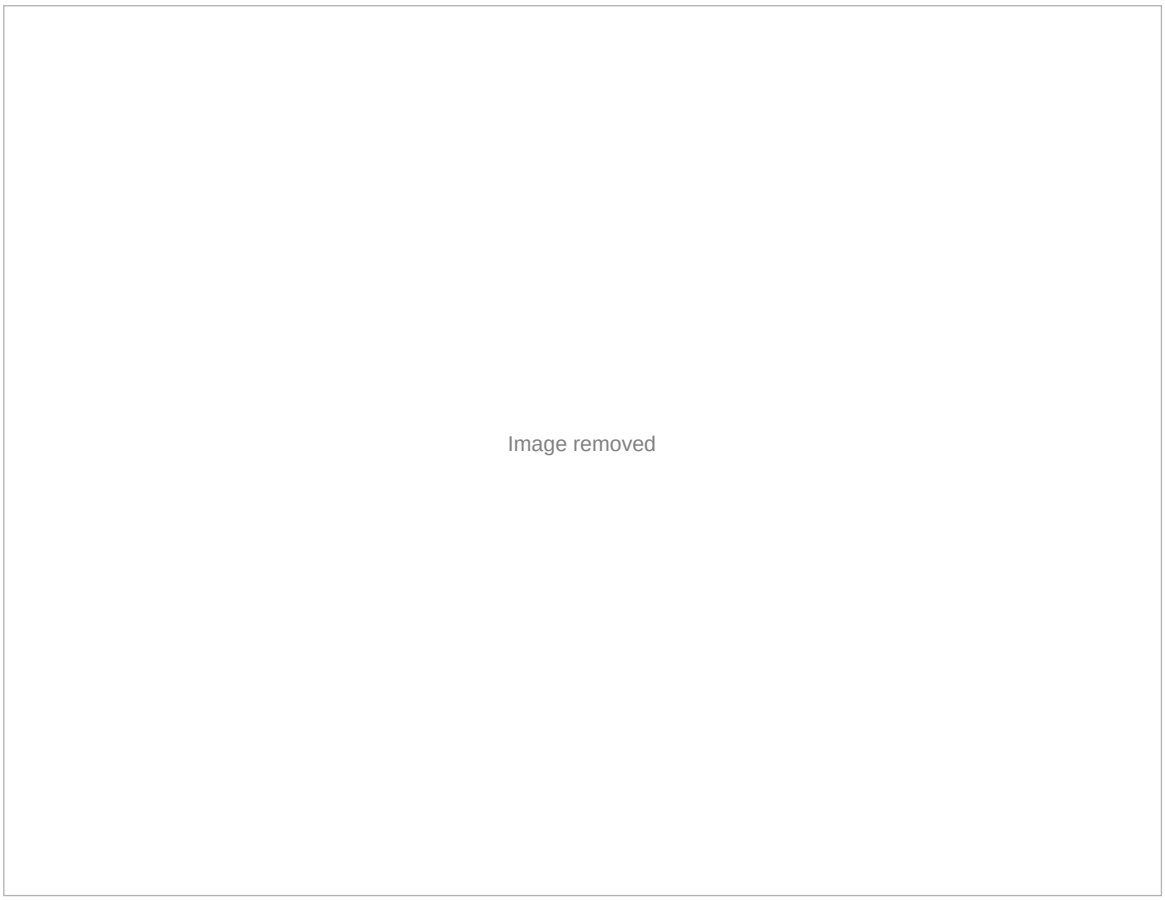


Figure 5-10: 'Sometimes, in my dreams… I can see', in *Daredevil* Vol. 3 #1 (Waid, writer; Martin, art, 2011). Inset panels visualise Daredevil's heightened senses, highlighting specific sounds, textures, and smells as if they were mapped across the city.

In *Doctor Strange* (Aaron and Bachalo, 2015), different colour features distinguish realities: the 'common' world accessible to ordinary senses is shown in black and white, while the invisible world accessible only to the wizard (depicting elements like interdimensional bacteria) is shown in colour, allowing him to act as a kind of human microscope, simultaneously showing the standard view and the 'magically' augmented view (Figure 5-11). This constitutes a worked example of post-minimal visualisation: colour encodes ontological difference, not decorative contrast—demonstrating precisely the kind of layered epistemic work ECtC are designed to perform in contexts where knowledge states resist univocal depiction.

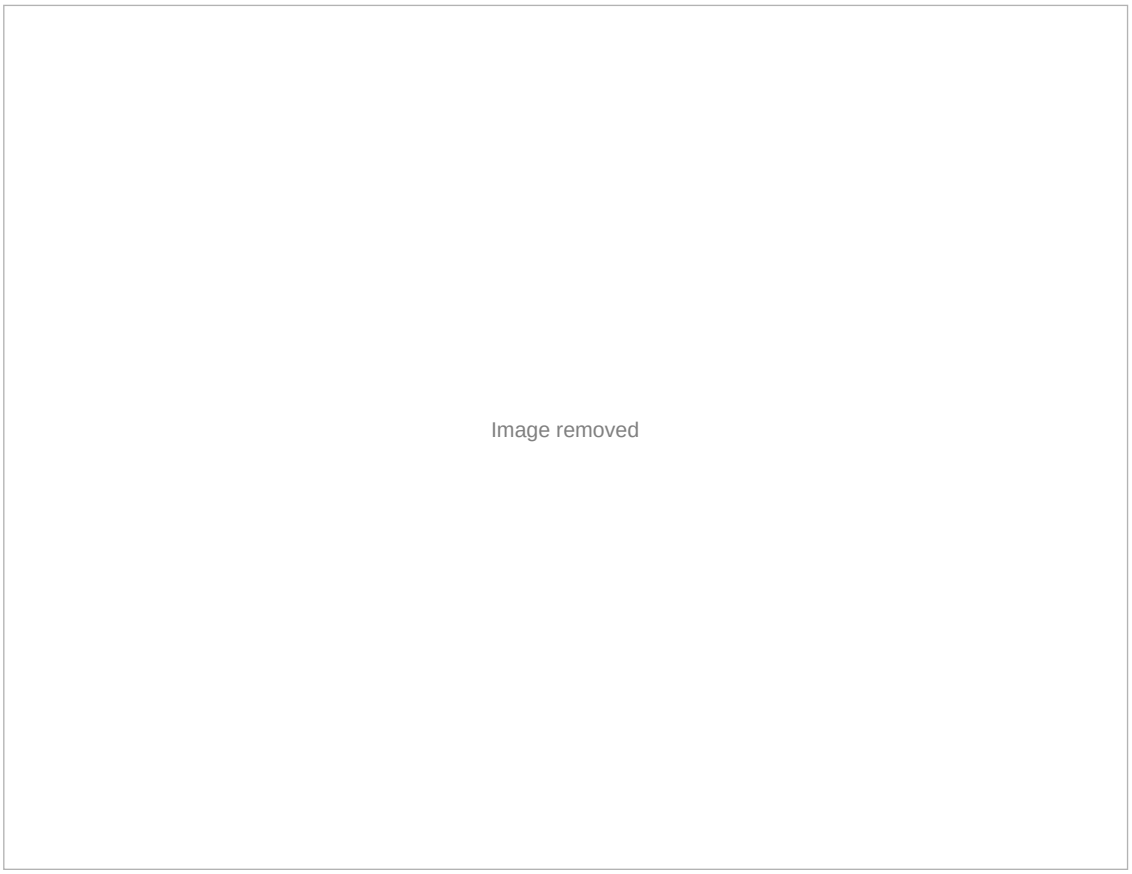


Figure 5-11: *Doctor Strange* Vol. 4 #1: 'The Way of the Weird' (Jason Aaron, writer; Chris Bachalo, art, 2015). Colour differentiation contrasts ordinary and magical perception, visualising interdimensional bacteria perceived only by the sorcerer.

In *Hawkeye* (Fraction and Aja, 2012), inset panels with distinct backgrounds—notably an orange background helping separate them—deconstruct the character's combat process by isolating key perceptual details (such as threats or objects) and moments of internal reflection. This serves to 'slow down' and fragment the main action depicted in the main panels to

provide greater level of detail and focus on specific information (Figure 5-12). The structural logic—simultaneously slowing and fragmenting perception without loss of coherence—directly exemplifies the affordance for 'slowness' and spatial simultaneity that differentiates ECtC from conventional sequential DV, showing how the medium can make the texture of attention itself visually legible.

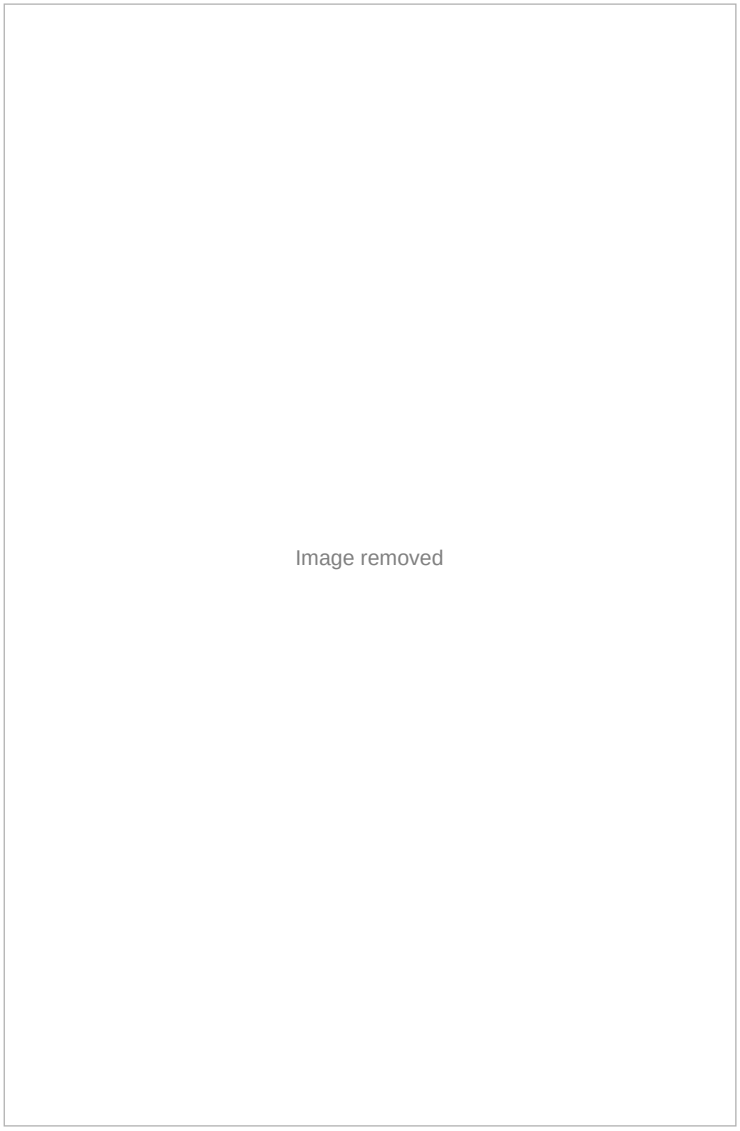


Figure 5-12: *Hawkeye* Vol. 4 #1, 'Lucky: A Clint Barton / Hawkeye Adventure' (Matt Fraction, writer; David Aja, art, 2012). Inset panels with distinct backgrounds deconstruct the protagonist's combat process, isolating key perceptual details (threats, objects) and moments of internal reflection to convey heightened attention and subjective time.

Comics are also particularly well suited to engage with perspectives that go beyond the human, including non-anthropomorphised and post-human ones. In Woodrow Phoenix's *Rumble Strips* (Phoenix, 2008), a pamphlet/documentary about road fatalities, the road is depicted from the subjective viewpoint of the viewer/reader/driver, avoiding most human depiction (Figure 5-13).

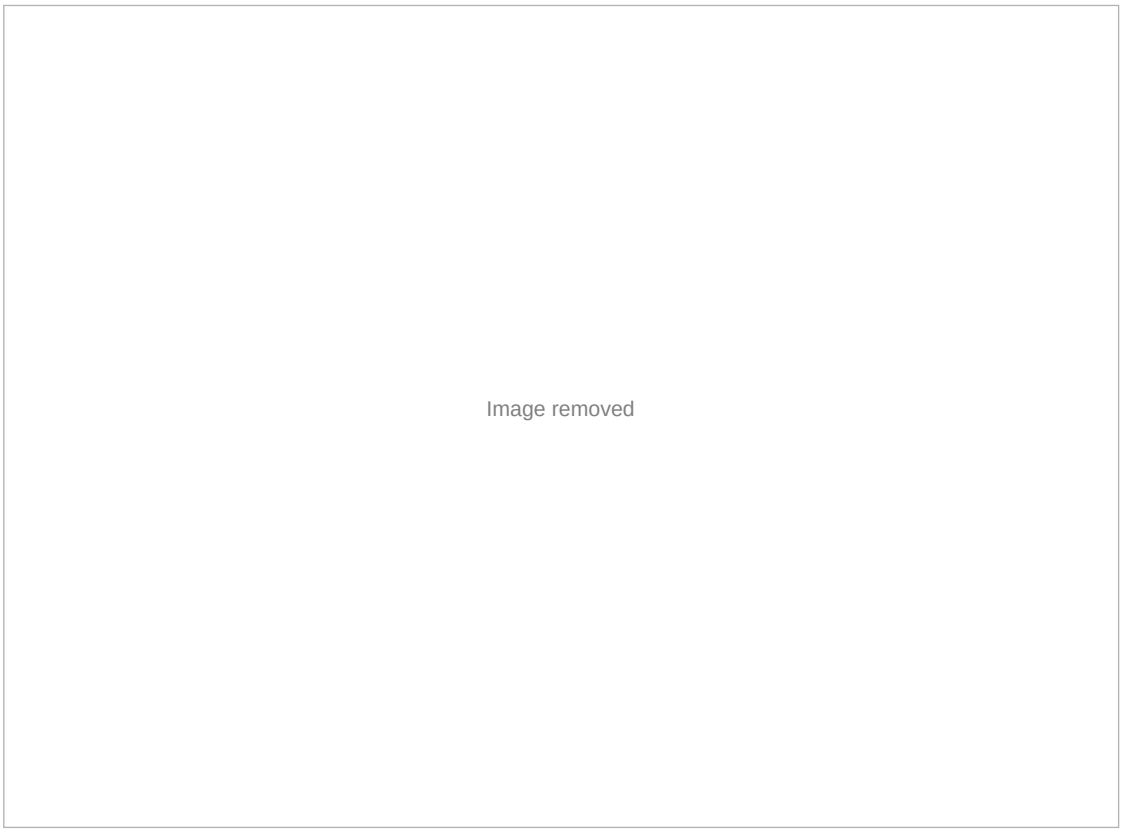


Figure 5-13: *Rumble Strips* (Phoenix, 2008, pp. 120–121). Extract from a comics on road fatalities. The scene visualises the street from a dehumanised viewpoint, adopting the perceptual position of the driver while suppressing direct human representation.

In Martin Panchaud's *La couleur des choses* (2022), the protagonist—similarly to the other human and non-human agents in the book—is visualised as a coloured dot navigating infographic-like scenarios (Figure 5-14).

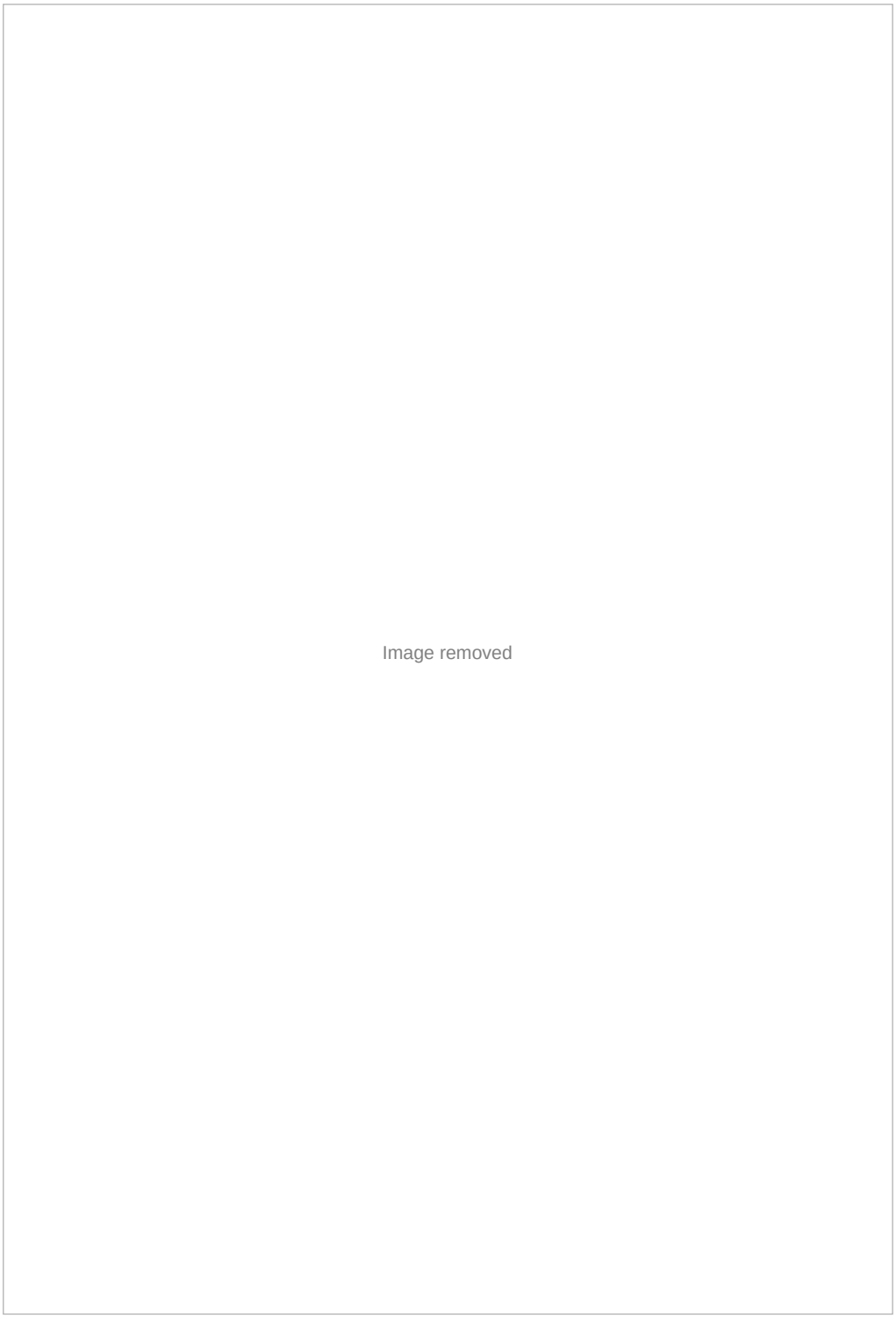


Figure 5-14: *La couleur des choses* (Panchaud, 2022, p. 195). In this infographic-inspired comics, all characters—including the protagonist—are depicted as coloured dots, navigating stylised environments that visualise narrative and spatial dynamics through a powerful diagrammatic suggestion.

.Finally, *Hawkeye: Pizza Is My Business* (Fraction and Aja, 2013) conveys canine perception through icons, scent trails, and spatial cues (see Figure 7-30 in Chapter 7). This capacity reinforces the idea that a human-centred approach to visualisation need not be anthropocentric, and that embracing constructed subjectivities can broaden, rather than limit, the expressive scope of visual communication. In doing so, they expand the epistemic scope available to ECtC: where conventional DV defaults to a disembodied, human-centric viewpoint, these works demonstrate that the medium can adopt and sustain radically decentred perceptual positions—a capacity directly relevant to representing the distributed, multi-scalar, and non-linear phenomena that this thesis identifies as the frontier of visual knowledge work in HE.

5.3.6. Comics as Inspiration: Implications for Data Comics and Advanced Visualisation

This section has preliminarily positioned comics within DV not just as an alternative, but as a rich model offering distinct representational strategies suited for post-digital knowledge communication. Its predilection for figurativity allows communication of context and human experience; its management of ambiguity fosters interpretive complexity and critical thinking; its native multimodal integration creates layered meaning and facilitates insight; and its exhibition of subjectivity and artificiality promotes critical awareness about representation.

These characteristics, rooted in the medium's unique structure (diagrammatic, cartographic, meshwork interface), make comics an epistemic system particularly suited to the complexity, relationality, and multimodality required by new pedagogical frameworks. Comics offer a repertoire of visual and cognitive solutions that can inspire more humanistic, interpretive, and engaging forms of visualisation, possessing their own analytical specificities. Having outlined comics' intrinsic potential as a model for complex visual communication, subsequent sections will use this understanding to critically evaluate current hybridisations between comics and DV, particularly Data Comics, identifying challenges and opportunities for future innovations.

5.4. Defining Data Comics: Origins, Foundational Concepts and Limitations

Data Comics (DC), a recent format, attempts to bridge comics' narrative affordances with Data Visualisation's (DV) informational capacity. Current DC conceptualisations and implementations, however, are often constrained by linear models and a limited understanding of the comics medium, failing to exploit its full epistemic potential. This critique informs the subsequent reimagining of DC, aligning it with Chapter 4's theoretical framework and Chapter 3's discussion of contemporary knowledge communication demands.

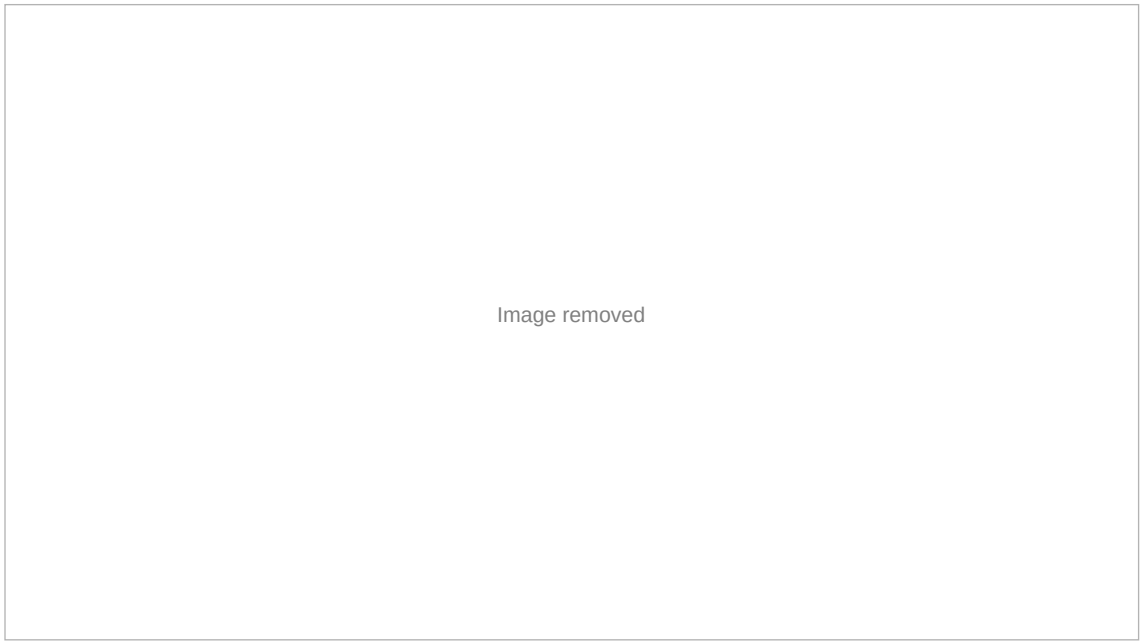
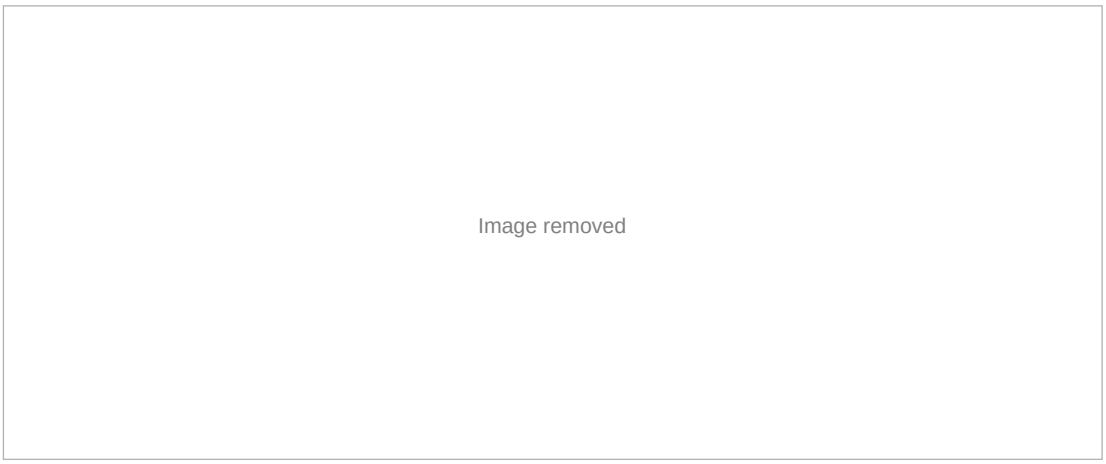


Figure 5-15: Infographic sequences from *House of X* and *Powers of X* (Marvel Comics, 2019), written by Jonathan Hickman with design by Tom Muller and artwork by Pepe Larraz and R. B. Silva. These pages, integrated into the narrative, visualise complex diegetic structures—such as mutant classification, timelines, and protocols—through minimalist data visualisation techniques. They exemplify a fictional use of information design as a narrative and diegetic device.



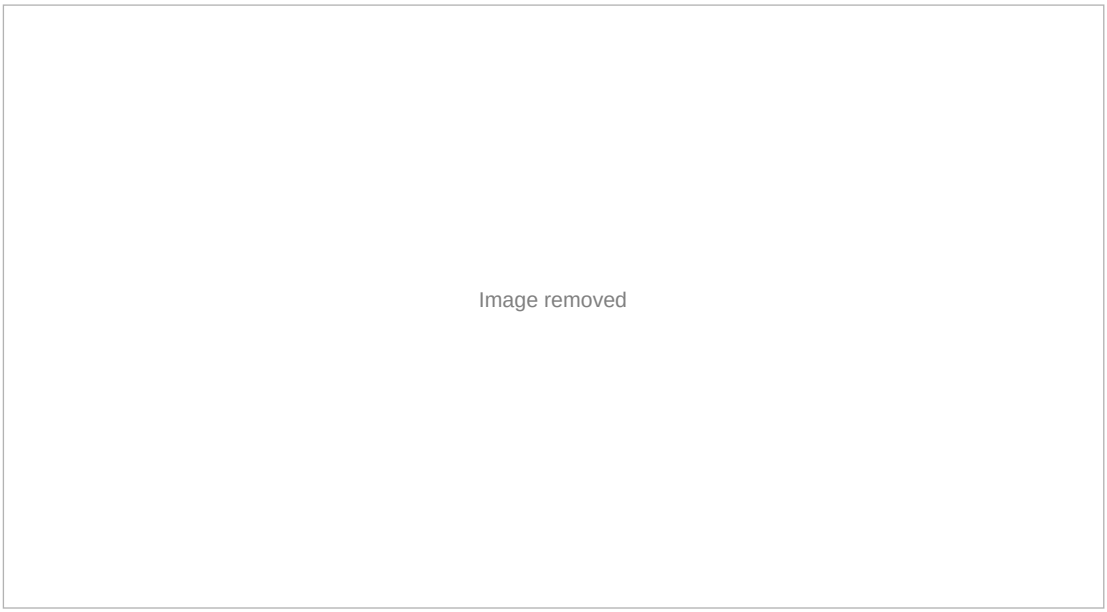


Figure 5-16 Information design in *ODY-C* (2015), written by Matt Fraction and illustrated by Christian Ward (2014). Top: cosmological chart (pp. 1–2) introducing the mythos. Bottom: star map (p. 5) outlining the spatial structure of the setting. These diagrams integrate narrative, spatial, and conceptual information within the comics' layout, illustrating the use of infographics in speculative fiction world-building.

Although precursor examples integrating comics and data displays exist (Jin and Szekely, 2009; Victor, 2011; Bach et al., 2016), and instances of fiction and non-fiction comics integrating DV are not uncommon (Figure 5-15 and Figure 5-16), the term DC gained currency around 2015 (Zhao et al., 2015). Described as 'a vehicle for telling stories about data' (Zhao et al., 2015, p. 1), the format is commonly understood as combining 'techniques from infographics, data visualization, journalism, and other formats of visual explanations [...] based on the notion of a sequence of panels' (Wang et al., 2019, p. 2, emphasis added). Early

conceptualisations appear heavily influenced by Segel and Heer's (2010) classification of comics as primarily author-driven narrative visualisations (see Section 4.3), alongside the legacy of linear and minimalist approaches associated with McCloud and Tufte. Consequently, the perceived benefits of DC are often framed in terms of wide audience engagement, narrative appeal, and assumed ease of readability compared to traditional DV forms like graphs or charts. An influential introductory article by Bach et al. (2017), presented in comics form, identifies four foundational features (Figure 5-17) characterising the perceived strengths of DC:

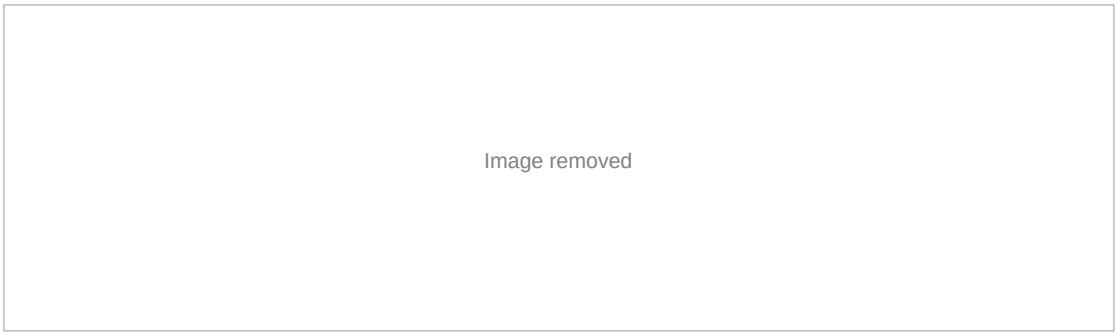


Figure 5-17: The four foundational components of Data Comics, as defined by Bach et al. (2017): *Visualisation*, *Flow*, *Narration*, and *Words and Pictures*. This schema, extracted from a comics-based research article, formalises the hybrid structure of DC by emphasising their multimodal and sequential logic.

Firstly, *Visualisation* is highlighted, ranging from iconic realism to conceptual abstraction, deemed particularly effective for depicting change, akin to Muybridge's photographic sequences. The capacity for simultaneous multiple visualisations (e.g., different graph types or abstraction levels) is noted, resembling the function of MERs in providing diverse perspectives. Secondly, *Narrative* elements, frequently conveyed through explicit narrators ('talking heads') and words (the fourth feature: *Words and Pictures*), provide contextualisation and explanation, mirroring the traditional role of textual components in clarifying visual information. Thirdly, *Flow* (Figure 5-18) is introduced, described as the ability of comics to simplify complex data by segmenting information into discrete panels, adhering to a 'one message per panel' principle. This flow can range from undirected, exploratory sequences to explicitly directed, linear paths guiding readers. However, the authors acknowledge that strict

linearity can be overly simplistic or inadequate for representing the inherent complexity of some data.

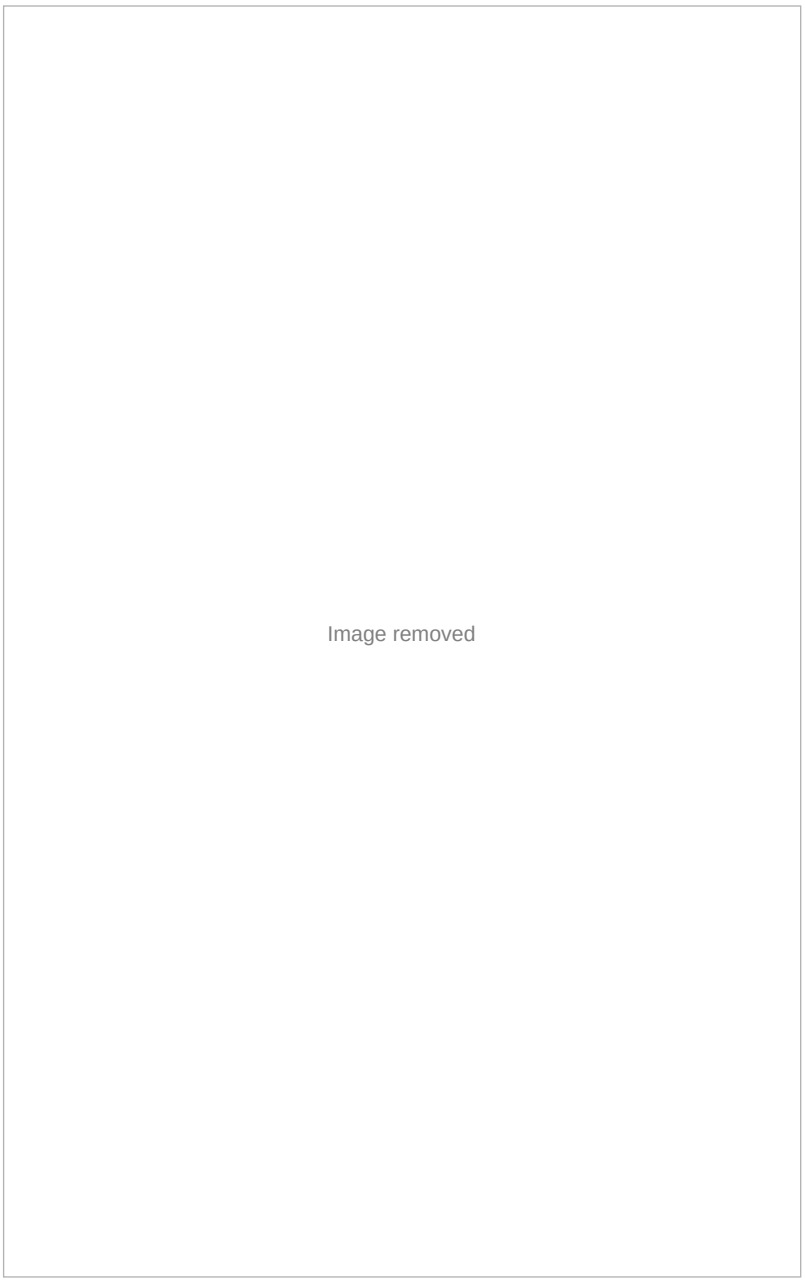


Figure 5-18: Visual model of *Flow* in Data Comics, from Bach et al. (2017). The diagram illustrates a spectrum from undirected to directed panel sequences, framing flow as a structural mechanism for segmenting complex information. Examples include transitions such as moment-to-moment, level-of-detail, or message-to-message, demonstrating how comics guide, complicate, or allow for multiple interpretive paths.

Fourthly, the interplay of these elements aims for an engaging and understandable whole (Figure 5-19).

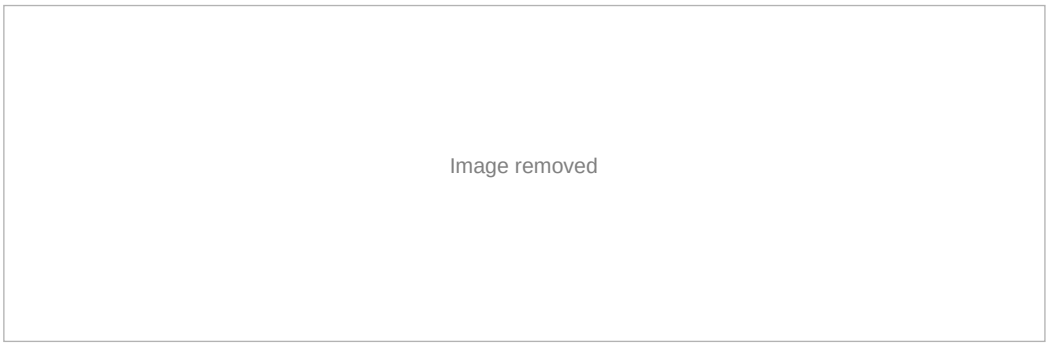


Figure 5-19: Illustration of strategies for combining the four core components of Data Comics, from Bach et al. (2017). The sequence highlights how visualisation, flow, narration, and text-image synergy can be orchestrated through stylistic variation, narrative structures, audience adaptation, and genre blending.

Early DC was thus primarily conceived as a linear container for diverse, often pre-existing, visualisations. The structure typically adheres to an author-driven narrative, with marginal acknowledgement of non-linear possibilities. The distinction between DC and other sequential displays like infographics or small multiples often remains subtle (e.g., Graph Comic; Bach et al., 2016. See Figure 5-20).

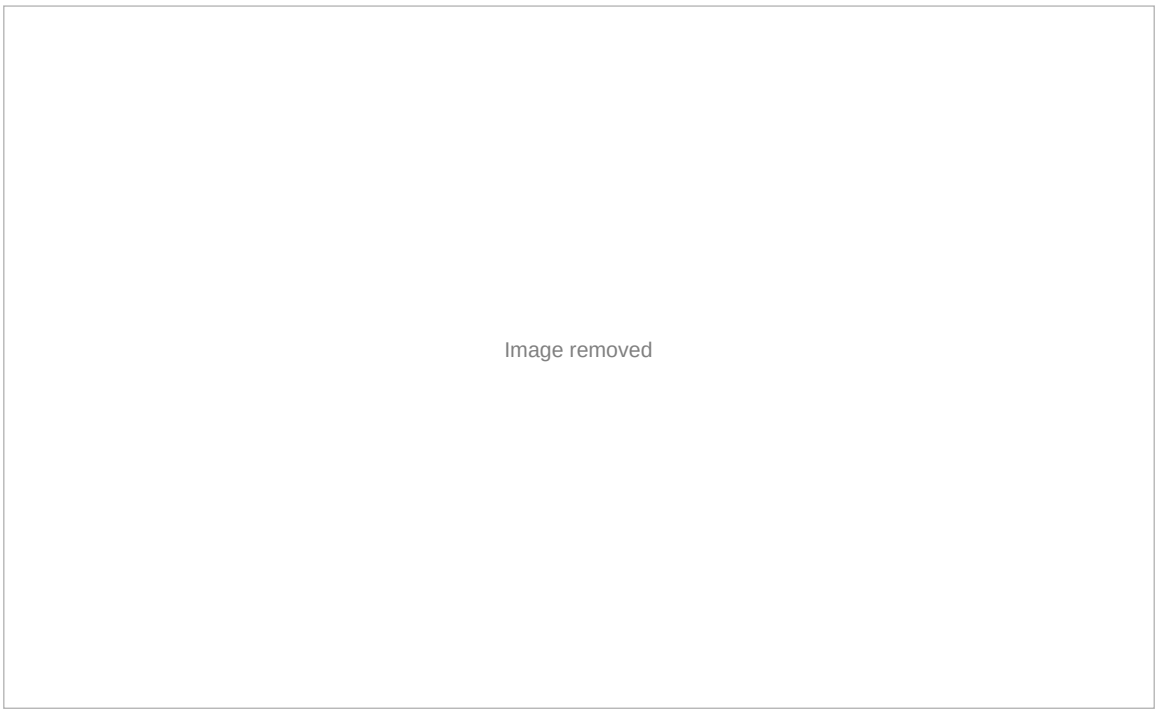


Figure 5-20: *Graph comic* illustrating European alliances before World War I, from Bach et al. (2016). This example, co-designed with a history teacher, breaks down complex political developments into sequential panels combining narrative text and topological maps. It exemplifies a linear, author-driven approach to communicating temporal changes in dynamic networks.

DC must also be differentiated from Educational Comics (ECs). While both use the comics medium and narrative elements, their primary foci differ, though distinctions can be subtle and overlaps possible. DC prioritises data communication and exploration, integrating visualisation directly into the narrative to enhance accessibility and engagement. ECs, conversely, explains educational or scientific concepts, employing narrative primarily as a didactic tool. Despite this, early DC limitations often echo ECs constraints (see Chapter 1), particularly reliance on linear models, text-heavy artefacts, and underutilised medium potential. Subsequent analysis will explore these limitations and alternative possibilities.

5.4.1. Critique of Current Data Comics Practices

Despite growing interest, current DC implementation often fails to harness the full potential of comics. Highlighting the gap between effective narrative comics and simplistic approaches, Zhao et al. (2019) rhetorically ask: 'surely it is not enough to just add some speech bubbles and clipart to your PowerPoint slideshow to turn it in a data comics?'—immediately before introducing their own investigation into the more fundamental mechanisms of partitioning and sequence. And yet, many current examples of DC seem to amount to little more than conventional DVs embellished with talking heads, speech bubbles, or clipart (see Figure 5-21).[27]

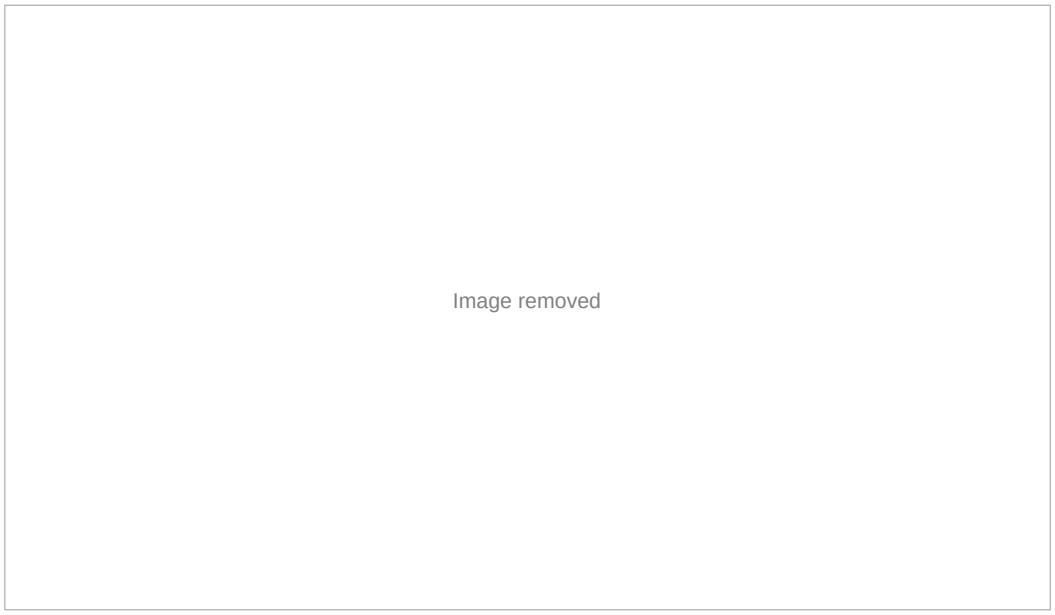


Figure 5-21 A data comics by Zhao et al. (2019) illustrating US census population data (1960–2000) using conventional statistical charts (population pyramids, line chart) integrated into a comic-strip layout. Comics-style elements—such as a recurring narrator figure and speech bubbles—support a guided, panel-by-panel narrative structure to present demographic trends.

This suggests many practices offer superficial embellishment, not establishing DC as a distinct representational mode. Consequently, structural, conceptual, and practical limitations hinder

[27] For a more comprehensive list of examples, see the Data Comics for Visual Storytelling website. Available at: https://datacomics.github.io/ (accessed 23 May 2025).

its effectiveness, restricting its role primarily to simplified data communication, despite declared epistemic aims.

The logocentric and linear limitations identified for ECs in Chapter 1 are equally traceable in current Data Comics. This is evidenced by the field's reliance on a linear 'strip' model, often explicitly defined in DC literature as 'a sequence of panels organised into one-dimensional tiers (or strips)' (Zhao et al., 2019, p. 1) or 'a visual storytelling method based on sequential images consisting of data-driven visual representations' (Zhao et al., 2019, p. 3). As discussed in the opening chapters, such sequentiality restricts the inherent capacity of the medium for multidirectional and spatial readings—a trend consistently found across most current DC scholarship (e.g., Jin and Szekely, 2010; Zhao and Elmqvist, 2023). Consequently, DC frequently functions merely as a tabular container for conventional DV elements, compartmentalising them within panels rather than integrating data representation into the visual and spatial logic of the comics page. This often yields DC lacking visual dynamism and narrative complexity, appearing more like segmented infographics. The distinction between DC and other visual aids thus blurs, undermining the claim of DC as a distinct format.

This structural limitation often stems from reliance on outdated or partial theoretical understandings of comics. References frequently focus narrowly on McCloud or Eisner, emphasising sequence and partitioning while neglecting spatiality, layout as a meaning-making resource, and non-linear navigation. Even science comics guidelines sometimes define comics merely as 'illustration', downplaying visual complexity for simple engagement, thereby underutilising the cognitive potential of the medium. Resultantly, the unique possibilities comics offer for synchronic presentation, rhizomatic exploration, and inferential meaning-making through spatial relationships—affordances vital for complex knowledge work—remain largely unexploited. Layout is treated as secondary, not a 'communicative resource in its own right' (Bateman et al., 2021, p. 210). Exceptions attempting to use DC for presenting research (Wang et al., 2021), often struggle to move beyond linear structures, sometimes proving indistinguishable from traditional textual reports (Wang et al., 2021, p. 968).

Current DC practices often exhibit strong reliance on anthropocentric narrative devices, particularly explicit narrators. Zhao et al. (2015, p. 3) state,

> To drive the narration in a Data Comic, the designer should include characters that complement the data-driven visualizations. Because this requires artistic talent, Data Comic designers should probably be furnished with a visual library of existing characters [...] The visuals [sic] in sequential art is typically scaffolded by text in both captions, speech balloons, and thought balloons. A Data Comic should support these same mechanisms.

Even without visual narrators (e.g., Figure 5-20), textual presence in captions is significant. This frequently leads to text-heavy models where verbal narration carries the primary informational load, relegating visuals to a supporting role and neglecting the potential of the image for autonomous meaning generation. This contrasts the tendency in traditional DV towards disembodied presentation conveying objectivity.

A further challenge is the production context and quality of many DC instances. Like some ECs and Comics-Based Research (CBR), DC is often produced by researchers lacking professional comics creation skills. The suggested need to provide DC creators with 'a visual library of existing characters' to compensate for lacking artistic capabilities (Zhao et al., 2015, p. 3) acknowledges this. This frequently results in aesthetically unrefined, structurally simplistic, or monotonous works—especially with insistent use of online digital tools—hindering engagement and credibility. The lack of established DC-specific graphical-conceptual models exacerbates this. Many examples are thus traditional DV techniques embellished with narrative elements, not a genuine integration of the unique affordances of comics. Data are rarely presented *in* comics form; comics often serve as paratext or container.

5.4.2. Reimagining Data Comics: Towards Untapped Potentialities

Current DC limitations highlight a gap between potential and realisation. Bridging this requires moving beyond the linear, container model to embrace the unique affordances of comics as spatial, multimodal, epistemic interfaces; otherwise, consolidated DV and infographics are preferable. This reimagining aligns with broader visualisation shifts towards complexity, context, and humanistic concerns.

Data humanism or a 'second wave' of DV, embracing complexity, context, subjectivity, and interpretive richness, resonates with the inherent characteristics of comics. Lupi's (2017) principles offer a productive lens for reimagining DC:

- **New Points of View:** Comics inherently challenge technical impersonality and resist templates. Stylistic variation (polygraphy), subjective framing, and diverse visual language integration offer a vast vocabulary for expanding data representation beyond default aesthetics, aligning with feminist critiques advocating for visualisations that acknowledge their situatedness (D'Ignazio, 2015; Alberda and Feigenbaum, 2023).

- **Slowness:** Dense, unconventional comics layouts can promote the *slow reading* and *slow thinking* advocated by Lupi (2017) and Lacković (2020, p. 91). By requiring active navigation and interpretation of complex visual relationships, comics foster deeper engagement and discovery beyond the rapid information consumption often associated with simpler infographics (Chute, 2016, p. 37). The structure of the medium supports rereading and detailed visual analysis, facilitating inquiry over mere information transfer (Lacković, 2020, p. 90).

- **Non-linear Storytelling:** The native multilinearity, synchronicity, and spatial juxtaposition of comics address the need for structures exploring interconnectedness and secondary pathways, offering 'interconnected knowledge' and 'unexpected parallels' (Lupi, 2017). The meshwork-like quality of the medium

allows relational data navigation, challenging binary hierarchies (D'Ignazio and Klein, 2016) and offering a powerful alternative to linear data narratives.

Reimagining DC involves embracing drawing not merely as illustration but as active reasoning and inquiry, a 'way of thinking' integral to the design process (Sousanis, 2015a; Lupi, 2017), reflecting on the user and offering alternatives to auto-generated DV that 'can deny a sense of personhood' (Alberda and Feigenbaum, 2023, p. 56). As Berger (2005, p. 43) notes:

> The drawn image contains the experience of looking [...] A drawing slowly questions an event's appearance and in so doing reminds us that appearances are always a construction with a history [...] A photograph is static because it has stopped time. A drawing or painting is static because it encompasses time [...] Drawing reveals the process of their own making, their own looking, more clearly.

These perspectives shift DC from *post-hoc* communication tools to potential instruments within the research process for exploration and hypothesis generation, akin to a 'data first' approach (Thorp in Lupi, 2017). Although the research dimension will not be explored here, it goes without saying that producing effective DC or ECs necessitates professional creators, integrating theory, realisation, and application on a continuum.

Berger's insights extend to auto-generated tools and image databases, which can depersonalise visualisation. Improved DC should integrate aesthetics into its foundation. As Cairo (2016, p. 56), paraphrasing Norman (2004), notes, 'beauty matters because attractive and pleasing things work better'. Functional beauty requires visual coherence, clear information design, and appropriate stylistic choices, moving beyond amateurish presentations.

Finally, leveraging the demonstrated capacity of comics for non-human and post-human perspectives allows DC to visualise systemic processes and complex phenomena extending beyond individual human experience, contributing to a more nuanced understanding of interconnected systems such as *hyperobjects* (Morton, 2013a).[28] Such phenomena, due to their vast scale, temporal distribution, and inherent complexity, often

[28] Hyperobjects, a term coined by Timothy Morton, refer to entities so massively distributed in time and space that they transcend localised human understanding (e.g., climate change, nuclear radiation, Styrofoam).

elude conventional human-centric modes of depiction and require frameworks that can articulate their distributed and often intangible nature.

5.4.3. Synthesis: Data Comics Beyond the Strip

Current DC often functions as a linear, compartmentalised presentation, failing to leverage the rich spatial, multimodal, and epistemic potential of the comics medium. It frequently shares ECs limitations: outdated theoretical models, prioritising narrative simplicity over structural innovation, and acting as a container for traditional DV rather than being a distinct approach. It often reinforces, not challenges, linear, logocentric paradigms in academic communication and education.

However, by embracing complexity, context, non-linearity, and aesthetic engagement—principles aligned with data humanism and the inherent strengths of comics as diagrammatic and cartographic interfaces—DC can be reimagined. Such reimagined DC, functioning as ECtC, would transcend the limitations of the strip model, utilising the full range of comics' affordances to visualise intricate relationships, foster deep inquiry, and communicate nuanced understandings. It offers a promising avenue for visualisations that are informative, engaging, critical, ethical, and aligned with the interconnected nature of post-digital knowledge, potentially bridging science/humanities divides. These potentials pave the way for exploring new frontiers in visualisation, where comics can play a vital role. This theoretical repositioning sets the stage for the design prototypes discussed in Chapters 6 and 7, where these affordances are operationalised as Educational Comics to Come.

5.5. Mapping Complexity: Cartographic, Diagrammatic, and Speculative Visualisations

The critique of conventional DV and the identified limitations of current DC necessitate an exploration of alternative representational frameworks. As knowledge production increasingly grapples with complexity, interconnectedness, and phenomena that defy linear or purely objective depiction, new visual models are required. This section examines several advanced and speculative approaches to visualisation—diagrammatic reasoning, knowledge cartography, posthuman perspectives, and deep mapping—highlighting their relevance to the challenges previously outlined and hinting at the unique capacity of comics to embody these evolving epistemic strategies.

5.5.1. The Diagrammatic Turn: Beyond Representation in Visualisation

Calls for more 'humanised' or context-rich DV challenge the primacy of analytical accuracy often associated with the field. While precision is valuable, it does not equate to truth or comprehensive understanding, as 'what humans can grasp and define is very much like truth, but not the very truth itself' (Lacković, 2020, p. 58). Moreover, what visualisations may lack in scientific precision, they compensate for with imaginative scope and the capacity to represent forces beyond direct measurement. The power of visualisation often lies in revealing the unexpected or 'bizarre' within complex datasets—patterns defying prior theories. Yet, this complexity can also evoke *unknowability*, a sublime encounter with the limits of comprehension exceeding the absolutist versions and total knowledge fantasies of first-wave DV.

This moves the focus towards the diagrammatic function of visualisations. Unlike purely representational images, diagrams operate as data structures where information is indexed spatially (Larkin and Simon, 1987, pp. 65–68), fostering relational understanding through a 'poetic of relations' rather than sequential statements (Drucker, 2014, p. 54). This spatial logic, echoing Euler's 'a geometry of position, not of measure' (Barnett, 2005, quoted in Drucker, 2014, p. 54), allows diagrams to function as generative systems for modelling and reasoning (Drucker, 2014, p. 106, citing Allwein and Barwise, 1996, p. 14). Building on Peirce, and extending into Deleuzian territory, this generative capacity positions the diagram as an abstract machine. Unlike the static figure, it is not merely a tool for visualising existing relations but one that suggests and generates novelty because 'its function is not to represent or visualise some essence, but to "suggest", and in this role, to generate' (Deleuze, 2003, p. 101, quoted in McCosker and Wilken, 2014, p. 160). Following McCosker and Wilken (2014, pp. 156, 159), 'rather than the figure or end product, the potential of data visualisation can be located in the processes of "diagramming"' because 'it is in the diagram [rather than in 'the sublime beauty of the visual figure'] that we can develop the means for generating understanding'. DV

should therefore operate in the gap between data and abstraction, functioning as a starting point for knowledge production. Thus,

> the promise of data visualisation as a form of visual knowledge has been closely connected to the sublime encounter. But [...] its potential lies with its diagrammatic capacities. (McCosker and Wilken, 2014, pp. 159–160).

This resonates with the diagrammatic potential inherent in comics (Section 4.8), where the layout functions as a spatial system—a *mise en système* rather than just a *mise en page* (Drucker, 2014, p. 157; Groensteen, 2007 [1999])—capable of structuring thought and generating insight beyond linear narrative.

5.5.2. Knowledge Cartography: Visualising Intellectual Landscapes

Knowledge cartography complements diagrammatic reasoning, providing methods for visualising the structure and dynamics of intellectual domains themselves (Okada et al., 2014, p. vi). *Knowledge mapping*, a core practice, involves techniques for identifying, organising, and visually representing complex knowledge structures, including relationships between concepts, skills, and processes (Hellström and Husted, 2004; Cañas and Novak, 2014; Börner, 2015).

Various knowledge maps have been developed—*concept maps* structuring concepts relationally (Cañas and Novak, 2014; Hill, 2005), *argument maps* visualising argumentation (Rider and Thomason, 2014), *curriculum maps* (Sherborne, 2014), *collaborative maps* (Selvin, 2014), and comprehensive knowledge atlases connecting micro, meso, and macro information levels (Seemann and Cohen, 1997; Börner, 2015; Jeschke et al., 2021). These cartographic techniques are effective across HE disciplines (Suthers, 2014; Kinchin and Gravett, 2020; Hyerle, 2014), supporting cognitive structure-building, critical thinking, and active engagement with learning material (Cañas et al., 2017; Okada, 2014; Machado and Carvalho, 2020). They also function as assessment tools making abstract knowledge concrete and learning visible (Kinchin et al., 2008; Kinchin, 2014). In interdisciplinary contexts, they reveal cross-disciplinary connections and make disciplinary structures visible (Hellström and Husted, 2004; Sherborne, 2014).

While implementation challenges remain (e.g., training, institutional resistance, maintenance) (Selvin, 2014; Cidell, 2008; Machado and Carvalho, 2020; Cañas et al., 2017; Kinchin et al., 2008), knowledge cartography principles align strongly with the spatial, relational, and multimodal logic of comics. As argued in Section 4.9, comics function as cognitive maps. Works such as Harder's *Alpha…Directions* exemplifies this cartographic potential. As a multimodal knowledge atlas, it maps cosmological concepts through visual-spatial associations, mirroring the meshwork logic of comics as theorised in Section 4.9. As

multimodal visual maps, comics operationalise the spatial cognition that knowledge cartography formalises.

5.5.3. Speculative Visualisations: Posthumanism, Deep Mapping, and Non-Linear Time

Representing phenomena that are vastly distributed, inherently complex, or operate beyond direct human perception pushes visualisation towards more speculative, theoretically informed models (Pande and Chandrasekharan, 2017, p. 2). This aligns with posthumanist perspectives challenging anthropocentric viewpoints and acknowledging non-human and material agency (Harman, 2002; Latour, 2005; Bennett, 2010). As discussed (Section 5.3.5), the capacity of comics for adopting non-human or 'alien' perspectives (cf. Bogost, 2012), suits exploring these theoretical frontiers visually.

This move beyond human-centred frames accompanies a critique of linear time representation. Conventional timelines often fail to capture dynamic processes' complexity. In biology, this includes representing phenomena across vastly different scales (molecular to evolutionary), often exhibiting *fractal temporality* where similar patterns recur across levels (Secrier and Schneider, 2014, p. 771), or accounting for differing organismal perceptual timelines (*Umwelt*) (Barnett, 2023, pp. 204–205). Static, sequential diagrams risk obscuring life's dynamic nature (Ratcliff, 1999, p. 255; Anderson-Tempini and Dupré, 2023, pp. 1–4). Similarly, in history, timelines can impose artificial linearity, suggest unwarranted causality (Moktefi, 2020, p. 511), and erase alternative, non-Western temporalities (Meeken, 2021, pp. 91–92) and mask historical complexity (Meeken, 2021, pp. 88–89). A recognised need exists for scalable, multilevel visualisations showing different states simultaneously and accommodating non-linear navigation (Gilbert, 2023; Meeken, 2021), including artistic ones. The evolution towards multi-scale, multi-temporal digital visualisations like 'Google Maps for Tissues' (Niendorf et al., 2020) or fine-grained Google Location History data analysis (Ruktanonchai et al., 2018), further underscores this.

Deep mapping emerges as a methodology attuned to these challenges. Defined as an attempt 'to record and represent the grain and patina of place through juxtapositions and interpenetrations' of diverse data types (historical, contemporary, political, poetic, discursive, sensual) (Pearson and Shanks, 2001, pp. 64–65), it moves beyond the focus of traditional cartography on accuracy and standardisation (Bodenhamer et al., 2015a, p. 223). Instead, deep mapping embraces complexity, subjectivity, layered meanings, and participatory engagement (Bodenhamer et al., 2015a, p. 227; Springett, 2015; Bodenhamer et al., 2015b, p. 4; Bodenhamer, 2015, p. 21; Bodenhamer et al., 2015a, p. 228). It functions through assembling heterogeneous elements, offering an open-ended, multi-perspectival, relational approach to knowledge organisation, reflecting the humanities' spatial turn (Warf, 2015, p. 134) and finding application across HE disciplines (van der Vaart et al., 2023; Bodenhamer et al., 2015b, p. 5).

The principles of deep mapping show strong convergence with both posthumanist thought (OOO, flat ontologies) and the inherent affordances of comics. Like deep maps, comics excel at layering information, juxtaposing different temporalities and perspectives (including non-human ones relevant to concepts like Morton's (2013a) hyperobjects) within a unified spatial framework, and requiring active navigation from the reader. The meshwork structure of comics, their capacity for multi-scalar representation, and their embrace of constructed subjectivity make them ideal vehicles for the kind of complex, situated, and polyvocal representations championed by deep mapping theorists.

In conclusion, the exploration of advanced diagrammatic reasoning, knowledge cartography, and speculative models like deep mapping reveals a clear need for visualisations that can handle complexity, non-linearity, multiscalarity, and multiple perspectives. These approaches challenge the limitations of minimalist DV and simplistic DC. Comics, reconceptualised as dynamic diagrammatic and cartographic interfaces, navigated as meshworks, and capable of embodying posthuman perspectives, emerge not just as suitable, but potentially essential tools for meeting these representational challenges. They offer concrete ways to structure and explore the complex knowledge landscapes of the post-digital era. This potential is concretely realised in the ECtC design experiments developed in Chapters 6 and 7.

5.6. Synthesis and Transition: Educational Comics to Come as Integrated Epistemic Interfaces

This chapter exposed limitations across established visual representation formats—MERs' tendency towards cognitive overload and fragmentation, minimalist DV's prioritisation of supposed objectivity at the expense of interpretive depth, and current DC's replication of these shortcomings as linear containers for conventional data displays. Underlying these critiques is a broader challenge to a representationalist epistemology that treats visual artefacts as neutral containers rather than active mediators of meaning.

Comics offer a powerful counterpoint. Their native ability to weave visual, verbal, and spatial elements into a unified, relational field supports 'translational fluency' across representational modes and facilitates coherent mental model construction through both sequential and simultaneous processing (cf. Mayer, 2021; Johnson-Laird, 1998; Schnotz, 2021). Yet it is necessary to ask what kind of cognitive operations such integrated visualisations enable beyond structural coherence.

Moving beyond comics as mere cognitive aids, this chapter posits them as active epistemic environments. Building on the cognitive foundations for navigating comics explored in Chapter 4 (including visual-verbal processing discussed in Section 4.2, diagrammatic reasoning in Section 4.8, and a framework grounded in schema theory—image schemas, multi-schematic orchestration—detailed in Section 4.5), comics can embody *inquiry graphics* (Lacković, 2020) or *epistemic objects* (Evagorou et al., 2015, p. 2)—constructs actively participating in knowledge generation. This resonates with a transactional view of knowledge (Dewey and Bentley, 1949), where meaning is actively negotiated between reader and representation. The comics interface becomes not a passive surface but a transactional field, inviting the reader to traverse, interpret, and reorganise cognitive structures through situated visual reasoning, particularly when encountering challenging concepts that require significant

conceptual reorganisation (Merrill et al., 1992).[29] This active, schema-informed negotiation is enriched by the medium's capacity for *polygraphy*, allowing diverse visual styles and information types to coexist within the integrated space. This view of comics as active environments for meaning-making aligns strongly with Rhizomatic Learning and Edusemiotics principles (Section 3.6.1), highlighting the medium's capacity for generating situated knowledge. Through this profound transactional engagement—where integrated multimodality, spatial structure, and activated cognitive schemas converge—the unique epistemic outcome termed the comics-fact can emerge: a distinct moment of insight, synthesis, or affective resonance arising directly from interaction with the comics interface itself.

In conclusion, this chapter has critically situated comics within visual knowledge work, contrasting their potential with the limitations of conventional MERs, DV, and current DC. Exploring diagrammatic reasoning, knowledge cartography, posthuman perspectives, and deep mapping has underscored the need for representational tools addressing complexity, non-linearity, multiscalarity, and subjectivity. These speculative frameworks, introduced in Section 5.5, established the theoretical groundwork for understanding how comics might engage with these representational demands—not as isolated illustrations, but as structurally and cognitively integrated epistemic environments. Comics, reconceptualised as integrated, transactional, diagrammatic, and cartographic interfaces, emerge as uniquely positioned for these contemporary challenges. They are not simply another option but represent a necessary evolution in visual epistemology, offering a framework inherently supporting how knowledge is structured, navigated, and generated in the post-digital age. The development of Educational Comics to Come (ECtC) is thus a theoretically grounded and practically necessary step. ECtC aim to consciously leverage the unique affordances of comics, moving beyond simplistic applications towards creating sophisticated tools for critical inquiry, visual learning, and knowledge exploration in HE. The next chapter articulates the theoretical and

[29] Mechanisms for cognitive structure evolution and adaptation are detailed by theorists such as Howard (1987), Rumelhart & Ortony (1977) (focusing on concepts within activity theory). While not elaborated here, the principle is that engaging with complex representations like comics can actively reshape cognitive frameworks.

operational criteria that ground this proposal and define what ECtCs must be to fully realise the potential visual epistemology outlined here.

6. Selection Criteria for Educational Comics to Come (ECtC)

6.1. Preliminary Remarks on Selection Criteria

As Jüngst (2000) notes, comics for education should be regarded not as a single text type but as multifaceted formats integrating a range of textual genres, each with distinct conventions and communicative purposes. Within this hybrid form, narrative components engage readers emotionally, descriptive passages offer detailed depictions, expository elements clarify complex ideas through text-image dynamics, and instructional sections provide clear guidance. These components coexist fluidly, contributing to the rich semiotic and pedagogical potential of the medium. This magma of plural orientation requires choosing less travelled, more promising paths. Dependence on standard text-types makes comics easy to understand, fulfilling reader expectations. However, comics can transcend merely accommodating pre-existing text-types; a less conventional 'panel-and-bubble' approach could foster a new generation of educational and informational comics (Jüngst, 2000).

From this perspective, this chapter establishes selection criteria for identifying prototypes of Educational Comics to Come (ECtC). These ECtC should align with a post-digital, multimodal, and transdisciplinary approach to Higher Education (HE) (see Chapter 3) and reflect ongoing shifts in reading habits and knowledge acquisition. The prototypes aim to transcend the limitations of current academic comics production, deliberately departing from prevalent tropes to foster innovation and address emerging educational needs. Given the potentially unlimited corpus of comics, specific contextualisation of these criteria is necessary.

6.2. Limitations of Current ECs and Rationale for New Criteria

Determining the most suitable layout and 'style' for a comics page, even for a specific educational purpose or teaching area, is challenging—not only because the study of educational comics (ECs) remains marginal within comics scholarship, but also because research explicitly focused on ECs is scarce. The majority of existing literature centres on the narrative effects of entertainment comics, often within narrow genres such as superhero fiction (e.g., Bateman et al., 2021; Brown, 2023). Even in systematic recent works, such as Cohn's *The Pattern of Comics* (2024), which analyses 361 stories to support his Visual Language Theory (VLT), educational comics and instructional genres are explicitly excluded 'such as instruction manuals or expository works of graphic non-fiction (science comics, health comics, etc.)' (Cohn, 2024, p. 242). Cohn merely notes that layouts in other 'visual languages' (e.g., instruction manuals) 'often maintain grid structures comparable to those in comics, if sometimes simplified' compared to 'the more robust visual languages used in comics' (Cohn, 2024, p. 236), calling for further research on the permeability and hybridisation of these visual languages.[30]

Therefore, the purpose with which EC is approached may differ substantially from that for entertainment comics. This distinction significantly shapes readers' engagement, expectations, and interpretative strategies, decisively influencing selection criteria for conceptual prototypes. An approach like Cohn's, derived from entertainment comics and aimed at narrative reconstruction, may view layout and meaning as separate but interacting. However, if the goal extends beyond chronological or narrative reconstruction—to explore concepts or seek targeted answers—how readers *use* an EC layout may differ. As highlighted

[30] While reiterating that '***comics are not a visual language***' (Cohn, 2024, p. 3), Cohn highlights the influence of written and oral language on the composition and reception of comics. However, he omits how other models—such as chronographies or maps—have influenced the evolution of comics (e.g., Tosti, 2019, 2021; Mainardi, 2007), or how more recent digital reading modes might reshape how comics are drawn and interpreted.

(Chapter 1), readers of ECs might favour deduction, information extraction, and memorisation over purely narrative comprehension. Consequently, cognitive processes in reading ECs can differ markedly from reading entertainment comics. Applying Wysocki's (2022, p. 20) perspective on *applied comics*, ECtC (as a specific form of applied comics), can be defined as:

> comics with a specific job. They communicate information to a target AUDIENCE, a goal that shapes choices made throughout the comics-making process and differs from a general category of non-fiction comics.

This fundamental difference in reading purpose and cognitive engagement (pertinent to ECs in general) underscores why ECtC require distinct selection criteria from those for entertainment comics.

Like rigorous academic writing, ECtC should strive for a distinct identity aligned with their purpose, mediating new meanings rather than just transmitting information (cf. Hyland, 2009, pp. 186–187). While insights from entertainment comics and the field of Data Visualisation (DV) (Chapter 5) can enrich ECtC, this integration needs careful consideration.[31] ECtC, potentially aligning with models like inquiry graphics (Lacković, 2020), should invite critical inquiry and promote deep thinking through visual exploration, not just simplify information. Similarly, narrative techniques from entertainment comics, while engaging, may not directly align with ECtC' inquiry-driven objectives unless thoughtfully adapted.

This absence of a definitive framework does not imply a lack of guidelines. General principles can be deduced from existing practices and critical analysis of the current corpus of ECs (Chapter 1) and DC (Chapter 5). A persistent limitation of this corpus is a 'monotony' stemming from a narrow vision of the medium, a lack of exemplary works for inspiration, and limited technical expertise among creators, exacerbated by software tools offering ready-made templates. Furthermore, recurring elements include an expository rather than inquisitorial attitude, a flattening of glottocentric, propositional, and linear didactic models, a distrust of the power of images to generate meaning (Chapter 3), and a paternalistic, hierarchical

[31] For example, as Lacković (2020, p. 91) notes, tools such as inquiry graphics share similarities with Data Visualisation (DV) in their ability to represent information or concepts visually but differ in their depth of analysis and interaction.

attitude, often exemplified by explicit narrators. These limitations necessitate specific criteria to guide selection towards innovative and effective ECtC.

6.3. Guiding Principles for ECtC Selection

Before detailing specific criteria, general principles provide a broader context for the ECtC prototypes envisioned. Building on previous theoretical discussions, conceptual prototypes should express potential comics that:

- **Overcome sequentiality:** Explain complex, non-linear concepts, information, and ideas unconstrained by the sequential nature of words.
- **Foster interdisciplinary connections:** Represent complex concepts through an interconnected, inter- and transdisciplinary approach, using a single space (the page) to integrate diverse perspectives.
- **Adopt post-human perspectives:** Explore complex phenomena with approaches including, but not limited to, post-human perspectives, acknowledging human/non-human interplay.
- **Embrace productive ambiguity:** Leverage comics' interpretive openness—conceptually framed in Chapter 3 (specifically Section 3.5) as a pedagogical resource and formally explored in Chapter 4—to spark connections and foster critical engagement, moving beyond purely expository modes.
- **Harness multiscalar and temporal complexity**: Represent phenomena across multiple spatial, conceptual, or temporal scales within a single visual field, enabling layered, non-linear understanding (Chapter 5).

Ultimately, selection criteria derived from these principles aim to balance innovation with practicality, offering a framework recognising HE's diverse needs. By leveraging the affordances of the medium as relational systems based on spatial configuration, these criteria should inspire ECtC that are visually and conceptually engaging and adaptable to various pedagogical goals and disciplines. The following criteria translate these principles into

operational dimensions, offering a pragmatic lens for identifying conceptual ECtC aligned with this vision.

6.4. Criteria for Selecting Conceptual Prototypes (ECtC)

Moving beyond theories focused solely on narrative coherence, ECtC selection must consider how layout can foster *deep viewing* (Wolf and Barzillai, 2009, p. 131; cf. Chapter 3). Arrangements demanding holistic interpretation over simple sequential reading, even if initially challenging (e.g., due to panel representational distance), can be deliberate strategies promoting critical analysis and inference central to HE learning. The following criteria aim to identify works embodying such potential:

- **Reduced Verbal Dominance and Enhanced Visual Inquiry**
    - Choose comics that minimise reliance on written text or *verbalism* (Hoban et al., 1937), favouring non-text-heavy models (Chandra and Jin, 2022), thus reducing the glottocentric model and highlighting visual sense-making (Lacković, 2020). Such comics move beyond an 'aggressively linguistic' view of cognition (Stafford, 1996, p. 7) and encourage an inquisitive, image-centred approach, helping learners engage visually and spatially.
    - Regarding comics as multimedia artefacts, favour works embodying a 'new writing' paradigm (Van Leeuwen, 2020, p. 482), where words and images interact spatially, freeing them from linearity. These comics should not require or promote reading aloud, functioning as relational systems based on spatial configuration rather than linear sequencing.

- **Emphasis on Aesthetic Qualities and Aesthetic Schemas**
    - Select 'aesthetically pleasing' comics. Although subjective, aesthetic quality is a fundamental ECtC selection criterion in HE. Aesthetic experience intensifies perception and transcends rigid cognitive categories, fostering flexible, exploratory, open-ended engagement (Desideri, 2016; Bartalesi, 2017). This encourages analogical, intuitive understanding, guiding learners towards new

conceptual connections beyond linear, schematic processing. Schaeffer (2015) notes aesthetic attention diverges, emphasising contextual complexity and multifaceted relations. Thus, pleasant comics not only capture emotional engagement and sustain hedonic-emotional attention but also reinforce intrinsic motivation, supporting interdisciplinary, experiential, and transformative learning.

- **Beyond Expository Use: Inquiry and Engagement**
    - Avoid comics that serve merely illustrative or disseminative purposes, reinforcing linear, text-heavy structures. Prefer instead those that foster interpretive engagement, prompting learners to infer, question, and explore conceptual relations independently.
    - Emphasise comics that cultivate spatial intelligence (Messaris and Moriarty, 2004, pp. 487–490) and visual intelligence (Barbatsis, 2004b, p. 289, 2004a, p. 334) as skills complementary to linguistic reasoning. This includes the ability to detect patterns and relational structures within complex visual fields. Favour works that scaffold meaning through visual architecture, encouraging learners to orient themselves within educational spaces (pages and beyond) through context-sensitive navigation and conceptual inference.

- **Rhizomatic and Meshwork Explorative Reading and Non-Linear Structures**
    - Move beyond fixed Z-path reading and linear narrative. Choose comics allowing multiple reading paths, simultaneity of perspectives, and hyperlink-like structures reflecting cognitive complexity and meshwork-like organisation (Chapter 4). Prioritise comics where tabularity, multilinearity, and spatiality (or spatial-temporality) are more relevant than sequentiality, linearity, and predetermined reading order or knowledge building, noting that linear and non-linear modes often coexist and should be evaluated based on their dominant cognitive function.

- Chosen works should facilitate ergodic reading, in which the reader's gaze and exploration are task-influenced and variable (Yarbus, 1967; Rayner, 1998; Hiippala, 2012), where meaning is actively constructed by the reader through navigation across visual-spatial layers. Readers shift between local (panel, strip) and global (page, issue, book) levels, adopting a task-driven, context-sensitive approach to interpretation.

- **Complexity Management and Conceptual Abstraction**

  - Integrate comics guiding learners from concrete, visually grounded concepts to abstract principles, scaffolding progressive conceptual understanding (potentially leveraging concreteness fading, Chapter 5).
  - Include comics tackling complex ideas; for instance, conceptual abstraction can involve synthesising symbolic, scientific, and experiential dimensions, as exemplified by the Moon's cultural-scientific stratification (Blunden, 2012, p. 5), which illustrates how symbolic, scientific, and experiential dimensions can converge in a single conceptual object. Such works encourage holistic conceptual synthesis through layered meanings and relational structures.

- **Post-Digital Sensibility and Transdisciplinary Relevance**

  - Select comics mirroring post-digital knowledge ecologies (Chapter 3), fostering cross-disciplinary links and recognising younger generations' comfort with hybrid texts and non-linear engagement.

Having established the criteria, the following section addresses scope limitations. Applying these elastic, exclusionary rather than inclusionary criteria, conceptual prototypes fulfilling the proposed ECtC vision can be identified. This involves selecting comics that minimise text dominance, foreground inquiry-driven visuals, embrace aesthetic schemas, and transcend linear logic, thereby aligning ECtC with a post-digital, transdisciplinary framework that

enriches understanding, nurtures visual thinking, and fosters creative exploration—transforming comics into holistic educational artefacts beyond traditional expository media.

6.5. Final Remarks and Scope Limitations

Before moving to concrete prototypes, certain aspects falling outside or extending beyond these criteria must be acknowledged.

- **Firstly**, prioritising how images or panels interconnect (a systemic approach) has reduced emphasis on analysing intra-panel representation (a more semiotic approach). While comics bridge pure visuality and multimodal texts, this does not significantly affect this analysis. Although visual culture research is not reducible to image culture, images remain central (Pauwels and Mannay, 2020, p. 3). For multimodal texts, image importance relates to media specificity, and visual analysis should exceed mere image analysis. The choice to concentrate on the systemic level does not imply a disregard for the represented content, which will be addressed in the prototypes.

- **Secondly**, the role of narrative has not been particularly emphasised. Whether comics can be non-narrative was discussed (Chapter 4). A middle position was adopted, following Postema (2013), Baetens (2011, 2021) and others: comics do not necessarily build a plot, possibly configuring a latent narrative where meaning arises from reader interpretation and inter-element relationships. A comparative reading with Data Visualisation (DV, see Chapter 5) was used to sideline the narrative problem, already much addressed in the literature on educational comics (ECs) (Chapter 1). As detailed in Chapter 4, narrative remains relevant but is no longer a required structural axis in ECtC, which may instead foreground spatial and configurational logics.

Regarding the last point, reducing narrative's role in ECtC was possible by treating them as comics with a specific purpose. Chapter 4, while questioning linguistic metaphors for comics, highlighted spatial, relational, and configurational structures in meaning-making. Here, the focus is on how ECtC can harness these affordances for specific educational goals. Reading comics is a complex operation with partially understood rules. Rather than following written

texts' sequential logic, comics—especially ECtC—operate as relational systems based on spatial configuration. They foster an interpretive reading grounded in layout navigation and visual structure, inviting exploratory engagement rather than fixed progression (though sequentiality may be present; cf. Sections 4.3–4.5).

This requires a new design approach for ECtC and readers familiar with the medium's potential, even if informally gained. As Baroni and Aydemir (2022) suggest, imposing recursive rules or regular grammars on comics risks oversimplifying their richness; their unconventional paths demand nuanced understanding, as

> non-linear reading paths cannot always be approached empirically based on a predictable and statistically homogeneous progression, but rather based on local possibilities of divergence from a conventional path. [...] In the field of education, the study of comics often leads to an awareness of the specificity of this medium, thereby enabling learning to wander around the page, to contemplate it like a painting (Baroni and Aydemir, 2022, p. 20).

If users/readers make choices regarding reading comics interactively, imagining new ECtC types means imagining a utilitarian reading approach considering ECtC specificity and particular purposes (educational, analytical, learning, investigative), partially overriding narrative/pleasure goals. Beyond authorial design, reader collaboration is crucial; awareness of dealing with an ECtC, not generic comics, influences engagement. Reading, especially in multimodal contexts, depends on social conventions between designer and observer (Kostelnick and Hassett, 2003). Prior knowledge of semiotic resource configuration for the task and the task itself guide navigation (Yarbus, 1967; Rayner, 1998). In this framework, navigation is neither entirely free nor fixed but is guided by contextual cues and prior semiotic competence (Hiippala, 2012, p. 319).

Returning to local-global dualism (see Section 4.4), reading comics involves local grammars but is inseparable from textual discourse and coherence (c.f. Ariel, 2009). Observation is always guided and exploratory. While conventional layouts favour sequential reading (Baroni and Aydemir, 2022), the overall 'look-at-all' reading persists. The topographical interweaving of part and whole results from context-impacted choices. Approaching ECtC reading requires explicit attention to medium, format, product, and purpose, mirroring design. It involves applying specific 'literacy'.

As discussed (Sections 3.1 and 3.2), younger generations have partially internalised non-linear reading habits and are more fluent with hybrid, multimodal texts. Such familiarity reinforces the potential of ECtC to support exploratory reading and spatial, inference-driven engagement—an opportunity these selection criteria aim to formalise. To consolidate this framework, Table 6-1 synthesises the six guiding selection criteria from Section 6.4, summarising each by focus and conceptual markers. Table 6-1 is intended not as a fixed checklist, but as a flexible conceptual map guiding prototype conceptualisation.

Table 6-1: Summary of the six guiding selection criteria for the design of Educational Comics for Teaching and Learning (ECtC). The table outlines the title, primary focus, and key conceptual markers for each criterion.

#	Criterion Title	Primary Focus / Key Concepts
1	Reduced Verbal Dominance and Enhanced Visual Inquiry	Reducing textual density; privileging visual sense-making; image-centred inquiry; spatial interaction; challenging glottocentric models.
2	Emphasis on Aesthetic Qualities and Aesthetic Schemas	Aesthetic experience as a cognitive trigger; open-ended, divergent engagement; analogical and intuitive comprehension; intrinsic motivation.
3	Beyond Expository Use: Inquiry and Engagement	Moving beyond illustration and information delivery; stimulating inference, discovery, and active interpretation; fostering representational competence.
4	Rhizomatic Reading and Non-Linear Structures	Avoiding fixed Z-paths; enabling multiple reading paths; simultaneity of perspectives; tabular, spatial, and reticular layouts; configurational logic; ergodic reading.
5	Complexity Management and Conceptual Abstraction	Representing and organising complex ideas; guiding learners from concrete to abstract; layered meanings; relational structures; holistic conceptual synthesis.
6	Post-Digital Sensibility and Transdisciplinary Relevance	Reflecting post-digital knowledge ecologies; fostering cross-disciplinary connections; hybrid textuality; non-linear, multimodal engagement.

Although elastic and non-prescriptive, these selection criteria aim to identify essential traits for designing ECtC: works enhancing comics' visual, spatial, multimodal, and post-digital dimensions, promoting critical, explorative learning. Having outlined these guidelines, Chapter 7 moves from theoretical principles to creating and analysing prototypes. This analysis will show how criteria can be applied, identifying limits and future scenarios for new ECtC generations. Thus, ECtC represent not just an evolution of the ECs tradition but a blueprint for rethinking visual knowledge design, navigation, and interrogation within HE, suggesting a shift in pedagogical tools and epistemological frameworks.

7. Conceptual Prototypes of ECtC

7.1. Introduction

Building on the selection criteria established in Chapter 6, this chapter turns to the practical articulation of the medium's epistemic potential. Several issues nonetheless remain unresolved, particularly concerning potential practical applications: the available data are limited, and the specific corpus of comics used in HE remains scarce. Moving beyond the limitations of traditional ECs and Data Comics, this chapter explores the largely untapped potential of comics as a tool for DV and knowledge representation in HE.

The prototypes presented herein seek to bridge this gap by expanding possibilities for using comics in HE within a post-digital context. This context, characterised by networked knowledge and multimodal interactions (Chapter 3), necessitates new representational strategies. They aim to meet emerging educational needs and evolving modes of knowledge acquisition, situating themselves in multimodal and transdisciplinary learning.

These prototypes are ***conceptual constructs***—flexible starting points for future ECtC designers rather than prescriptive solutions—developed in alignment with the selection criteria established in Chapter 6. Following a progressive micro-to-macro structure—from the panel as a representational unit, to the grid, the page, and finally the book format—the chapter examines how each level of comics organisation can be reimagined as a site of epistemic potential (for the operational definition of epistemic potential as used throughout this thesis, see Sections 1.5 and 4.1). The following section begins at the level of the panel, examining its potential as a quantitative display.

7.2. Panels as Quantitative Displays: Limits and Adaptations

Comics panels, though primarily narrative, can also function as DV tools. Tversky (2018) identifies key structural aspects supporting this role:

- **Segmentation:** Comics segment time and space using frames, breaking complex information into manageable chunks.
- **Panels:** Each panel presents a specific data aspect or analytical step, useful for depicting event sequences over time.
- **Panel Size:** Panel size can indicate the relative importance of different data points or sections.

However, Tversky offers little practical guidance on the feasibility of these cues for rigorous, granular, and precise visualisations. This section thus focuses on *comics panels as discrete units*, highlighting their potential as independent carriers of quantitative and qualitative information before considering their integration into larger visual structures. Specifically, this study explores how panels can represent temporal variables and information density, allocate data across time intervals, and facilitate comparisons, inferences, and exploratory analysis.

Time, as detailed in Section 5.5.3, is crucial in DV, offering a framework for analysing dataset patterns and trends (Aigner et al., 2007, p. 401; Kuchar et al., 2006, p. 81). Visualising time-oriented data is inherently complex due to the need to address multiple temporal scales and patterns (Kriglstein et al., 2014, p. 204). Different time representations (linear, cyclic, branching) offer varied analytical affordances (Aigner et al., 2007; Kuchar et al., 2006, p. 81), and scale/interval selection directly affects interpretation; inconsistencies can cause misinterpretations (Unwin, 2008, pp. 74–75). Visual representations must be expressive regarding temporal relations to aid insight generation (Kriglstein et al., 2014, p. 205; Aigner et al., 2007, p. 401). Also, a clear sense of time passing, even if implicit, can improve visualisation (Odewahn, 2010, p. 141).

Information density and its effectiveness, also discussed in Chapter 5, is similarly complex. Optimal information density is not absolute nor about maximising data in minimal space; it depends on data type, target audience, communication goals, and cognitive load. Therefore, beyond theory, the practical application to comics—*how much*, *how*, and *how accurately* comics communicate data, especially quantitative—warrants further investigation.

By isolating panels and examining features like size, density, and distribution, their dual function as qualitative and quantitative data carriers can be explored in greater detail. This allows examining how panels can visualise temporal intervals, information density, and complex relationships, drawing on established DV principles. This process facilitates a reconceptualisation of the panel, shifting focus from its rhetorical/narrative roles to its structural/organisational potential. Matt Madden's *99 Ways to Tell a Story* (2005) offers a valuable starting point for this analysis.

7.2.1. Exploring Panel Constraints through 99 Ways to Tell a Story

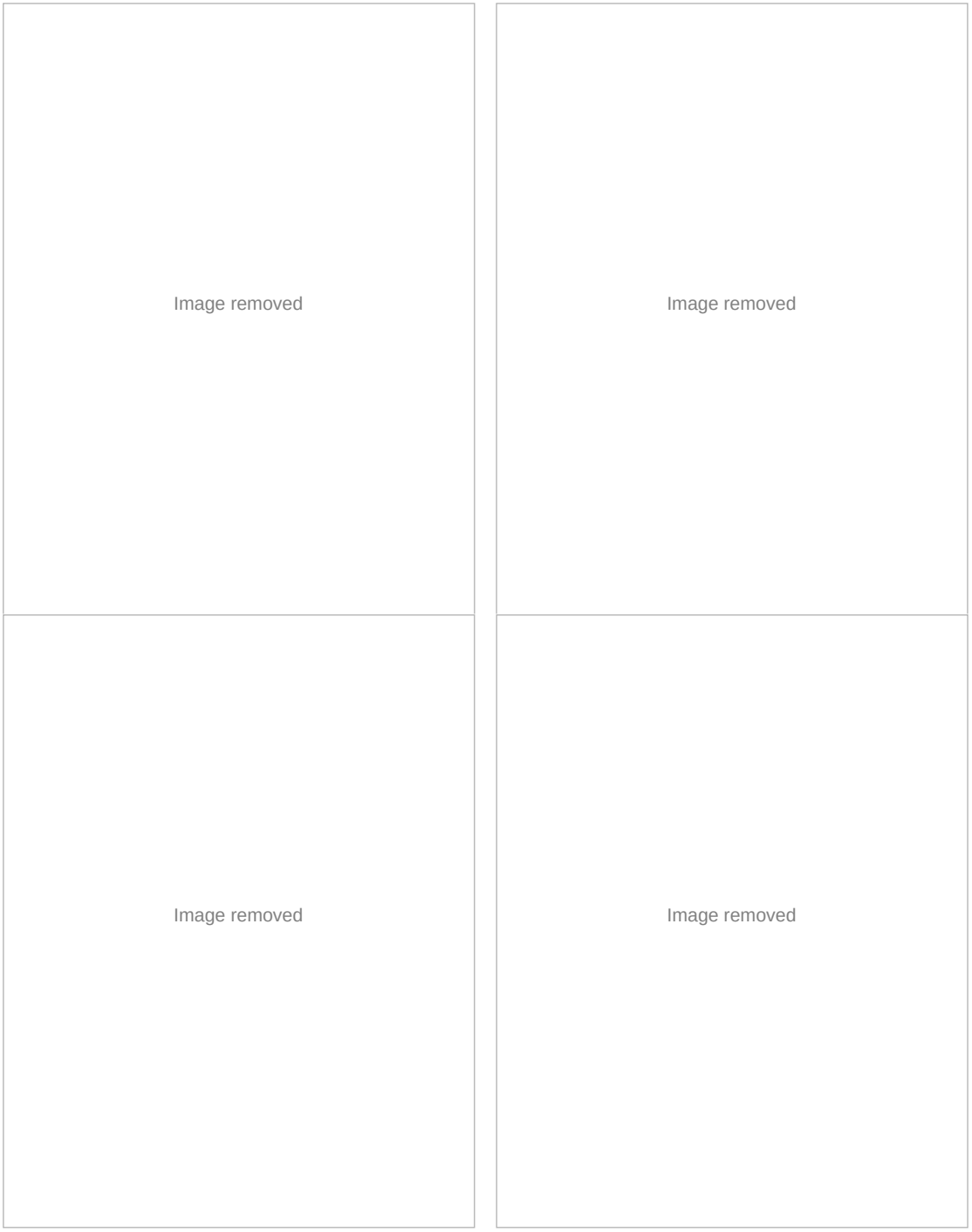


Figure 7-1: Four variations from Matt Madden, *99 Ways to Tell a Story* (2005): 'Template' (p. 3), 'A Life' (p. 141), 'Evolution' (p. 147), and 'A Lifetime to Get to Refrigerator' (p. 151). These examples demonstrate how an identical eight-panel layout can represent vastly different temporal scales—from minutes to a lifetime to human history—or symbolic journeys. This highlights the comics medium's flexibility in conveying time through minimal changes in representational content, relying instead on contextual cues and reader inference regarding the *fabula* and *syuzhet*.

Inspired by Raymond Queneau's *Exercices de style* (1947), Madden's book transforms a basic eight-panel plot (the 'Template', Figure 7-1 A) into 99 variations, manipulating graphic style, layout, genre, and temporal, spatial, formal, and conceptual constraints.

Madden's transformations maintain 'visual anaphors' (Tversky, 2018, pp. 45–46)—recurring elements that enable variation within coherence. The key insight is that identical layouts can support radically different temporalities: the 'Template' depicts minutes, 'A Life' spans a lifetime through setting changes alone, 'Evolution' extends to human history, and 'A Lifetime to Get to Refrigerator' symbolises a life's journey Figure 7-1. This flexibility—distinct fabulae and syuzhets coexisting within the same spatial arrangement—is intrinsic to comics' multilinearity (Baroni, 2016).

An empty layout provides spatial arrangement, hierarchies, and rhythm, but minimal (if any) *fabula* or *syuzhet* information. Cohn (2024, pp. 75–76) emphasises that layout and meaning, while interactive, are distinct; a single layout can accommodate infinite narratives (Figure 7-2). This raises questions about a 'data-less' panel or layout's communicative capacity, particularly for temporal information.

Image removed

Figure 7-2: 'Different Images' from Matt Madden, *99 Ways to Tell a Story* (2005, p. 193). This page illustrates that a single, fixed panel layout can accommodate entirely different narrative content, underscoring Cohn's (2024) point that layout and semantic meaning, while interactive, are distinct structural layers in comics.

Comics' temporality is complex, often becoming a thematic and structural element (Silva and Wolterbeek, 2019). Precisely determining a panel's *action time* (real-world duration of depicted events) is difficult, especially with multiple simultaneous actions (Groensteen, 2007, p. 91; Conard and Lambeens, 2012). The reader's experience of time is ultimately subjective, shaped by panel size, visual elements, textual density, content, and contextual factors (Bares, 2008; Cohn and Maher, 2015; Ikuta et al., 2023; Conard and

Lambeens, 2012; Silva and Wolterbeek, 2019; Pratt, 2009), as well as the author's graphiation (Marion, 1993, pp. 35–36).

Therefore, multiple temporalities coexist within a single layout/panel, making action time in comics inherently imprecise. Determining a panel's informational content is similarly challenging; perceived density is influenced by panel size, text, visual complexity, and subjective interpretation. Comparing informational density across panels is thus contingent on these variables, reflecting comics' interpretative flexibility. A key distinction between comics and many DVs is structural: comics' panel size/organisation is usually artistically/narratively driven, not by pre-defined informational/temporal units, whereas DV elements (bars, lines) are typically proportional to data. However, viewed differently, comics panels can be reconceptualised as qualitative/quantitative displays visualising temporal intervals, information density, and complex relationships. Subsequent examples will illustrate these parallels.

7.2.2. Panels as Temporal Quantifiers

Comics panels, while primarily narrative devices, can function as temporal quantifiers, akin to time representation in DVs like time series charts. Time series charts use a horizontal axis to represent time, composed of either time points (instants) or time intervals (durations) (Aigner et al., 2007, p. 403). Similarly, comics panels segment and structure temporal information via tabular/sequential arrangements.

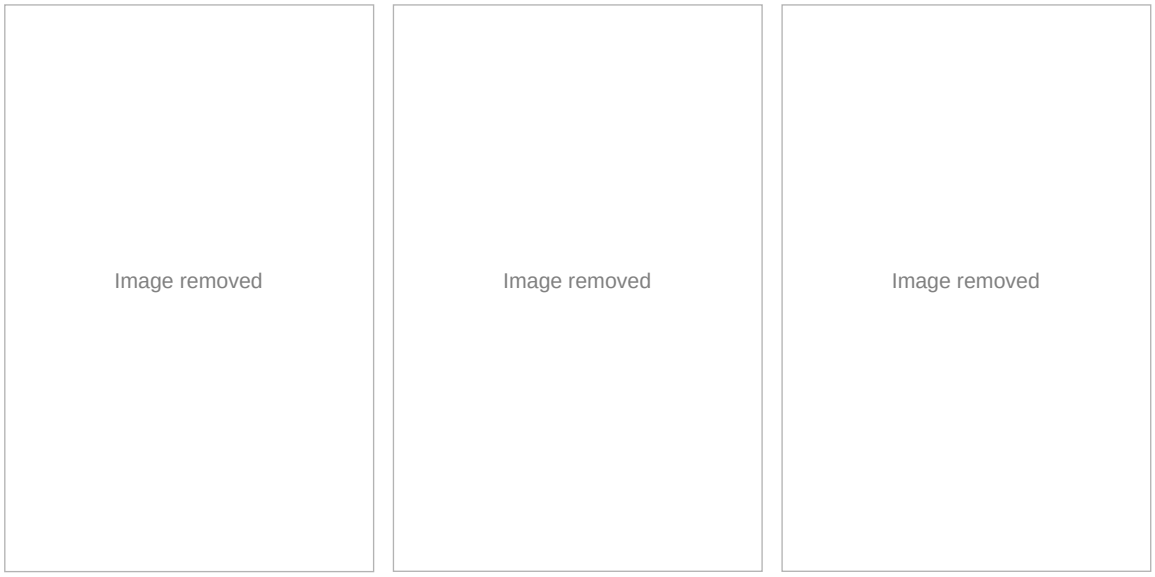


Figure 7-3: Pages 16–18 from Frank Miller, *The Dark Knight Returns* #1 (1986). This sequence depicts shifts in narrative pacing and perceived action time. The flashback to Bruce Wayne's traumatic childhood memory dramatically slows down time compared to the present-day scenes, despite identical panel dimensions, while a subsequent increase in panel density within a single row signals an acceleration of events.

Miller's *The Dark Knight Returns* (1986) demonstrates how content can override formal convention to manipulate perceived time (Figure 7-3). Three pages deploy a uniform 4×4 grid, initially implying steady temporal progression—yet this expectation is subverted: a flashback to Bruce Wayne's parents' murder dramatically slows perceived duration despite the panels remaining identically sized. Content, not form, governs action time here. On the third page, a grid disruption (the third row doubles its panel count) signals a shift in narrative rhythm: increased density corresponds to temporal compression, with events in the smaller panels unfolding far faster than those in the surrounding grid. The same formal unit thus hosts radically different durations depending on content and position within the sequence.

Crumb's Bo Bo Bolinsky (Crumb, 1998, p. 78; Figure 7-4) offers the inverse case: a 9-panel grid presenting multiple angles of a seated character within a zero-time interval. Here each panel functions as a *time point*—an instant devoid of duration—foregrounding spatial mapping over temporal sequence (Chute, 2016, p. 104). Yet the grid structure, conventionally associated with temporal progression, introduces cognitive dissonance: readers perceive time passage even when the fabula contains none (Cohn, 2024, pp. 100–101). Consequently, panels in *The Dark Knight Returns* function as time intervals with measurable duration, while Bolinsky's panels serve as time points. Between these poles, comics can deploy explicit conventions to refine temporal perception: Gene Luen Yang's *Dragon Hoops* (Yang, 2020; Figure 7-5) uses on-panel annotations resembling axis labels to indicate seconds passing during a basketball game, enabling readers to approximate action time with greater precision.

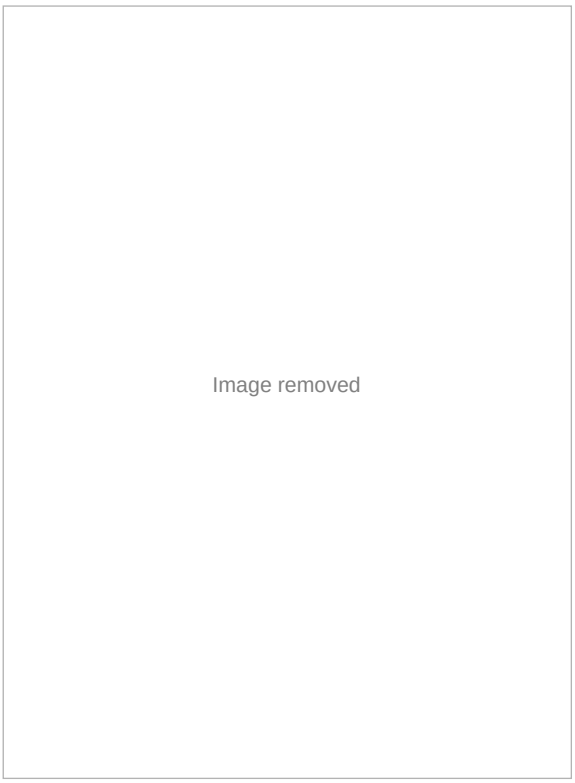


Figure 7-5 Bo Bo Bolinsky, 'He's Just a Nutty Little Nobody From Newark, N.J.', by Robert Crumb (1970; in R. Crumb, *The Complete Crumb Comics, Vol. 7: Hot 'N' Heavy!,* 1998, p. 78). The nine-panel grid presents multiple synchronic perspectives of the character within a theoretically zero-time interval. This creates a multi-angle portrait where action time per panel is null, foregrounding spatial representation over temporal sequence, as discussed by Chute (2016).

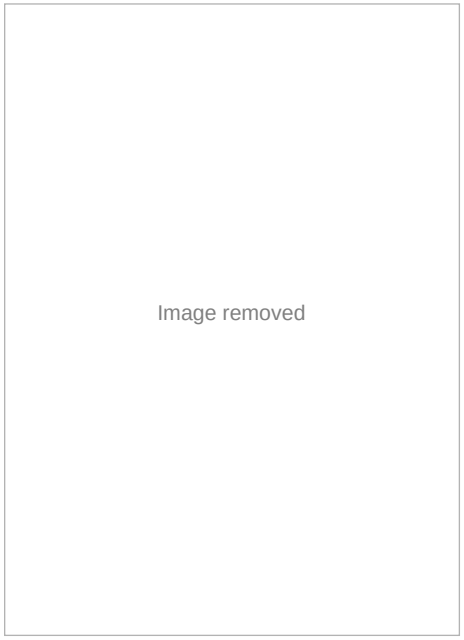


Figure 7-4: Page from Gene Luen Yang, *Dragon Hoops* (2020, p. 413). This example demonstrates an explicit quantification of action time within comics panels through the use of on-panel annotations resembling axis labels, indicating the seconds passing during a basketball game. This allows the reader to approximate the duration represented in each panel segment.

Comics can also modulate perceived time through a different formal property: panel size itself, independently of explicit annotation or fixed-interval deduction. *Captain America* #111 (Steranko, 1969) demonstrates this through a single acrobatic sequence (Figure 7-6): a larger opening panel captures the push-off phase (minimal speed), two smaller panels compress the mid-air rotation (acceleration), and a larger closing panel marks the landing (deceleration). While not mathematically precise, these size variations perceptually encode physical parameters—speed and duration—through the reader's intuitive association of spatial extent with temporal weight. This constitutes a third type of temporal operation, distinct from Bolinsky's instantaneous time-point and Dragon Hoops's explicit annotation: panel size as an analogue encoder of kinetic quality rather than a neutral container.

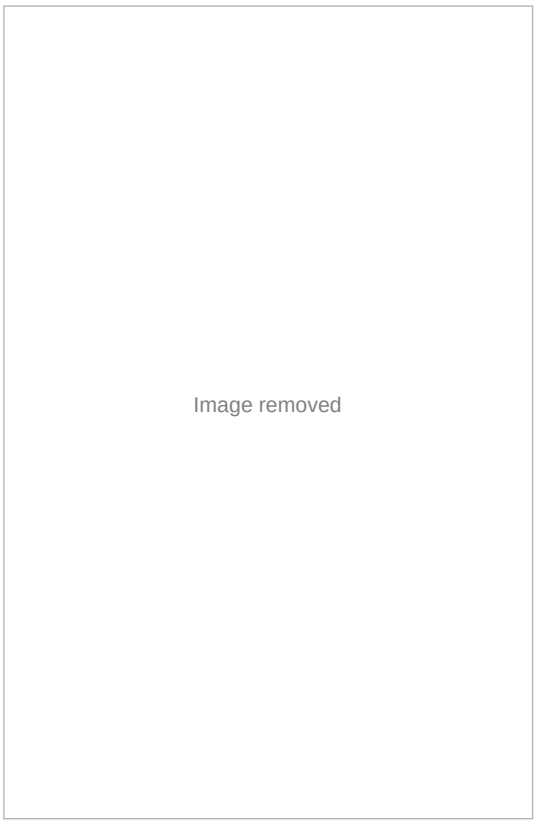


Figure 7-6: Highlighted sequence from 'Tomorrow You Live, Tonight I Die!', in *Captain America*, Vol. 1 #111 (Jim Steranko, 1969). This sequence illustrates how varying panel sizes, even within a uniform arrangement, can perceptually reflect physical parameters like speed and duration. The character's movement is broken down, with panel dimensions suggesting shifts in velocity during an acrobatic manoeuvre.

This section has explored how comics panels can be reconceptualised as temporal devices—capable of segmenting, stretching, or compressing perceived time—functioning both as intervals and instantaneous points. The following section will investigate how they also operate as modulators of information density, shaping how data is structured, emphasised, or withheld.

7.2.3. Panels as Data Density Modifiers

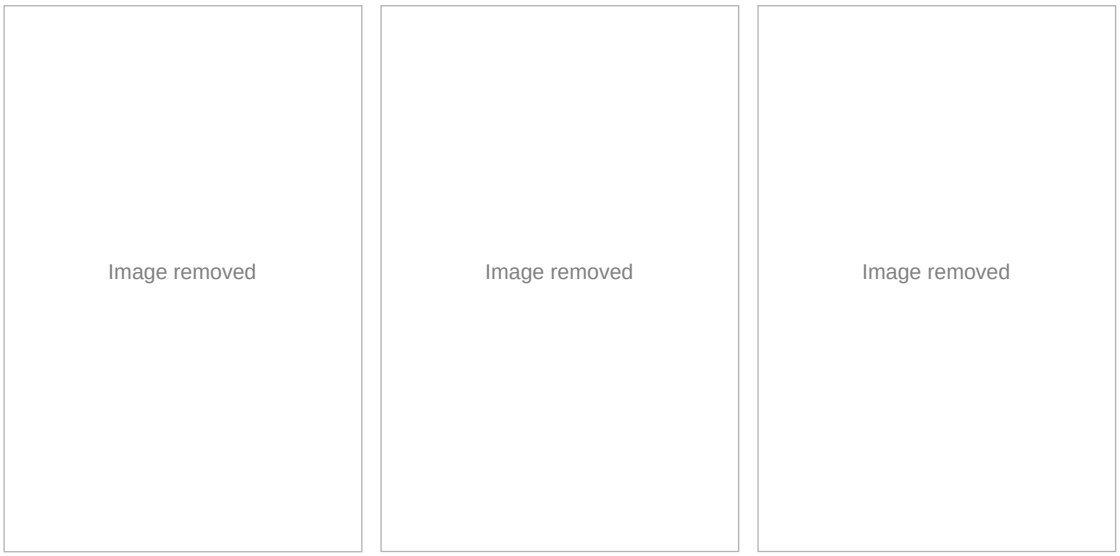


Figure 7-7: Selected pages (first, an intermediate, and one near the end) from Ray Fawkes, *One Soul* (2011). This graphic novel uses a fixed 9×9 grid on every double-page spread to present parallel moments in eighteen characters' lives. The black panels opening and closing individual narrative threads symbolise ontological absence (pre-birth and post-death), functioning as quantitative displays of non-existence within a structured comparative framework.

While panels function as temporal quantifiers, they simultaneously convey information density. However, relating panel size to informational content introduces vagueness and quantitative imprecision, unlike in DV where larger areas generally mean more data/information (Wilke, 2019, p. 174).[32] The intuition that larger panels contain more data is not always straightforward in comics.

Comics have a long tradition of using visually 'empty' panels—null panels (completely empty) or affixing panels (containing only a speech balloon without showing the speaker) (Cohn, 2024)—as expressive tools. Graphic omission, comparable to rhetorical figures like apophasis and ellipsis, invites active reader participation in inferring meaning (see Tosti, 2016, pp. 299–313). Variable panel shapes and sizes can additionally guide the reader through action despite visual absence, functioning as qualitative cues rather than representational content. Beyond

[32] Larger areas are generally perceived as corresponding to more data/information. This is natural but can mislead if not handled properly (e.g., on a map, a larger region might draw more attention, suggesting more information, even if untrue).

temporary perceptual or informational absences, comics also depict ontological absences—situations where characters do not yet exist or have ceased to exist. Ray Fawkes's *One Soul* (2011) (Figure 7-7) powerfully illustrates this.

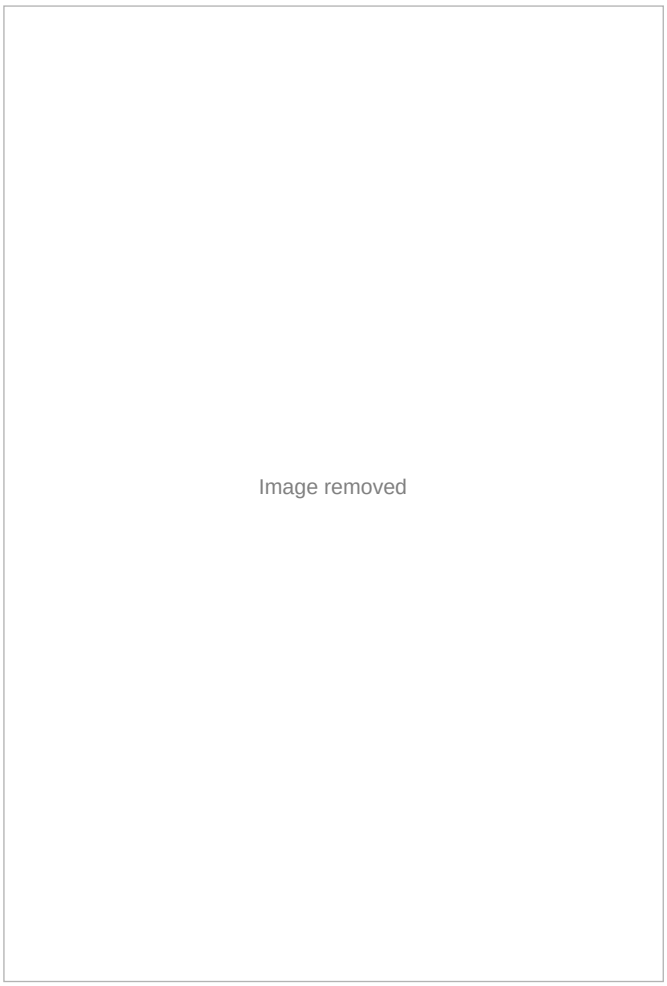


Figure 7-8: Page 54 from Paul Chadwick, 'The Transatlantic Swim', from *Concrete, Vol. 1: Depths* (2005 [1990]). This page features a dense 150-panel grid depicting the protagonist's arduous swim. The rhetorical effect of conveying extended effort and duration through sheer panel repetition and minimal variation arguably outweighs the informational content of individual minute panels.

Fawkes employs a fixed 9×9 grid across every double-page spread, presenting parallel moments in eighteen lives spanning from an indefinite past to the present. Black panels open and close each narrative thread, symbolising ontological absence—non-existence before birth and after death—rather than mere informational gaps. Within the rigid grid, these empty panels function as quantitative displays: their uniform size implies equal relevance regardless of content, establishing a visual equivalence between depicted experience and its absence. This highlights missing-data scenarios analogous to 'black holes' in DV (Wong and Varga, 2012, p. 290), where absences compel inferential reasoning from context and structure. When panels empty, they reduce to Groensteen's spatio-topical qualities—size, shape, arrangement become the primary meaning carriers (Witek, 2008, pp. 154–155)—demonstrating that a panel's size does not necessarily reflect its informational content.

This poses a broader challenge: determining the overall information density of a comics page (or an entire work) is complex. Dunst and Harte l (2021), analysing visual/textual

complexity in graphic novels, define visual density via parameters like Shannon entropy,[33] shapes per page, and panels per page (p. 204), stressing density is multifaceted and hard to measure quantitatively alone. Groensteen (2013, p. 44) suggests panel count can imply density, but not always.

Panel count does not straightforwardly correlate with informational complexity—a point that complicates approaches such as Dunst and Hartel's (2021) use of panel count as a visual complexity metric. Paul Chadwick's *Concrete* (2005) exemplifies this: its 150-panel grid—far exceeding the average 6.4 panels per page (Cohn, 2024, p. 81)—derives its dominant meaning not from individual panel content but from the rhetorical effect of sheer repetition, conveying the swim's arduousness and duration. As Cohn (2024, p. 211) observes, increased intra-panel repetition reduces inter-panel cognitive load, reinforcing the overall effect over individual content (Figure 7-8).

[33] In Claude Shannon's information theory, entropy quantifies information in a message. It is minimal with uniform images, maximal with evenly distributed brightness values. Image complexity increases with information content, approaching a maximum when no recognizable patterns remain (Dunst and Hartel, 2021, p. 204).

This section explored how comics panels modulate *information density*, challenging simplistic assumptions. In traditional comics, panel size/information content relation is complex, mediated by layout, spatial organisation, and reader interpretation. While panel *visual density* often correlates with perceived information density, this isn't strict; a black panel isn't necessarily more informative than a blank one. Greater inter-panel content variation increases reader inferential cost. Empty panels reveal information via size, arrangement, and placement, prompting inference from absence, analogous to DV gaps or *cartographic silences* (Quinn, 2020; Robinson, 2019) where deliberate omissions highlight uncertainty or guide interpretation.

Increasing panels per page generally increases granularity, enhancing segmentation but potentially losing detail.[34] This introduces a detail/clarity trade-off, a *scalability challenge* familiar in DV (Telea, 2014, p. 487): more elements in fixed space increase complexity/cognitive load, requiring simplification/abstraction strategies.

Having examined how panels' structure both time and information, the potential of comics as quantitative displays will now be explored. The interplay of panel size, arrangement, and data perception demonstrates that comics can offer valuable insights into visual communication strategies, beyond their traditional narrative role. The work of Matt-Heun Hong offers a compelling example of this convergence between comics and DV, employing a structured design that blends storytelling with DV principles to enhance interpretability and engagement.

[34] *The Dark Knight Returns*' excerpt, contrastingly, alters temporal scale across panels, not panel count.

7.2.4. Comics as Quantitative Displays: Matt-Heun Hong

Matt-Heun Hong's DC is original and visually appealing, occupying a space between traditional comics and infographics. Unlike many examples analysed in Chapter 5, Hong's work uses clearly defined structures merging comics' engaging qualities with established DV conventions.

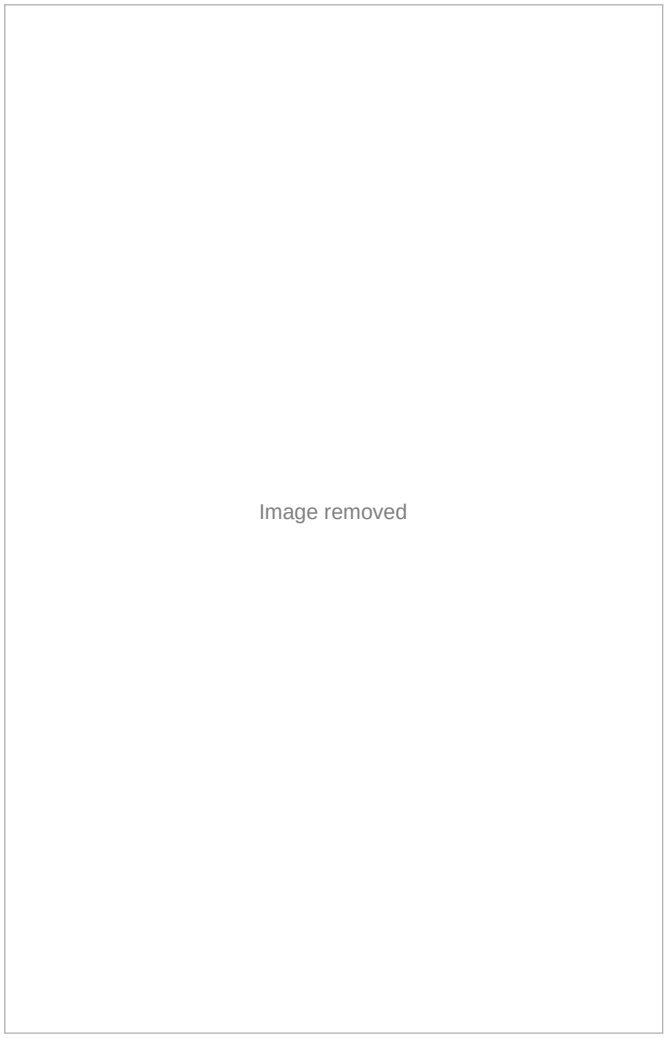


Figure 7-9: Matt-Heun Hong, *The Colors of Fall in New York City* (2018). This DC uses panel dimensions to proportionally represent the distribution of New York City's common tree species, grouped by autumn foliage colour, akin to a treemap. Colour is primarily applied to canopies, leaving space for text, demonstrating a hybrid comics-infographic approach. Source: *Medium*: https://medium.com/@MattIanHong/data-comic-3-the-colors-of-fall-in-new-york-city-252917294b33 (Accessed 17 May 2025).

In *The Colors of Fall in New York City* (Figure 7-9), Hong uses panel dimensions to proportionally represent New York City's most common tree species' distribution further grouped by autumn foliage colour (shown in legend and treemap chart).[35] Yellow-leaved species occupy about half the page (55% prevalence). While it remains unclear whether each individual panel reflects the exact proportions of the corresponding species, colour is applied only to tree canopies—leaving space for annotations—thus balancing narrative and graphic components.

Unlike most DC previously discussed—where conventional visualisations are inserted into a comics structure—Hong's work is a DV in itself: panel dimensions and spatial organisation directly encode quantitative data, rather than merely framing it. Hong's DC adopts a more declarative approach: panels dually organise visual narrative and convey structured data. Its rhetorical panel use aligns more with traditional DV strategies (repetition, segmentation for key insights), resulting in a reading experience prioritising clarity and comprehension over emotional immersion, guiding audiences through a predefined interpretative path.

Hong's work is selected here as a critical benchmark: it operationalises the transition from descriptive sequence to epistemic diagram, providing a concrete example of the 'quantitative potential' of the panel. By encoding data directly into the panel's spatial parameters, Hong demonstrates the panel's capacity to function as a 'dual-purpose tool'—combining narrative progression with measurable quantitative representation. This directly addresses the research question regarding the extent to which comics can support structured scientific discourse by proving that the medium's spatiality can be as rigorous as traditional DV.

[35] Hong (2018b) mistakenly compares this to an area chart. Treemaps are hierarchical visualisations recursively dividing space into nested rectangles, size reflecting data weight, offering intuitive overviews of complex structure proportions (Wilkinson, 2008, p. 135).

7.2.5. Considerations on Panels as Data Displays

In narrative comics, linking panel features to quantitative data presents inherent challenges: interpretation remains subjective despite guiding elements. Works like *Dragon Hoops* and *Captain America* demonstrate that approximate correlations between action time and panel size are possible, with varying degrees of precision. Empty panels—as in *One Soul*—convey inferable information through size, arrangement, and context rather than representational content. In regular grids, uniform spatial distribution implies equal interpretative weight; for irregular layouts, varying panel sizes may correspond to proportional information densities, though this relationship is never absolute. Overall, comics panels offer significant potential as data displays, but effectiveness depends on balancing spatial organisation, content density, and reader perception.

Having examined how comics panels can modulate information density and temporal representation, exploring their potential as structured DV elements is pertinent. This representational duality raises essential questions about how comics can transcend traditional storytelling to convey structured, data-driven insights. Frank Miller's *Holy Terror* exemplifies this transition from narrative to data-driven representation, employing panel arrangements that shift from anecdotal individual representation to an abstract, quantified depiction of collective trauma. This work offers a powerful case study for reconceptualising comics as visual tools capable of representing large-scale phenomena with emotional and analytical depth.

7.3. Building on Holy Terror: From Narrative to Data

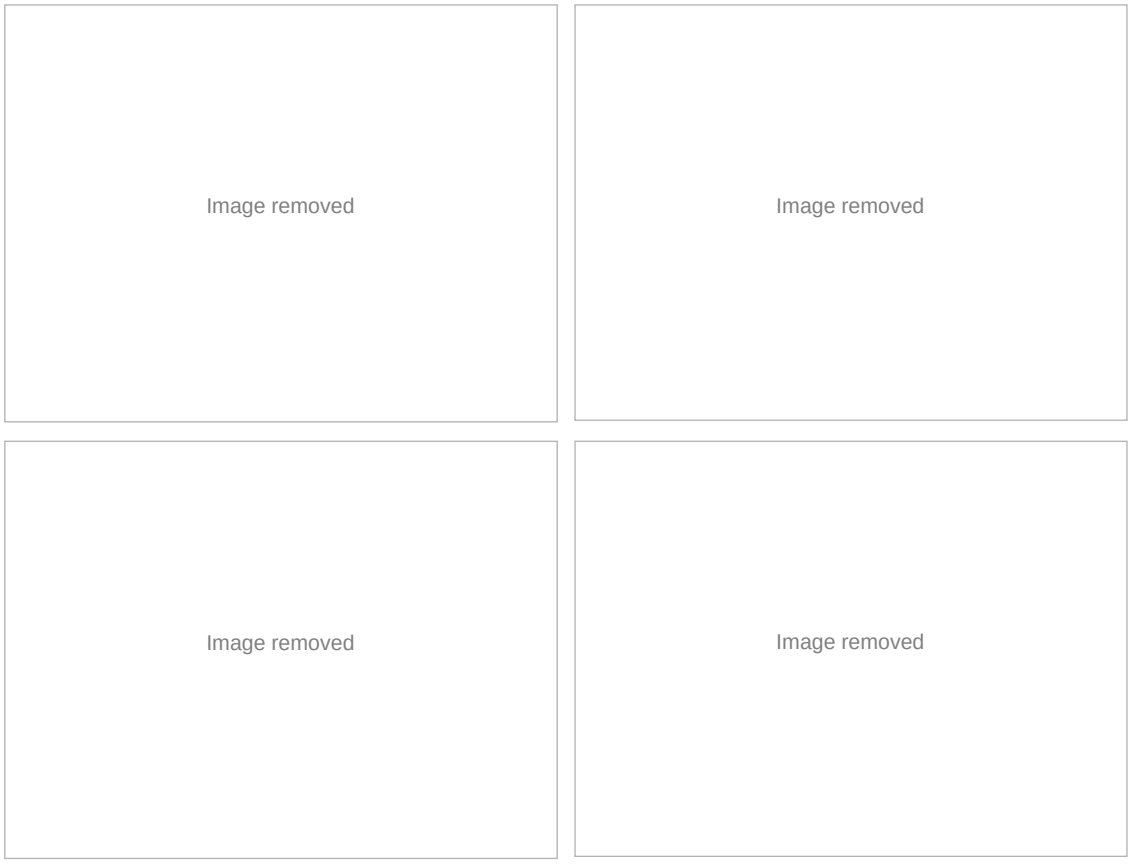


Figure 7-10: Frank Miller, *Holy Terror* (2011), sequence of pages. This series of double-page spreads depicts a terrorist attack and its aftermath. The visual progression moves from a splash page showing devastation, to regular grids sampling individual victims, and finally to increasingly dense empty grids quantifying the scale of loss, functioning as an emotional and abstract representation of collective trauma.

In Frank Miller's *Holy Terror* (2011), a terrorist attack and its aftermath are depicted through a visual progression both simple and incisive (Figure 7-10).[36] The first double splash page[37] shows the event's devastation. The next two pages, using regular 4×5 then 5×6 grids, show a victim sampling. The subsequent four pages display empty grids with increasing panel counts (30 to 160), suggesting the 'real' victim tally. Unlike many comics where splash pages 'freeze time',

[36] The comic has been much criticised for its depiction of Muslims, considered by many, rightly, as Islamophobic (Hernandez, 2011; Brothers, 2011; Ackerman, 2011). In 2018, Miller expressed partial regret, stating: 'When I look at Holy Terror, which I really don't do all that often, I can really feel the anger ripple out of the pages. There are places where it is bloodthirsty beyond belief […] I don't want to go back and start erasing books I did, […] I don't want to wipe out chapters of my own biography. But I'm not capable of that book again' (Thielman, 2018).

[37] The comics is produced in a horizontal panoramic format, so page pairs are shown simultaneously.

capture attention, or set context, here the grid serves a similar function, deliberately shifting focus from sequential narrative to a holistic event representation. It also adds a metaphorical dimension: empty grid panels can resemble tombstones.

Additionally, the white panels are used for a rhetorical effect distinct from uses of white space in other comics, where white space evokes immersive, sensory interpretation reflecting characters' reduced visibility while suggesting *fabula* progression. In *Holy Terror*, however, the white panels function as a visual device more aligned with DV strategies, transforming the narrative into an emotional and quantitative representation of trauma. The temporal dimension of these pages can be considered null; their function is not to illustrate linear narrative progression but to provide quantitative, comparative representation of the event's impact. The grid's static nature emphasises loss accumulation and scale over sequential unfolding. This transition from individual faces to blank panels creates a strong narrative and emotional impact. However, it can also be reconceptualised as an operational prototype for DV, for which several options exist.

7.3.1. Prototype 1: Temporal Progression and Cumulative Impact

This prototype reconceptualises *Holy Terror*'s grid sequence as a diachronic visualisation of disaster aftermath. Each page represents a distinct temporal interval (e.g., '5 years later'), with initial panels showing immediate victims and later grids using blank or abstract panels to indicate secondary consequences, such as delayed health effects or social trauma. The sequence thus functions as a diagrammatic interface for representing cumulative systemic loss over time, aligning with temporal abstraction strategies in DV and educational visual representation.

Example: In an industrial disaster context, the first page shows victims of a chemical explosion; subsequent pages visualise increasing deaths due to long-term contamination. This illustrative example supports the design of ECtC aimed at visualising environmental causality, intergenerational effects, and long-term systemic risk.

In doing so, this prototype responds to the central research question by demonstrating how a comics grid—typically a narrative device—can be repurposed as a quantitative display: transforming emotional representation into a structured visualisation of cumulative data, and offering HE educators a replicable model for representing large-scale, time-distributed phenomena without recourse to traditional statistical formats.

Full implementation strategies, including visual abstraction and colour coding for different causes of death, are detailed in Appendix A, which systematises this model's colour semantics, abstraction gradients, and pedagogical integration guidelines.

7.3.1.1. Further Insights into the Holy Terror Prototype

The prototype derived from Holy Terror shows panels can be effectively reconceptualised as quantitative and qualitative tools, independent of representational content, if given proper context. Furthermore, to enhance their effectiveness as accurate quantitative displays, incorporating DV visual reference elements is essential. These may include extra-diegetic components (guides, colour codes, legends) or less conventional diegetic elements (graphic representations of objects like clocks, as in *Dragon Hoops*). Such integrations support data interpretation while preserving the visualisation's narrative and emotional impact.

Moreover, just as the *Holy Terror* pages are part of a broader work, these conceptual prototypes can be envisioned as components of larger visualisations. They could extend across multiple pages, incorporating additional data layers like maps of the affected area pre/post-event, perspectives from those involved, or subjective explorations of the disaster site.

For instance, full-page comics can introduce a more complementary exploratory dimension than the grid—at once illustrative, contemplative, and investigative. This allows contextual data (e.g., aerial views, detailed descriptions) to be presented synchronously or asynchronously with the event chronology and other visual representations. This approach creates a navigable space enabling readers to explore information at multiple engagement levels, fostering profounder understanding. These spaces align with Kim Jooha's (2021) concept of *Navigable Space Comics*, expanding Manovich's *Navigable Space* in new media. Jooha defines Navigable Space Comics as works where space itself—not characters or plot—is the narrative experience core. Unlike traditional comics prioritising sequential storytelling, Navigable Space Comics encourage readers to traverse and interpret visual elements like exploring digital environments (video games, smartphone interfaces). This highlights comics' potential as immersive, multi-layered environments engaging readers in spatial and narrative inquiry.

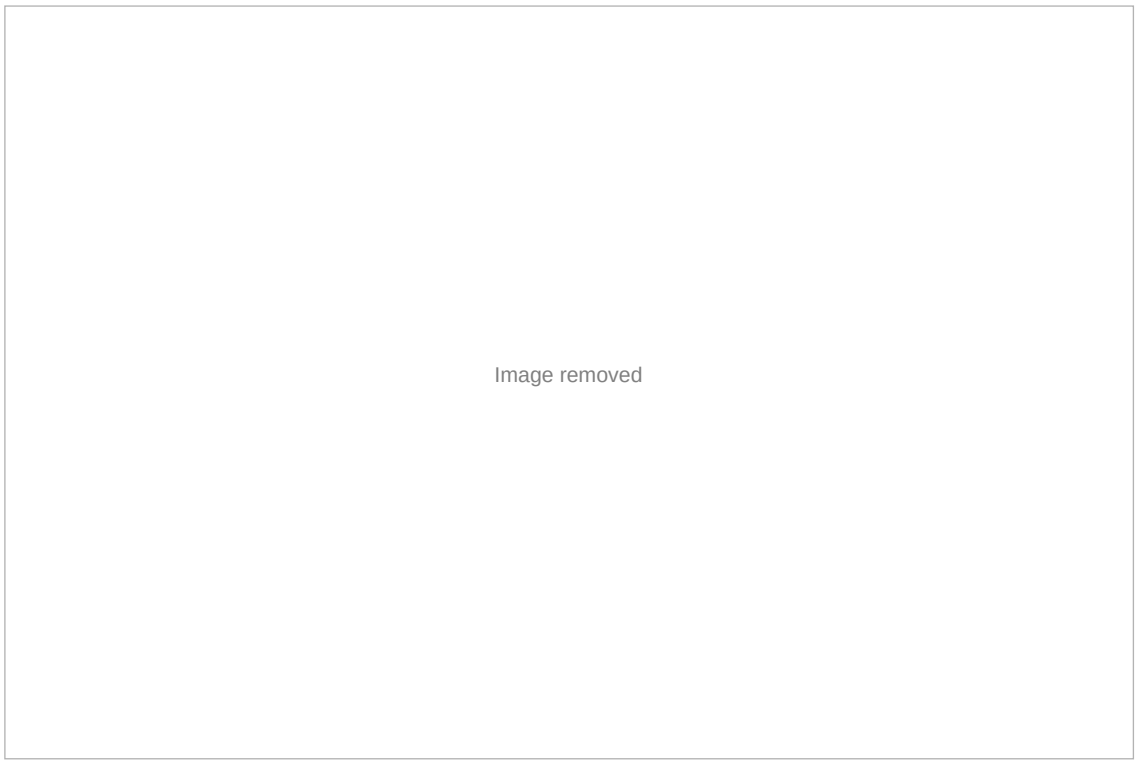


Figure 7-11: David Polonsky, **'**Strobe**'** (2004), first page. This comics uses a wide panoramic strip to establish a multi-character scene at a Tel Aviv intersection, with numbered individuals. Below, a grid of panels corresponds to these numbers, revealing each character's simultaneous sensory experiences (observations and sounds), creating a navigable space that offers multiple subjective viewpoints on a shared moment.

A compelling example of this navigability is David Polonsky's 'Strobe' (2004, Figure 7-11), a short two-page comics. The first page's wide horizontal strip illustrates a crowded Tel Aviv intersection with 27 numbered human/non-human characters. These numbers correspond to panels in the grid below, revealing each character's auditory and visual observations.[38] The second page, maintaining the structure, shows perspectives shifted after fifteen seconds. *Strobe* thus offers both navigable space and qualitative data representation, effectively portraying diverse individual viewpoints within a shared environment.

Another example is Joe Sacco's *The Great War* (2013, Figure 7-12). Its continuous leporello format and absence of text offer an uninterrupted visual timeline of the Battle of the Somme (July 1, 1916)—both panoramic and sequential. The fold-out format allows full unfolding into an expansive panorama or scene-by-scene reading, depicting key moments

[38] Note how panels for characters 24 and 25 are black as they have their eyes closed.

(soldier preparation, battle advance, aftermath). The comics unfolds left-to-right, following British soldiers' equivalent advance, guiding the viewer's gaze through time/space, creating an immersive experience mirroring the historical event's gradual unfolding. Unlike traditional panel-based comics, *The Great War* presents data (reprocessed via artistic interpretation) merging temporal continuity with spatial representation, useful for exploring large-scale, event-driven datasets.

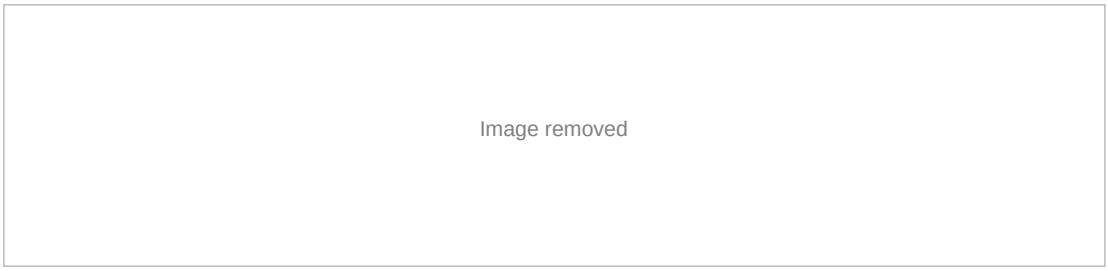


Figure 7-12: Joe Sacco, *The Great War: July 1, 1916: The First Day of the Battle of the Somme* (2013), section. This textless panoramic frieze, presented in a *leporello* (fold-out) format, provides a continuous visual timeline of the first day of the Somme. It merges temporal progression with detailed spatial representation, guiding the reader through the unfolding events of the battle from camp preparations to the aftermath.

In practical applications, *The Great War*'s visualisation techniques could be adapted to depict event impacts—as in the Holy Terror-derived prototype—focusing on casualty progression, infrastructure damage, and long-term consequences. The Leporello structure illustrates chronological/spatial dynamics, offering a more immersive, contemplative experience than segmented panel layouts. Such visualisations may coexist on one or several pages, complementing each other for a multidimensional view of one or more datasets.

7.3.2. Prototype 2: Contextual and Humanized Data Representation

This prototype combines multiple visualisation techniques—panel grids, panoramic layouts, and character-focused vignettes—to develop a multidimensional, human-centred representation of disaster events. Inspired by 'Strobe' and *The Great War*, the model is structured into three phases: pre-event, immediate crisis, and post-event recovery. Each phase juxtaposes individual perspectives with evolving spatial and systemic transformations.

Unlike the minimalistic numeric abstraction in Prototype 1, this approach fosters qualitative engagement and spatial-narrative correlation. It supports ECtC that seek to visualise the intersection of individual experience, structural damage, and social resilience.

Example: Prior to the crisis, a panel sequence presents diverse community members in routine scenes, contextualised by a panoramic map. As the event unfolds, grid density increases, and the panorama deteriorates. In the final phase, the same individuals are shown adapting to post-disaster conditions.

Where Prototype 1 deploys the grid as an instrument of scalar abstraction—reducing a complex phenomenon to its quantitative dimension—this prototype demonstrates a complementary strategy: that of contextualisation. By combining grid density, panoramic layout, and character-focused vignettes within a continuous visual space, it shows how comics can represent phenomena in which the relational and human dimensions are not supplementary to the data but constitutive of it—offering HE educators a model for events and processes where abstraction alone would be reductive.

The full three-phase layout, including implementation strategies and pedagogical implications, is detailed in Appendix B, which expands this into a customisable toolkit for narrative-datavis integration.

7.4. Processes and Transformations: Towards a Spatiotemporal Representation in ECtC

Having explored how individual panels and structured grids can encode time, relational data, and visual complexity (as in Prototypes 1 and 2), this section shifts focus to how comics represent processes and transformations—a critical, yet challenging, dimension of visual representation in science, education, and DV. The transition from discrete data points to continuous parallel storylines is already prefigured in works that leverage the medium's capacity for simultaneity, as previously observed in *One Soul*. Beyond the intrinsic complexity of works such as Fawkes's, more straightforward and structured approaches can achieve similar results within shorter temporal scales.

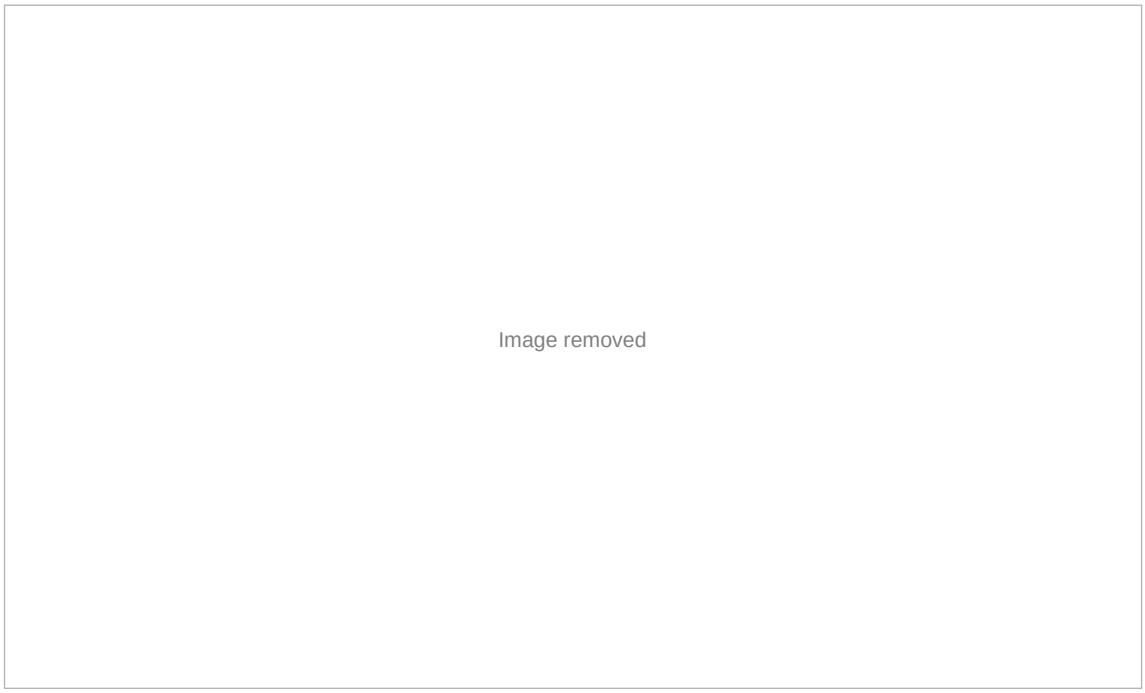


Figure 7-13: Double-page spread from Pierre Christin (writer) and Jean-Claude Mézières (art), *Valérian: Heroes of Equinox* (1983). This layout depicts four warriors' parallel journeys through four continuous horizontal strips. The structure invites comparative reading, enabling the audience to follow individual narratives sequentially or compare simultaneous actions and plot developments across different storylines within a shared temporal progression, highlighting comics' capacity for multi-linear storytelling.

For example, the double-page spread from *Valérian: Heroes of Equinox* (*Les Héros de l'Équinoxe*, Christin and Mézières, 1983 [1978]) narrates the journeys of four warriors through parallel

horizontal strips (Figure 7-13), providing a clear and intuitive comparative structure. Decisions may be made to follow the characters' stories one by one synchronously and contiguously (e.g., what all characters do in the first panel on the left) or synchronously and non-contiguously (e.g., comparing the actions of the first and fourth characters), while seeking connections.

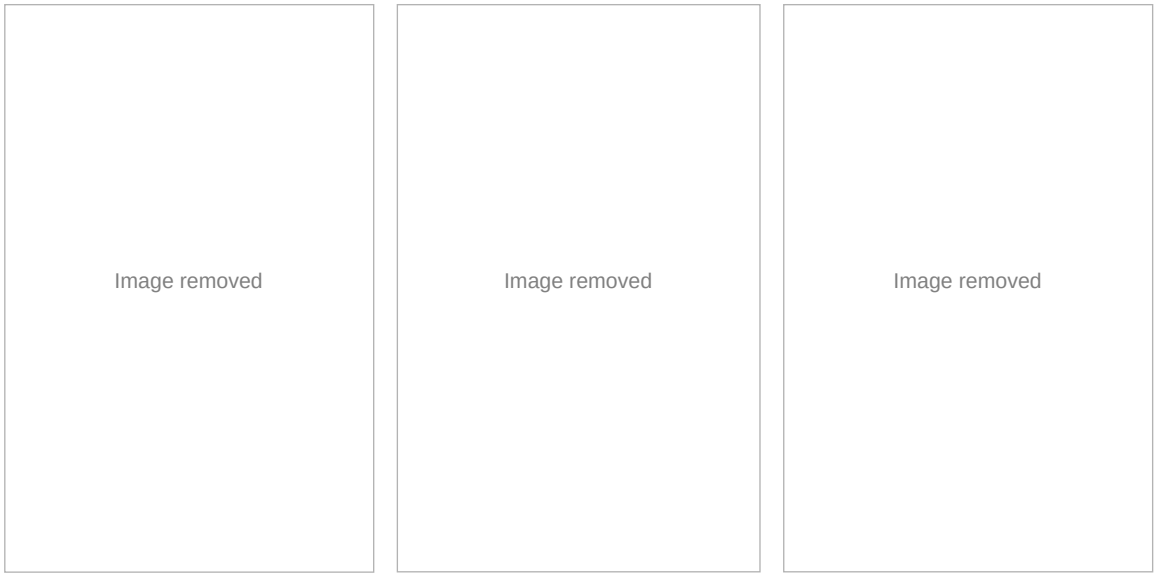


Figure 7-14: The first three pages of Alan Moore (writer) and Rick Veitch (art), 'How Things Work Out' (in *Tomorrow Stories* #2, 1999). This comics uses a multi-story house's architecture as a narrative grid. Each floor represents a distinct decade in the protagonist's life (1939 ground floor, 1979 top floor), enabling chronological reading within each 'decade-floor' and vertical, thematic reading across life stages within the same recurring spatial environment, compelling an inferential engagement with time.

A comparable technique is found in 'How Things Work Out' (Moore and Veitch, 1999), which employs a house's structure as a narrative grid. Each floor represents a different decade in the protagonist's life, from his youth on the ground floor (1939) to old age on the top floor (1979) (Figure 7-14). This layout allows both vertical reading—tracing life stages within the same physical space—and horizontal reading—following chronological progression within each decade. Such an arrangement compels the reader to move backwards through time, fostering an inferential approach to the narrative.

Among many possible examples, these two comics differ in genre, graphic style, and publication decade. However, they share a common goal: to play with—and against—conventional comics reading habits while creating a page where the reader's eye is compelled

to move in multiple directions and follow parallel narratives. This movement allows the reader to identify resonances, echoes, and connections contributing to a deeper story understanding. This inherent capacity for multi-directional navigation suggests that the medium could provide a sophisticated response to the challenges of knowledge representation.

Representing spatiotemporal data, particularly data with time-dependent variables, is inherently complex (Schmidt et al., 2019; Aigner et al., 2007; Laramee and Kosara, 2007). This complexity is evident in areas like network visualisation, where showing changes over time is conceptually and technically difficult (Chen, 2017), and in cartography, where integrating temporal data often requires multiple maps or layered representations that sacrifice spatial continuity.

The temporal dimension is particularly critical in representing networks and geographical data and necessary for a comprehensive view of evolving phenomena. Mapping time in geographic and cartographic representations is equally critical and difficult (Kraak, 1999) but indispensable, for example, when applying spatial thinking to geographic tasks (Çöltekin et al., 2011).

Maps usually represent a single snapshot in time (Kraak, 2000, p. 27). Multiple maps (Kraak, 1999) or overlapping layers in digital or online maps are usually used to integrate time in geospatial data, where each layer represents a temporal snapshot or progressive change (Wilke, 2019, pp. 169–171). This approach highlights changes over time but at the cost of spatial continuity in representation.

Given these challenges, several scholars have attempted to classify different types of time in visualisation. Aigner et al. (2007), drawing on Frank (1998), identify the most critical criteria from a visualisation viewpoint, summarised as:

- *Linear time vs. cyclic time*: Linear time progresses sequentially, while cyclic time describes recurring phenomena where event order is relative (e.g., seasons).

- *Time points vs. time intervals*: Time points represent discrete moments without duration; time intervals define periods with a start and end. These structure temporal data as isolated events or continuous spans.
- *Ordered time vs. branching time vs. time with multiple perspectives*: Ordered time follows a single sequence of events; branching time allows for alternative scenarios (e.g., in decision-making); multiple-perspective time accounts for differing viewpoints on the same event, as in eyewitness reports.

While earlier sections examined how comics panels can function as time points and intervals, this section expands the scope, arguing that the medium possesses unique, often underutilized, characteristics for representing a wider range of temporal modes and, importantly, change itself. As geographer Vasiliev (1997, p. 1) states, 'the passage of time allows for [...] changes to be perceived'.

Comics, frequently defined by their sequential nature, inherently fragment and reassemble time on the page. This section will investigate how comics can visually render processes and transformations, not just by segmenting time, but by revealing underlying flows, relationships, and changes within those segments. It will explore how the grid and overall page layout extend these capabilities, drawing connections between established DV principles and the potential for creating effective ECtC. Analysis begins with simple configurations before progressing to more complex structures addressing contemporary spatiotemporal representation challenges.

7.4.1. Comics as Processional and Transformative Medium



Figure 7-15: Sammy Stein's *Sculpture* (2016). This example of formalist comics uses a regular grid to depict a sculpted capital's subtle transformation over time. Inter-panel changes and narrow gutters emphasise a processional, almost imperceptible time passage, focusing on form and gradual change rather than overt narrative action, exploring the medium's temporal granularity.

In comics, particularly in highly formalistic experiments and at mainstream production fringes, representing time passage becomes almost an obsession. As Dejasse (2023) aptly puts it, these works are 'at the limits of narrations'; they focus more on exploring the medium's formal possibilities than on storytelling (see also Jooha, 2019, 2018a, 2018b). Examples include works by Sammy Stein (Figure 7-15)[39] and Alexis Beauclair (2019) (Figure 7-17).[40]

As Jooha notes regarding Stein, these works exploit comics' potential as a processional and transformative 'language', evoking 'the sense of time in the static world of comics' (Jooha, 2018b). This is not dramaturgical time but rather a reader's search for continuity within discontinuity or, as with Bo Bo Bolinsky, for discontinuity within continuity. These comics deliberately play with reading expectations, prompting the reader to actively negotiate continuity through unexpected disruptions in layout or sequencing. For instance, in Figure 7-17, starting from the first panel on the left, a ball's descent initially encourages downward gaze; however, from the third row, a sharp discontinuity forces a return to the z-path to reconstruct movement continuity. The final row may lead to reconsidering

[39] Image taken from Jooha, 2018b.

[40] The images of Loto, unless otherwise indicated, are taken from the website of the publisher Editions Matiere: https://www.matiere.org/livres/loto/

Image removed

Figure 7-17: Page from Alexis Beauclair, *Loto* #1 (2019). A grid traces a circle's ambiguous motion through seemingly continuous abstract space, later revealed as segmented. The layout plays with reading expectations: initial vertical tracking of movement is disrupted, forcing a Z-path return to reconstruct continuity, highlighting the reader's active role in resolving visual-spatial puzzles.

previously explored reading paths. Similar effects can be achieved with less stylised content (Parkin, n.d.) (Figure 7-16).

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Figure 7-16: Michael Parkin, *Great Circles in the Sky* (n.d.). This page presents the vertical descent of a human figure within a regular 3×4 grid. Through minimal variation and clean geometry, the comics conveys a sense of downward motion and transformation. Compared to more overtly formalist experiments, it uses less stylised content to achieve similar effects—evoking process, temporality, and spatial depth. The framing and consistent perspective encourage the reader to follow the motion sequentially, while the final row's variation prompts reflection on continuity and closure. Source:

7.4.2. Visual Strategies for Representing Motion

Leveraging the 'database' logic and the synchronic properties of the layout discussed in Chapter 4 (Sections 4.4 and 4.7)—whereby 'comics make [the process of selecting and ordering] material on the page—not as merely evocative but as literal' (Chute, 2012)—the visual strategies in these examples fragment action for analytical scrutiny. Beyond temporal progression, this modularity facilitates *subitizing*—the rapid perception of quantity without counting (Krzywinski, 2017)—enabling the grid to function as a cognitive *Gestell* that shapes the interpretation of information density.

The first example (Figure 7-15) uses a regular grid to represent transformations over time at various granularity levels and from a unique viewpoint. Beauclair (Figure 7-17), by contrast, in tracing the motion of a circle—whose direction remains ambiguous, whether downward, perpendicular to the reader, or along a plane viewed from above—depicts four distinct sections of a continuous space (panels 1 to 9), which nonetheless correspond to twelve contiguous portions of time.

This dynamic aligns with broader discussions on motion perception and underscores how comics engage with spatial-temporal ambiguities through structuring devices. Movement segmentation into discrete images is a common strategy in scientific and instructional visualisations. In comics, this gains particular significance through the grid: by overlaying a structured reading path onto fragmented motion, the grid establishes directionality—since graphics 'induces the perception of motion direction from reading direction' (de Souza and Dyson, 2007, p. 4)—while in certain instances generating deliberate ambiguities that prompt active reader exploration and inquiry.

Regarding most comics here, transformation and movement reconstruction are reinforced by specific visual strategies. One key element is the narrow gutter, which minimises the spatial gap between panels and facilitates the impression of continuity. As Cohn (2024, p. 77) notes, gutter width influences perceived panel relationships, thinner gutters reinforcing temporal fluidity. This near-absent separation makes frame transitions almost imperceptible,

strengthening motion illusion and giving a greater impression of constancy, regular rhythm, and temporal granularity, even with non-short/non-constant time intervals (Figure 7-15).

Another crucial factor is the fixed, frontal perspective, mostly unchanging throughout sequences. This perspective, with an external, unmediated viewpoint, reinforces a single continuous moment impression over fragmented instants. In Beauclair's ball or Stein's capital, the reader observes externally (unless objects are characters). This external, inhuman, or post-human perspective, contributes to objectivity, framing scenes as observations, rather than an experience. This impression is also reinforced by the absence of human and even non-biological, non-anthropomorphised characters, more often acted upon than agents.

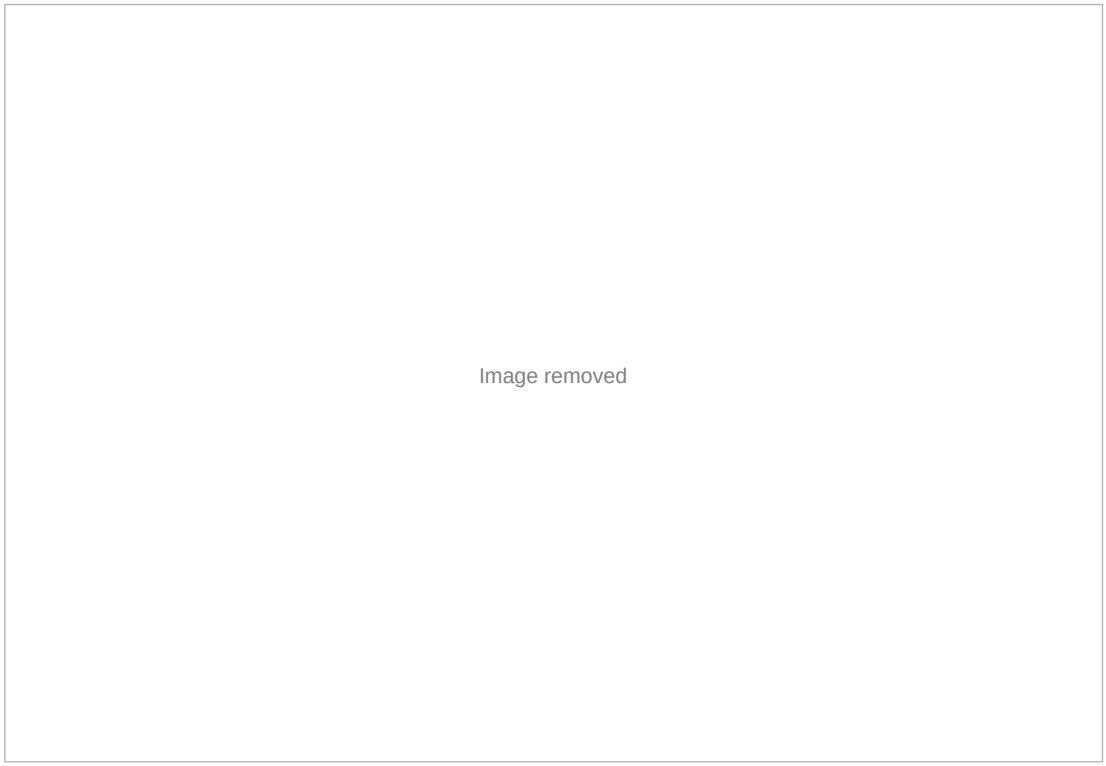


Figure 7-18: Alexis Beauclair, *Loto* #6 (2019). This sequence shows a circle moving through changing landscapes, with the observer's gaze consistently aligned with the circle. This creates ambiguity regarding whether the circle or the landscape is in motion, highlighting motion relativity and the role of the observer's frame of reference in perceiving spatiotemporal relationships within comics.

The background's role is also fundamental. In *A Transatlantic Swim* (Chadwick, 2005), the protagonist, Concrete, swims in a dense 150-panel grid, mostly against a black background (Figure 7-8). Lack of visual reference and constant character size vs. panel prevent determining

absolute (Concrete moving) or relative (static Concrete, shifting background) motion. Only final seven panels reveal background, retroactively confirming movement. Until then, ambiguity creates perceptual uncertainty. Figure 7-17's background (discontinuous in last row) also challenges object, representation, and observation point perception.

In another *Loto* issue (Figure 7-18), the shifting relationship between the moving circle and its background problematises the role of the observer. The reader's gaze remains aligned with the circle, which either appears stationary while the landscape shifts, or moves synchronously with the viewer through the space. This duality relativises motion, making it ambiguous whether the movement is a property of the object or its environment. Through this configuration—combining fixed perspective, minimal gutter, and post-human detachment—Beauclair explores how comics can construct perceptual ambiguity and prompt readers to reflect on the distinction between real and apparent motion. The apparent formal simplicity conceals a complex conceptual operation, foregrounding the observer's interpretive role in reconstructing spatial and temporal relationships.

How comics structure motion raises broader representation questions. Since movement in comics is reader-reconstructed rather than intrinsic, perception of motion becomes relative—dependent on page logic and observer position—recalling Galilean distinctions between absolute and relative motion (Ramírez, 2024), where movement can only be defined with respect to a given frame of reference. This formal property aligns with the concept of phase space—a mathematical framework representing all possible system states at a given moment (Nolte, 2010; Phase Space, 2015; Kelley, 2023). Like phase space, comics grids map multiple temporal states within a fixed visual field, each panel representing a distinct state; unlike phase space, however, comics offer an interpretative rather than predictive arrangement, in which meaning emerges relationally through reader inference rather than through defined variables.

Moreover, these strategies of structuring, display, and *mise en place*—rather than traditional *mise-en-scène*—within this multidimensional, quasi-otherworldly phase space, not only shape the reader's perception of movement and continuity but also redefine viewpoint

and agency, extending both the represented and the observer into post- or non-human dimensions.

From these considerations on vantage points and post-human and non-human frames of reference, the text now turns to a broader classification of temporal structures in comics. The goal is to identify recurring spatial and observational configurations that shape how time is segmented and perceived—both within sequences and across the comics page—moving from discrete intervals to layered and overlapping temporalities.

7.4.3. Typologies of Temporal Structures in Comics

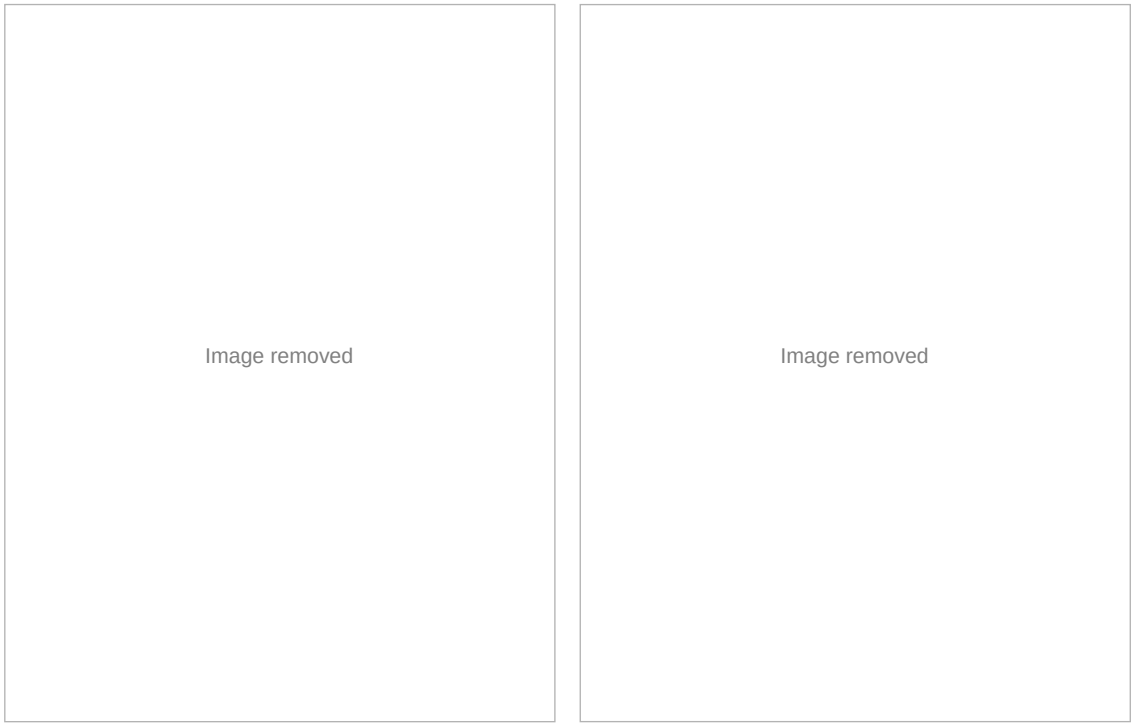


Figure 7-19: 'Fixed Point in Space' (left, p. 185) and 'Fixed Point in Time' (right, p. 187) from Matt Madden, *99 Ways to Tell a Story* (2005). These variations illustrate two spatiotemporal representation categories: the former shows events unfolding over time from a static spatial viewpoint (Time Interval); the latter captures multiple spatial aspects of a single frozen moment (Time Point), demonstrating formal constraints shaping temporal perception.

Partially building on Aigner et al.'s temporal typologies, this section proposes three observational categories for analysing spatiotemporal representation in comics:

1. **Time Intervals:** Observation point fixed in space, shifts through time (e.g., Figure 7-15), or both space/time shift simultaneously (e.g., Beauclair's works, Figure 7-18 and Figure 7-20).
2. **Time Points:** Observation point fixed in time, not necessarily space (e.g., the *Bo Bo Bolinsky* example, Figure 7-4).

These two, exemplified by *99 Ways* versions (Figure 7-19), were previously discussed.

3. **Time Planes:** (New category) Multiple temporal lines coexist in the same spatial configuration. Time not as discrete point/interval, but simultaneous layering of instants, enabling non-linear perception. Examples:
    - *One Soul* (Figure 7-7): multiple storylines, same page, different diegetic spaces.
    - *How Things Work Out (HTWO)* (Figure 7-14): decades mapped to building floors, architectural/temporal separation).
    - *Pax Americana* (Figure 7-23): multiple intertwined temporal layers, single setting. This category represents a reconciliation of typologies such as ordered time, branching time, and time with multiple perspectives.

Table 7-1: Typology of observational categories for spatiotemporal representation in comics. This table summarises the proposed classifications: *Time Intervals* (fixed space/shifting time, or shifting space/time), *Time Points* (fixed time/shifting space), and *Time Planes* (multiple coexisting temporal lines in one spatial configuration), providing a framework for analysing comics' temporal structures.

Category	Definition	Subcategory	Example(s)
Time Intervals	The observation point is fixed in space but shifts through time.	Fixed space, shifting time	Figure 7-15;
		Shifting space and time	Figure 7-18
Time Points	The observation point is fixed in time but shifts through space.		Figure 7-4
Time Planes	Multiple temporal lines coexist within the same spatial configuration.	Shared narrative space, distinct diegetic spaces	Figure 7-7
		Structurally segmented spatial-temporal layers	Figure 7-14
		Shared diegetic space, fragmented time	Figure 7-23

Table 7-1 summarises these generalising, non-exhaustive categories. They allow examining how comics actively map temporalities onto space and vice versa, producing alternative ways of representing, perceiving, and investigating transformations. This typology, though simplifying, clarifies vantage point evolution. Four examples illustrate how these categories operate in practice.

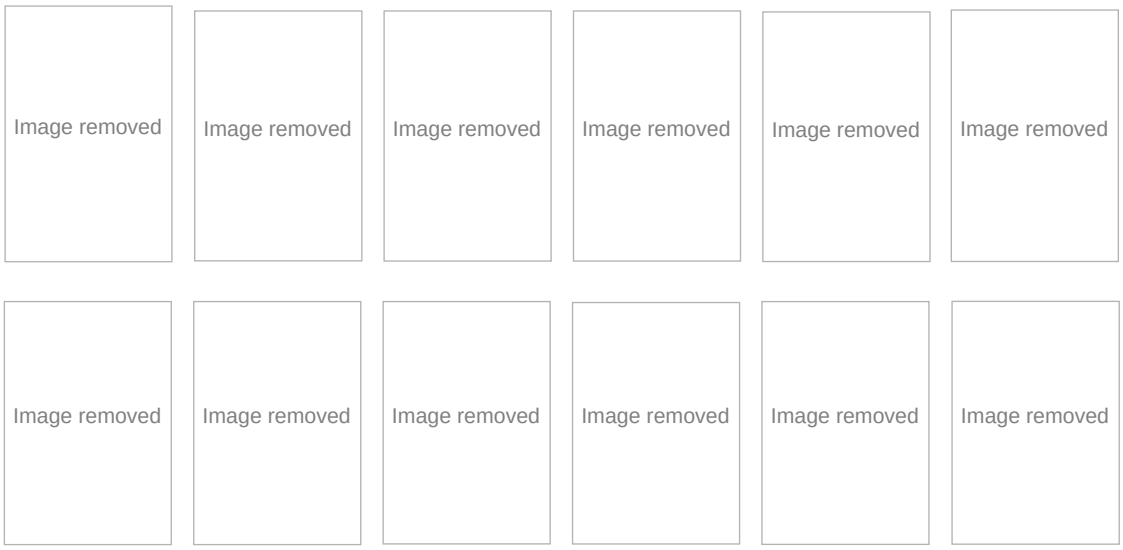


Figure 7-20: Alexis Beauclair, *Photon* (2014). This comics immerses the reader in a photon's trajectory through an optical instrument. The regular grid, consistent field of vision, and reversible reading create a hybrid perceptual mode, blurring external observation and embedded subjective experience of motion and time, functioning as an example of a Time Interval where space and time shift. Source: Monoskop.org: https://monoskop.org/Photon (Accessed 13 April 2025).

Alexis Beauclair's *Photon* (2014, Figure 7-20) exemplifies Time Intervals while challenging the category's boundaries. The reader moves inside an optical instrument, following a photon's trajectory through a regular grid that maintains a consistent field of vision. The book's reversibility—readable in both directions—reconfigures the reader's role from immersive perception to reflective observation, creating a hybrid perceptual mode that oscillates between an etic (external, analytical) and an emic (internal, experiential) perspective (cf. Pike, 1954; Mostowlansky and Rota, 2020).

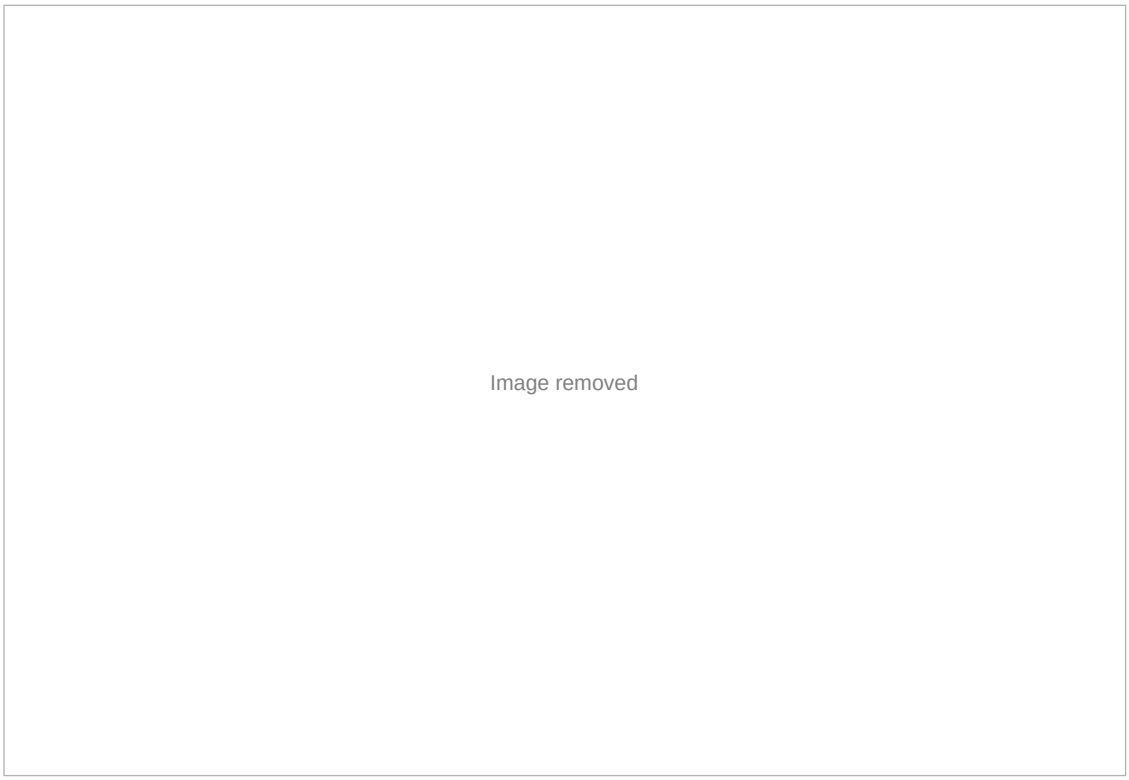


Figure 7-21: Robert Crumb, *A Short History of America* (1981 poster, originally 1979). This twelve-panel grid depicts North American landscape transformation (natural to 1960s urbanised town). The fixed vantage point and sequential arrangement facilitate comparative reading of environmental/societal change, exemplifying comics as a tool for visualising long-duration transformations. Source: https://arthur.io/art/robert-crumb/a-short-history-of-america (Accessed 17 May 2025).

Robert Crumb's *A Short History of America* (*ASHoA*, 1979, Figure 7-21)[41] also belongs to the Time Intervals category (fixed space, shifting time), but foregrounds comparison rather than immersion. Twelve panels depict a North American land parcel's transformation from a bucolic landscape to a bustling 1960s urban environment. The grid arrangement permits non-linear navigation, enabling comparisons between temporally distant moments—functioning like *small multiples* in DV (Wilke, 2019, pp. 255–260)—and extends to other temporal representations in comics such as *One Soul* (Figure 7-8) and *How Things Work Out* (Figure 7-17), which similarly function as comparative chronologies (Tosti, 2021). Non-linear paths—reverse reading suggesting de-urbanisation, selective omission implying industrialisation without an

[41] *ASHoA* was originally published in issue 23 of the environmental journal *Co-Evolution Quarterly* (1979) on four pages arranged in three before being republished the same year in *Snoid Comics* by Kitchen Sink Press and finally in poster format, with colours by Peter Poplaski, in 1981. Often, original work attribution is incorrect—for instance, the Wikipedia page dedicated to it shows a black and white version paginated like the later poster.

agricultural phase—demonstrate how the grid functions as an analytical tool rather than a purely sequential one. This comparative capacity depends on the grid's tabular structure: historically fundamental for structuring temporal and categorical data (Rosenberg and Grafton, 1996, p. 11), lists excel at linear enumeration but foreclose non-sequential navigation (Estrella and Estrella, 2020, p. 23), whereas tables introduce a bi-dimensional structure facilitating pattern recognition and comparative reading (Telea, 2014, pp. 134, 446). The dominant hue progression—from natural greens and blues to artificial greys and reds—further encodes transformation as a visual variable, analogous to sequential colour scales in DV (Wilke, 2019, pp. 29–30).

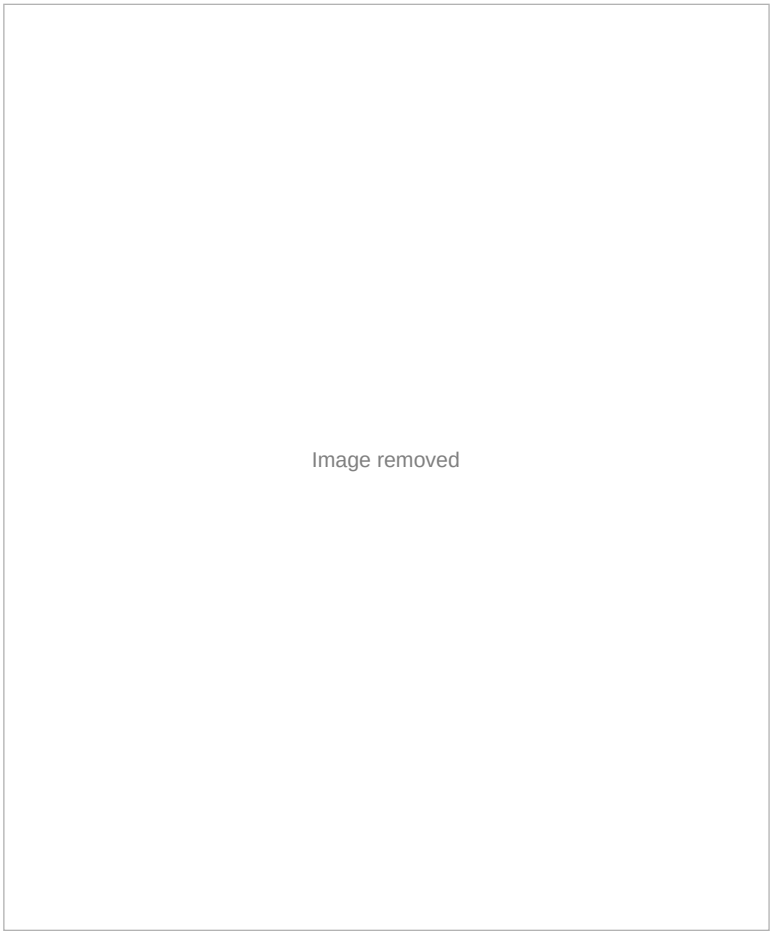


Figure 7-22: Frank King, *Gasoline Alley* (Sunday page, 24 August 1930). (A) Original: characters on a beach, continuous background, 12-panel grid. (B-C-D) Modified: potential alternative, non-linear reading paths (e.g., 1–5-9) to same narrative outcome. This demonstrates the page's function as a navigable, meshwork-like space allowing for reader-driven exploration of temporal and spatial relationships.

Frank King's Gasoline Alley (1930, Figure 7-22) exemplifies Time Planes, contrasting with both ASHoA and One Soul. Unlike ASHoA—which segments time into clearly defined intervals viewed from a fixed perspective—Gasoline Alley depicts a beach scene in which multiple temporal instances are interwoven across a continuous spatial background spanning twelve panels. And unlike One Soul, where parallel temporalities occupy separate visual spaces, here all actions occur within the same cohesive environment, reinforcing time as a fluid, layered continuum rather than a sequence of discrete moments.

The page functions simultaneously as a cartographic space and a diagrammatic structure—operating like a flowchart where intersections represent decision points rather than enforcing a single pathway (cf. Lima, 2013, p. 79). The grid's regularity introduces segmentation and modularity; the continuous background undermines this rigidity, encouraging a meshwork-like approach, (Ingold, 2007; see Section 4.9) where meaning emerges dynamically through multiple reading trajectories. The sequence can be shortened or rearranged via alternative paths while reaching the same narrative conclusion (Figure 7-22B–D), each condensing or expanding perceived movement within the scene. Each trajectory becomes a form of wayfaring, with meaning constructed through movement rather than passively decoded from a fixed sequence.

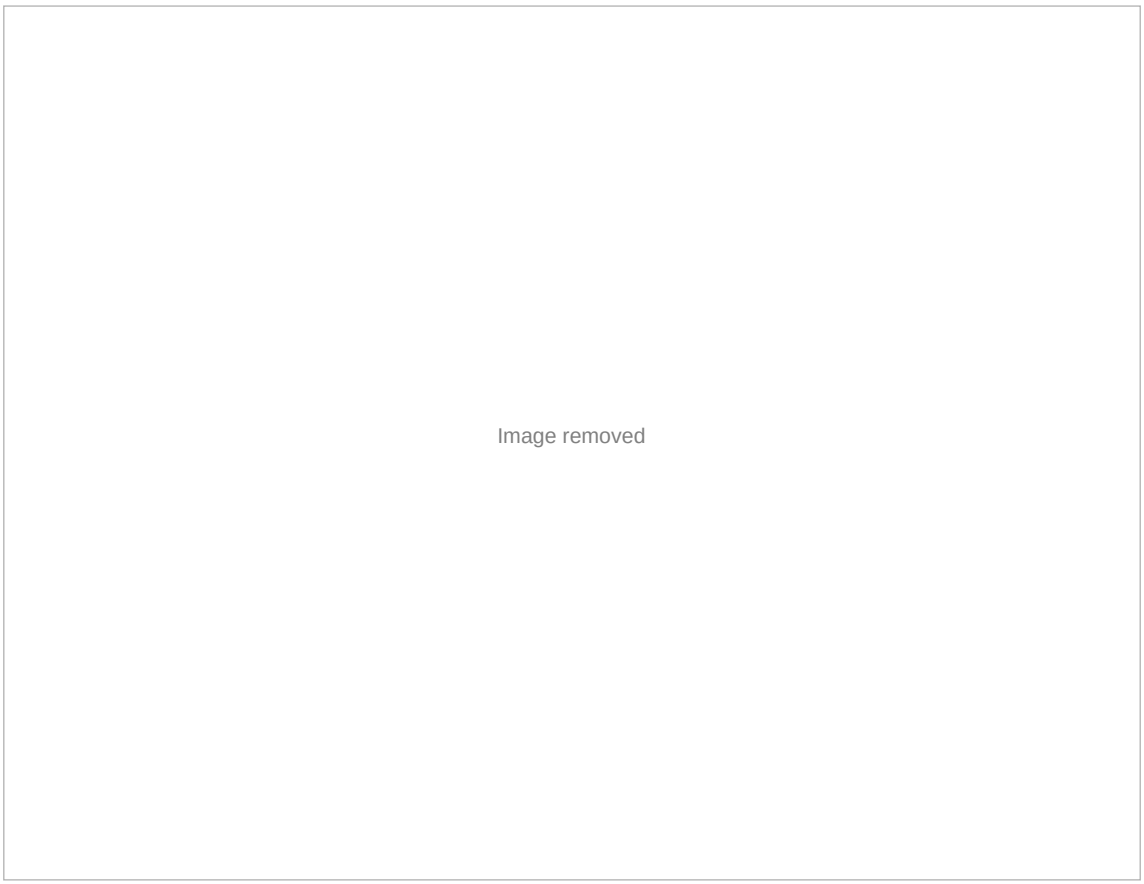


Figure 7-23: Double-page spread from *Pax Americana* (Grant Morrison, writer; Frank Quitely, art, 2015). The page uses a fixed setting (a single room) and a regular grid to represent multiple, intertwined temporal layers simultaneously. The reader must reconstruct events by distinguishing different moments (e.g., morning, nighttime) via visual cues, exemplifying the *Time Planes* category.

Finally, the double-page spreads from Pax Americana (Morrison and Quitely, 2015, Figure 7-23) advance the Time Planes category beyond Gasoline Alley by using a fixed setting for multiple, simultaneous, intertwined temporal layers. Where Gasoline Alley allows readers to navigate different trajectories within a mapped space, Pax Americana presents a single location fractured across distinct moments—shifting from spatial exploration to temporal deconstruction and rebuilding. Unlike One Soul, where parallel temporalities occupy separate visual spaces, and unlike How Things Work Out, where each building floor architecturally separates distinct decades, Pax Americana embeds past, present, and future within the same physical setting.

This is particularly evident in the spread where The Question examines a murder (Figure 7-24). A 6×5 panel grid structures the page, yet the reader simultaneously witnesses three distinct temporal moments in the same room: a morning conversation (warm natural light), a nighttime confrontation (dimmer lighting), and a later investigation (flashlight only). Lighting functions as the primary visual variable distinguishing temporal layers—the reader must actively parse these cues to reconstruct cause and effect across a non-linear framework. The panel grid acts as a network, segmenting time into distinct units; the fixed background creates a meshwork, allowing multiple temporal connections to emerge. Readers reconstruct time like piecing together evidence, each trajectory—following events, skipping panels by lighting cues, analysing recurring object placement—becoming a form of wayfaring through narrative space.

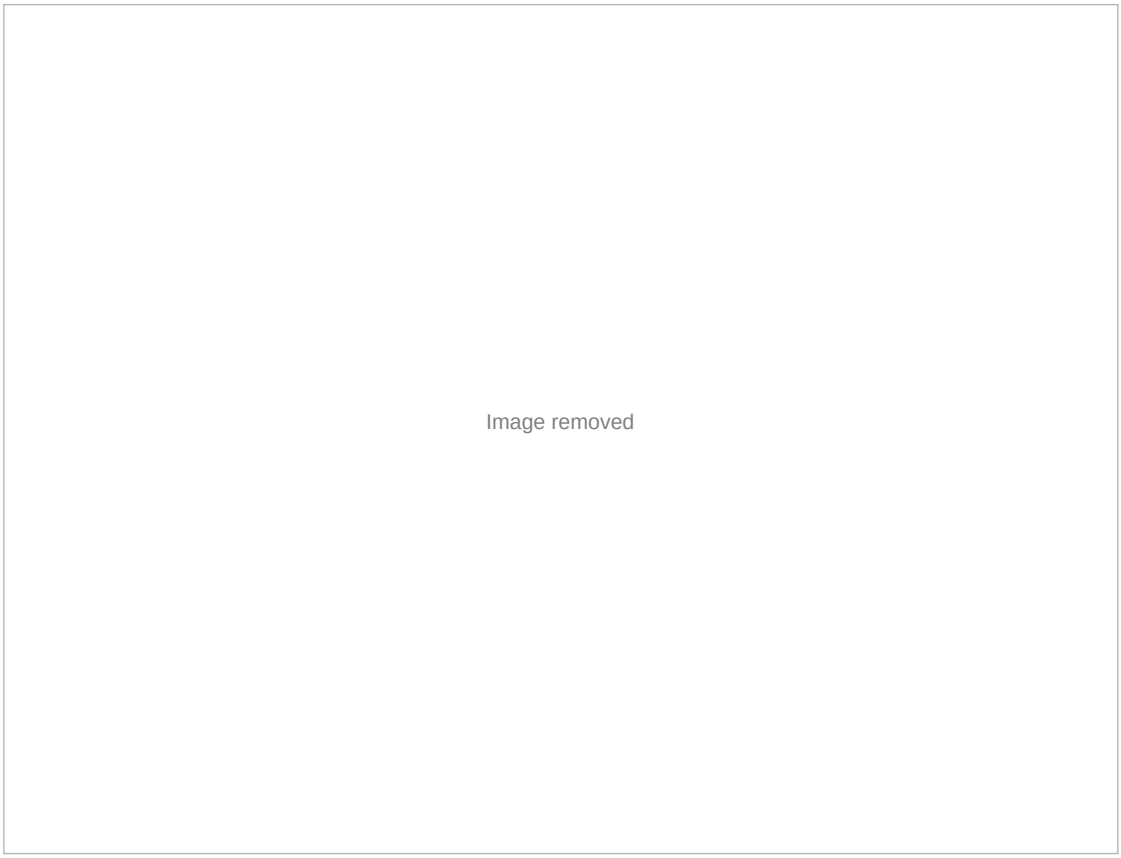


Figure 7-24: Analytical separation of the temporal planes in the *Pax Americana* spread. This diagram illustrates how the single room hosts three distinct, overlapping timelines (morning conversation, nighttime murder, later investigation). This visualisation clarifies how the reader must parse the composite image to understand the complex, non-linear narrative structure.

Pax Americana's spatialisation of time connects to broader discussions on representing temporal dynamics in cartography and DV. As digital mapping technologies transform maps into dynamic mediators of layered temporalities (Gekker et al., 2018, p. 1), comics similarly operate as hybrid systems of temporal inscription—tools for structuring and navigating complex temporal relations rather than merely depicting static reality. This perspective aligns with the conceptual frontiers discussed in Section 5.5 and reinforces the need for visual forms capable of expressing overlapping, non-linear temporalities across disciplines.

7.5. Expanding the Conceptual Prototypes of ECtC: Towards the Book-Format and Representation of *Hyperobjects*

This section argues that previously identified representational challenges—particularly the need for multi-scalar, non-anthropocentric, and diagrammatic models (see Sections 5.3 and 5.4)—necessitate new visualisation strategies for data, information, and knowledge representation. These demands align with developments in post-digital educational frameworks (see Sections 3.6.1, and 3.6.2), emphasising distributed and relational knowledge, and with DV's shift toward networked and rhizomatic approaches. This chapter's analysis has progressed from viewing individual panels as quantitative and qualitative displays to exploring more complex, interconnected structures. It adopts a macro-semiotic perspective foregrounding the relational, diagrammatic, and networked qualities of comics, with the page conceptualised as the minimal unit of meaning (Groensteen, 2007, 2013; Bateman and Wildfeuer, 2014b, 2014a; Bateman et al., 2017).

Thus far, analysis has focused on structures up to a page or double page—the maximum sensory space the gaze embraces 'at a glance'. The subsequent step considers the *multiframe*: the entire book format. According to Groensteen the multiframe permits complex cross-page connections at multiple spatial and temporal levels, constituting the sum of all frames and hyperframes within a comics.

DVs, particularly those adhering to minimalist principles (grounded in Bertin's and Tufte's approaches) and employing digital/interactive methods, can adopt strategies to maximise information density. These include simplifying data, ensuring mapping techniques produce comprehensible images, or using visual level-of-detail techniques (e.g., zooming) that simplify the resulting image without altering input data. The first requires simplifying or subsampling application data; the second needs strategies to simplify or subsample the mapped image (Telea, 2014, p. 487). Overlaying multiple layers (as in cartography) or using techniques like small multiples (displaying multiple smaller versions of the same visualisation type, each showing a data subset) are also possible (Wilke, 2019, pp. 255–260). From this

perspective, comics may possess limited adaptability and face different constraints. Specifically, ECtC might encounter a scalability issue: the finite representational surface limits visualised data quantity, while excessive simultaneous information can increase cognitive load, hindering interpretation.

7.5.1. Make Room

Two previously discussed cases illustrate this issue. In *Concrete* (Figure 7-8), the extremely high panel count makes each panel's individual information density almost irrelevant. Conversely, Sacco's one-panel panoramic comics (Figure 7-12) make excessive information density (and thus graphics) a deliberate prerequisite, detrimental to quantitative accuracy.[42]

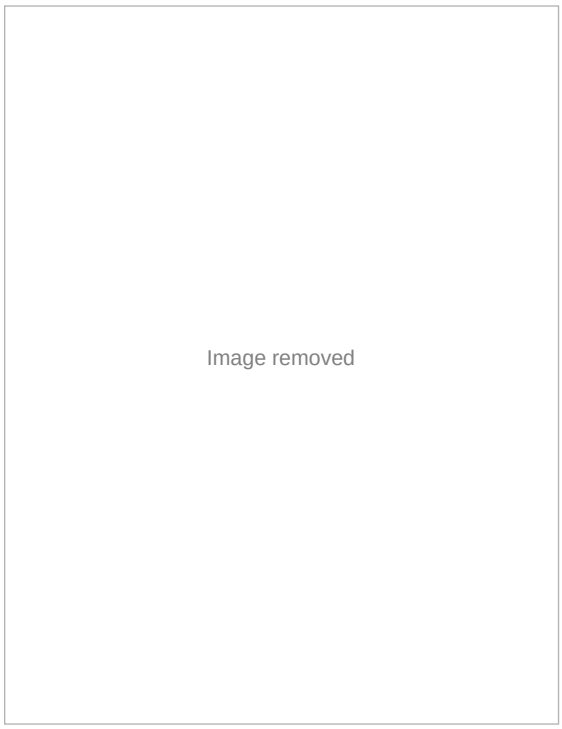


Figure 7-25: Craig Thompson, *Goodbye, Chunky Rice* (2003, p. 27). A central panel provides overall narrative context, while surrounding inset panels offer focalised mini-sequences. This layout exemplifies the *focus-plus-context* model, aligning with adaptive zooming principles in DV.

This chapter does not attempt to replicate DV techniques in comics—given their distinct structures and aims—but rather to explore ECtC' representational potential through parallels with visualisation strategies. *ASHoA* aligns with small multiples via its uniform layout highlighting variation; *One Soul* resembles multivariate visualisations (Wilke, 2019, p. 117), with empty panels marking missing data; *HTWO* evokes layered timelines by structuring decades into planes; *Gasoline Alley* and *Pax Americana* relate to flowcharts (due to their non-linear paths) and temporal heatmaps (via overlays), respectively.

[42] Sacco (2014, p. 1) notes that by rejecting perspective and proportional realism, he compresses up to a kilometre of real space into a few centimetres.

This continuity is further evident in a page from Craig Thompson's *Goodbye, Chunky Rice* (2003, Figure 7-25) that features a central panel providing overall context, while smaller surrounding panels act as focal points, unfolding in mini-sequences. This mirrors focus-plus-context and adaptive zooming strategies, where detailed views are embedded within a larger frame and progressively revealed (Lima, 2013, p. 95).

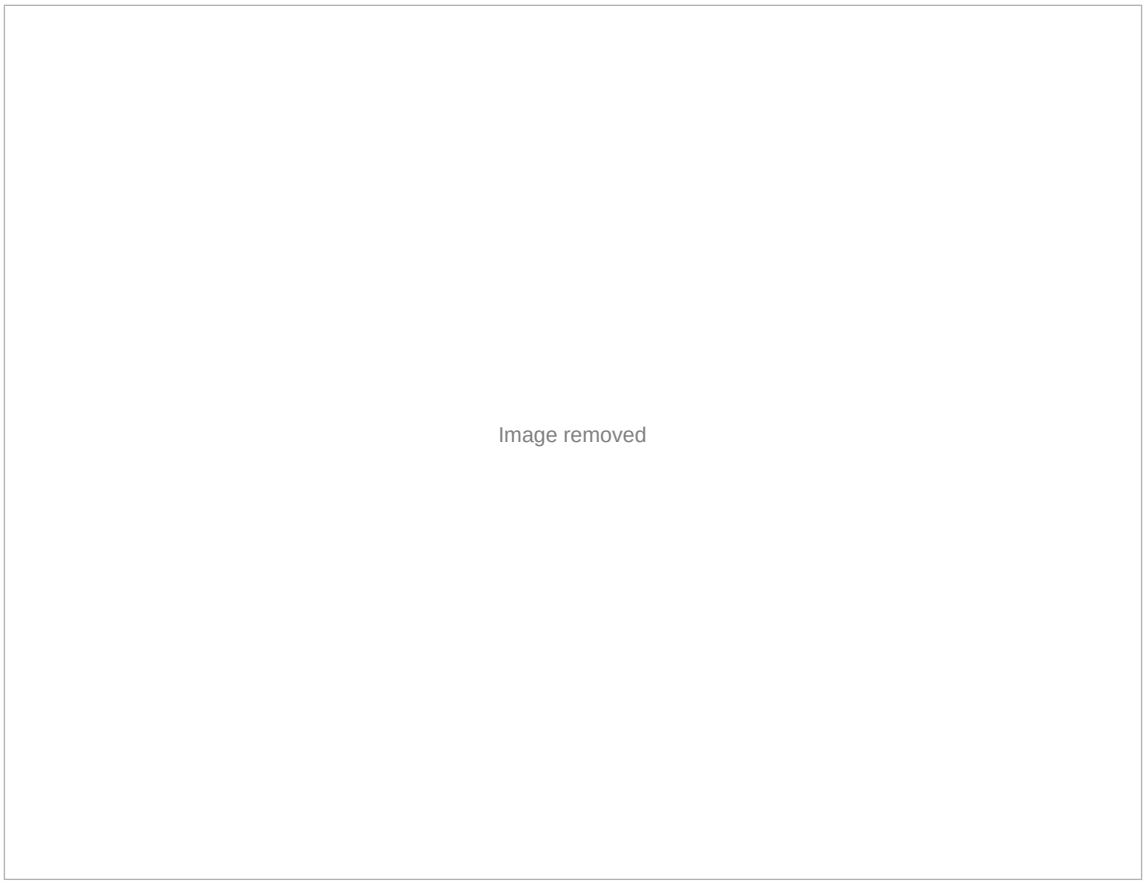


Figure 7-26: Grant Morrison (writer) and Frank Quitely (art), *WE3* (2004–2005), double-page spread. A dynamic action scene is decomposed into dense micro-panels that radiate from the main action, allowing multiple detail levels to coexist and be narratively reconstructed.

Layouts need not be hieratic. In *WE3* (Morrison and Quitely, 2011 [2004-2005]), a battle scene is fragmented into a dense array of inset panels (Figure 7-26). Unlike *Goodbye, Chunky Rice*, which centres visual focus, *WE3* disperses information across clustered fragments that radiate from the action core. This aligns with DV strategies like multi-scale representation, enabling

detail levels to coexist. The layout organises zoom levels and clusters around two full-width horizontal panels, supporting correlation, trajectory tracing, and scene reconstruction.

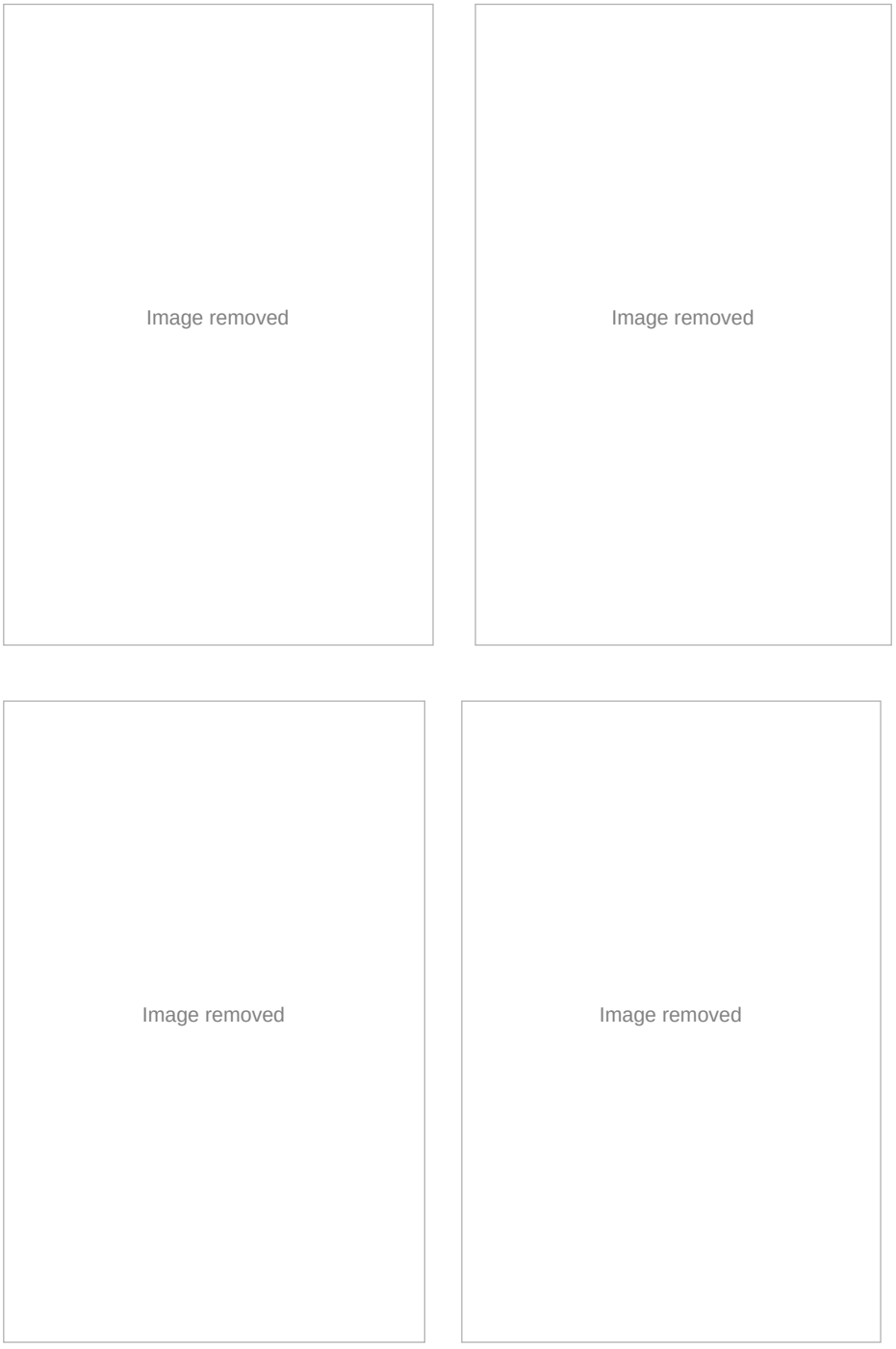


Figure 7-27: Eric Drooker, *Flood* (1992), pp. 44–47. This four-page sequence progressively multiplies the panel count (16–64–256), using increasing visual abstraction and density to represent the protagonist's disintegration within an oppressive urban environment.

Yet regardless of such strategies, drawing—as the core representational element—occupies space, both in terms of visual density and node complexity.[43] High representational density within panels necessitates larger panel sizes for readability, thus reducing the total number of panels per page. High-density panels require larger formats to remain legible, thus reducing total panel count. This is evident in Eric Drooker's *Flood* (1992), in which an anonymous protagonist's nocturnal misfortunes are depicted. Over four pages, the panel count increases exponentially (from 16 to 64 to 256), while visual clarity declines, culminating in a page of total blackness. This increasing panel density corresponds with increasing stylization of individual panel content, visually conveying the protagonist's downfall and dissolution within a decaying and oppressive New York City (Figure 7-27). Where *Concrete* demonstrated that high panel count can shift meaning from individual content to collective rhetorical effect, *Flood* illustrates a different and more fundamental constraint: the point at which exponential panel multiplication renders the comics page physically unreadable as a data display. This is not a rhetorical choice but a structural limit—the threshold beyond which information density becomes self-defeating, and comics can no longer function as a viable alternative to DV. At the opposite extreme, works like Drew Weing's *Set to Sea* (Weing, 2014) or early woodcut novels by Masereel and Ward (Beronä, 2008; Tosti, 2016, pp. 504–520) use one panel per page, maximising scale and detail but eliminating simultaneous narrative comparison entirely.

[43] 'Nodes' here refer to inter-panel relationships within the page layout conceived as a network, though they may also emerge within panels or their content connections—making the *meshwork* analogy more apt in this context.

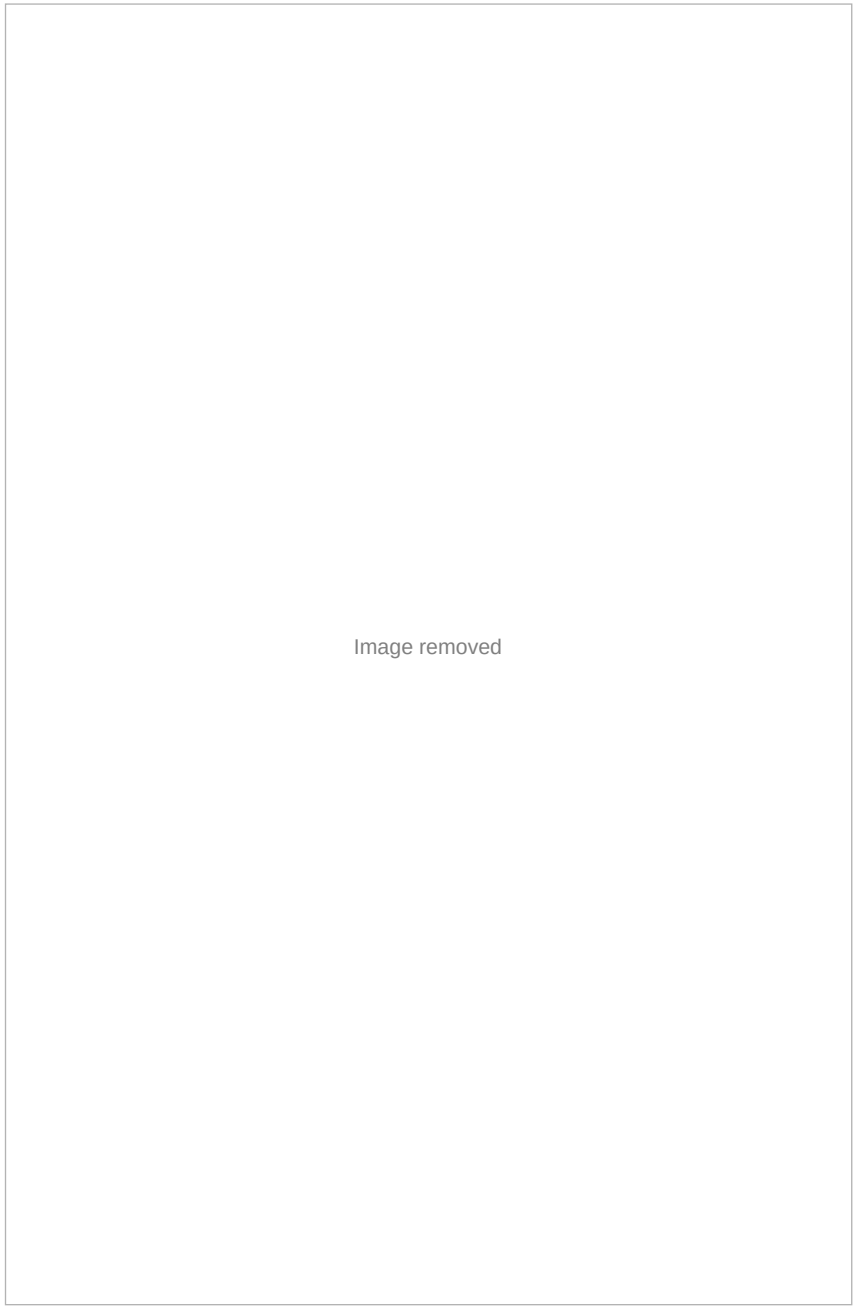


Figure 7-28: Grant Morrison (writer) and Frank Quitely (art), *Pax Americana* (2015, p. 38). Hundreds of shrinking panels represent fragmented memory, transitioning from narrative content to abstract pattern recognition. This evokes mnemonic compression and aligns with space-filling visualisation strategies.

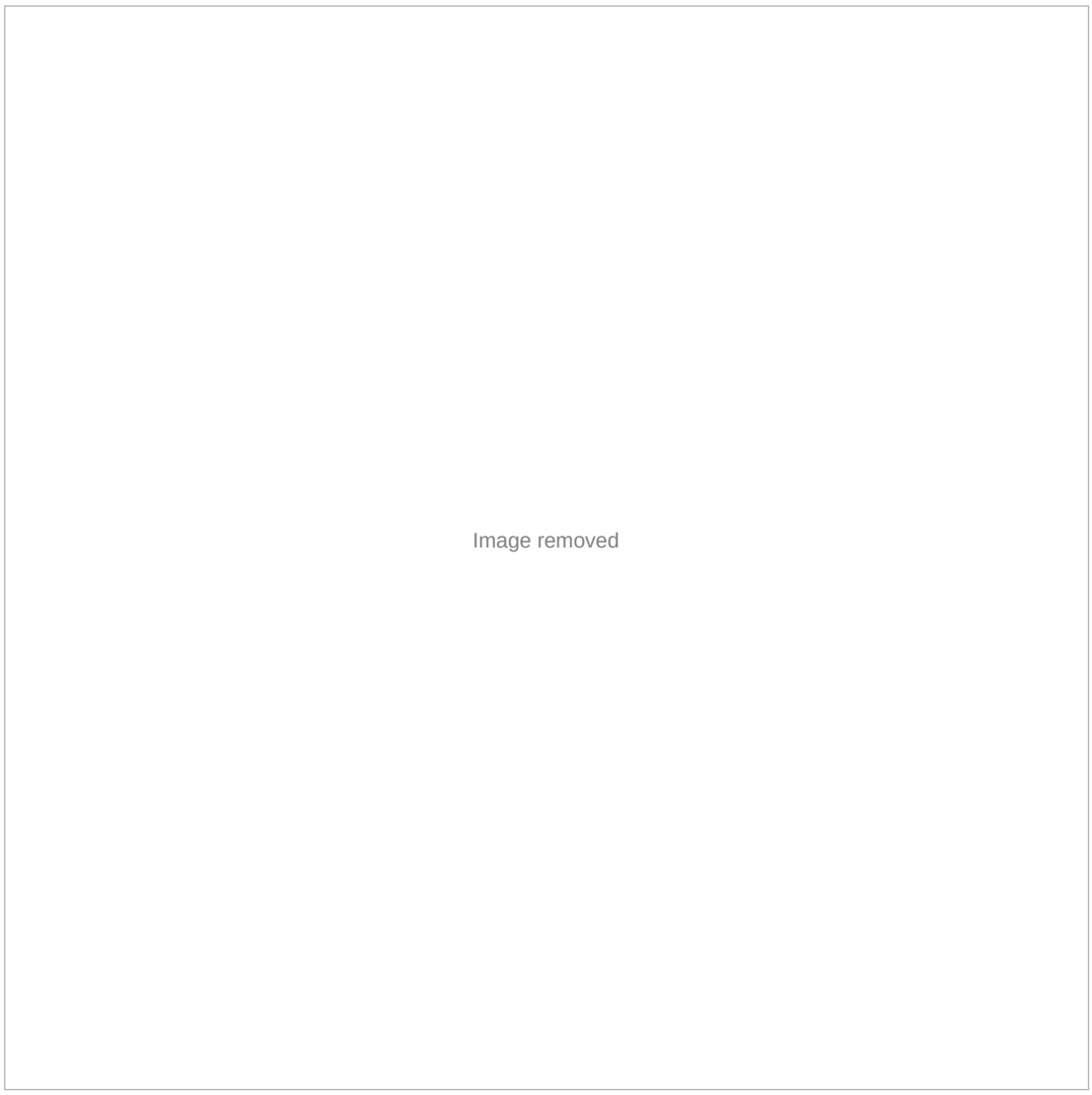


Figure 7-29: Bianca Bagnarelli, untitled illustration for 'Notes on Work' by Weike Wang, *The New Yorker* (2022). Panel multiplication and chromatic segmentation visually express the monotony of repetitive labour, approximating a dimensionality-reduction effect akin to PCA.

As panel count increases and visual detail diminishes, some works adopt indexical strategies in which panels cease to convey discrete narrative units and instead function as density markers. In another page from *Pax Americana* (Morrison and Quitely, 2015; Figure 7-28), hundreds of shrinking panels compress fragmented memories into near-abstraction, evoking mnemonic patterns through chromatic rhythm rather than individual content—a shift from discrete readability to pattern recognition recalling space-filling visualisations (Wattenberg, 2005). Bagnarelli's illustration for *The New Yorker* (Wang, 2022; Figure 7-29), employs a related strategy: exponentially multiplying panels depicting a woman at her desk until the figure

dissolves into chromatic segmentation, visually encapsulating repetitive labour. Both examples connect to concreteness fading (Section 5.2.1): comics' shifting panel structures can guide readers from granular representation to emergent pattern, paralleling DV techniques like focus-plus-context and adaptive zooming. This suggests that creating visual space through minimalist strategies or explicitly defining the diagrammatic role of page architecture are viable approaches for ECtC.

This logic of structured abstraction finds a different articulation in authors like Ware and Huizenga, who—while often associated with diagrammatic comics (Cates, 2010; Bartual, 2012; Cohn, 2017; Tirino and Paola, 2018; Troiani, 2016)—pursue distinct aims that prioritise formal intricacy or textual density over the kind of accessible multi-scalar navigation ECtC require.

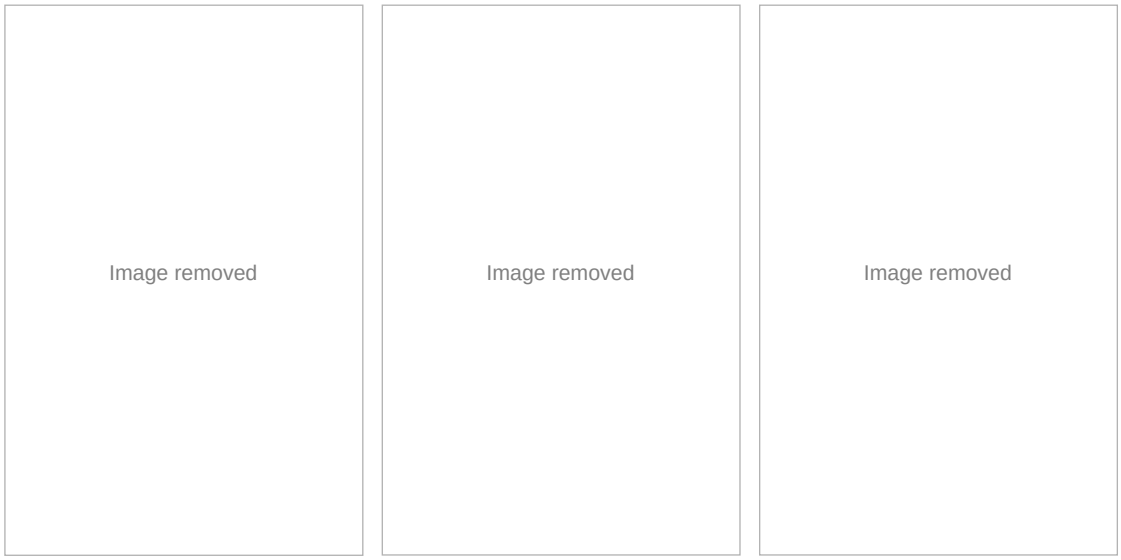


Figure 7-30: Matt Fraction (writer) and David Aja (art), 'Pizza Is My Business', from *Hawkeye* #11 (2013), pp. 3, 6 and 12. Narrated from a dog's perspective, this episode uses pictograms, isometric projections, and olfactory mapping to replace verbal elements, demonstrating a diagrammatic/infographic storytelling approach.

A more compelling approach—at least for the purposes of this thesis—can be found in two further examples. The first is *Pizza Is My Business* (Fraction and Aja, 2013).[44] This *Hawkeye* series episode, narrated from a dog's perspective, justifies near-total verbal element absence.

[44] Given its relevance, it is worth noting that Chris Eliopoulos, the letterer, is credited as 'producer' in the colophon.

Meaning is conveyed through pictograms; an infographic/diagrammatic stylistic approach extends to spatial representation, often depicted via floor plans, isometric projections, and olfactory-based relational mappings (Figure 7-30).

By eliminating verbal elements almost entirely and replacing them with pictograms and spatial diagrams, this episode demonstrates that comics can achieve high information density through visual means alone—a strategy directly relevant to ECtC design in disciplines where glottocentric communication is insufficient or where spatial and relational data need to be foregrounded over narrative description.

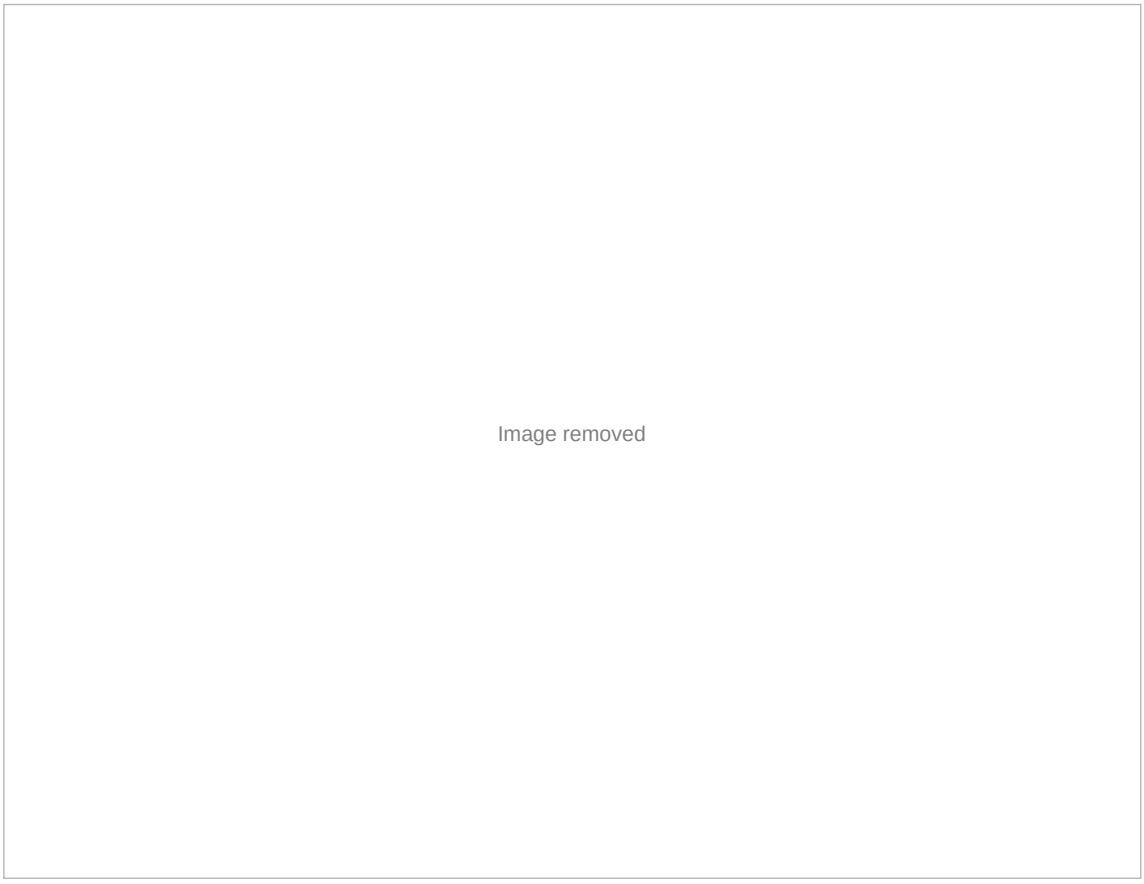


Figure 7-31 Kieron Gillen et al., 'Deus ex machine gunner', in *Young Avengers Vol. 2* #4 (2013), p. 3. A central axonometric panel anchors the spatial context of a fight scene, while numbered inset panels present synchronic highlights. This layout synchronises spatial mapping and narrative sequencing.

The second, from *Young Avengers* (Gillen et al., 2013), develops this further through an axonometric central panel anchoring the spatial context of a fight scene, while numbered inset

panels present synchronic highlights—using explicit numbering to guide readers through a spatialized event chronology (Figure 7-31).

These techniques for representing action/trajectories within continuous space—synchronised with varied zoom levels and/or simultaneous parallel narrative element depictions—have become a hallmark of many artists, particularly in American superhero comics. As Cohn (2024, p. 81), notes, American comics (dominated by superheroes) generally feature fewer panels per page than European publications. One might hypothesise that American comic books' typically lower page count (24–32) and smaller format encouraged space-maximising visual solutions, which, with a larger-than-life aesthetic, led to dynamic layouts enhancing readability and action sequence impact.

Table 7-2: This table summarises five strategies for managing representational density in comics—*Panel Density Adjustment*, *Minimalist Style & Colour Indexing*, *Focus-Plus-Context & Adaptive Zooming*, *Explicit Diagrammatic Structuring*, and *Spatial Clustering & Layering*—each paired with its associated techniques and narrative effects. Together, they provide a framework for analysing how comics negotiate informational load and spatial limitations.

Strategy	Technique Associated	Effect/Result
Panel Density Adjustment	Progressive panel multiplication	Modulates informational load, evokes narrative intensity.
Minimalist Style & Colour Indexing	Concreteness fading, PCA	Reduces visual detail while preserving coherence.
Focus-Plus-Context & Adaptive Zooming	Central focal panels, micro-sequence clustering	Ensures readability across multiple levels of detail.
Explicit Diagrammatic Structuring	Isometric layouts, pictograms	Optimizes spatial organisation, clarifies relationships.
Spatial Clustering & Layering	Layered timelines, flowcharts	Enhances readability in non-linear storytelling.

At any rate, regardless of graphic style reduction or informational density enhancement through inventive layouts, summarizing graphic elements, or indexical/quantitative colour use, comics will never achieve the density of, for instance, a *dense pixel display*.[45] In sum, comics address inherent medium spatial constraints by deploying techniques balancing detail,

[45] Dense Pixel Displays are a DV technique in which each data point is mapped to a single pixel, preserving spatial relationships without aggregation. Attributes are shown in separate sub-windows, with values encoded by colour, enabling pattern and correlation detection in large multidimensional datasets (Keim *et al.*, 2009).

context, clarity, and readability, including modulating visual density, optimizing spatial organisation, and enhancing narrative coherence via panel density adjustment, minimalist aesthetics, focus-plus-context approaches, explicit diagrammatic structuring, and spatial clustering (see Table 7-2)

Nevertheless, more information, greater complexity, additional data, or an increase in the number of nodes and connections inevitably require more space. Unlike DV, which can manage high-density information through both interactive techniques—such as layering, filtering, or zooming—and static strategies like abstraction, aggregation, or dimensionality reduction, comics must balance detail and clarity within the fixed constraints of the page. The book format not only allows for this expansion but also provides additional advantages in terms of the medium's representational capabilities.

7.5.2. From Scalar Complexity to Epistemic Cartographies

These spatial and representational challenges open up deeper questions concerning scale as a structuring principle. Section 7.5.2therefore shifts focus from density and visual strategy to scalar complexity and epistemic organisation. While the book format addresses spatial constraints, its implications surpass mere representational flexibility. The page-to-book transition shifts how comics manage and convey knowledge across complexity levels, pertinent for phenomena resisting single-scale representation or when exploring multi-layered epistemic structures.

Scale—'the systematic accounting for significant shifts in a measured range of observation' (DiCaglio, 2020, p. 459)—is not merely representational and quantitative, but also functions as a cognitive and epistemological device. As Clarke and Wittenberg (2017), note, it shapes how knowledge is perceived and organised. Grasping phenomena far removed from the human scale poses a major challenge across disciplines, from literature to science and visualisations of climate change or the Anthropocene. As Woods (2017) observes, engaging with scales inaccessible to human perception—drawing on Arendt and Merleau-Ponty—requires moving beyond linguistic and sensory models, as well as conventional categories of knowledge.

Horton (2017), engaging critically with the notion of *scalar collapse*, proposes three alternative models that reject purely quantitative scaling logics:

- **Microcosm**: a model in which each entity reflects a higher scale without losing the complexity of the relationships between levels. This model risks imposing a rigid order on the scales, assuming that the structure is always preserved without significant variations.
- **Serialized cosmos**: This model represents the progressive expansion of the scale without ever reaching a totalisation, suggesting a non-hierarchical vision of knowledge and the universe. The idea is that each move to a new scale introduces

new complexity, without there being an absolute reference point or fixed hierarchy. the risk of this model is the loss of fixed references, which can make it difficult to establish coherent relationships between the different scales

- **Resolved or mediated cosmos**: The third model is the one developed by the Dutch educator Kees Boeke in his book *Cosmic View: The Universe in 40 Jumps* (Figure 7-32). [46] This approach combines aspects of the microcosm and the serialised cosmos, proposing an educational representation of scale through a series of progressive images that show the world at increasingly larger or smaller orders of magnitude.

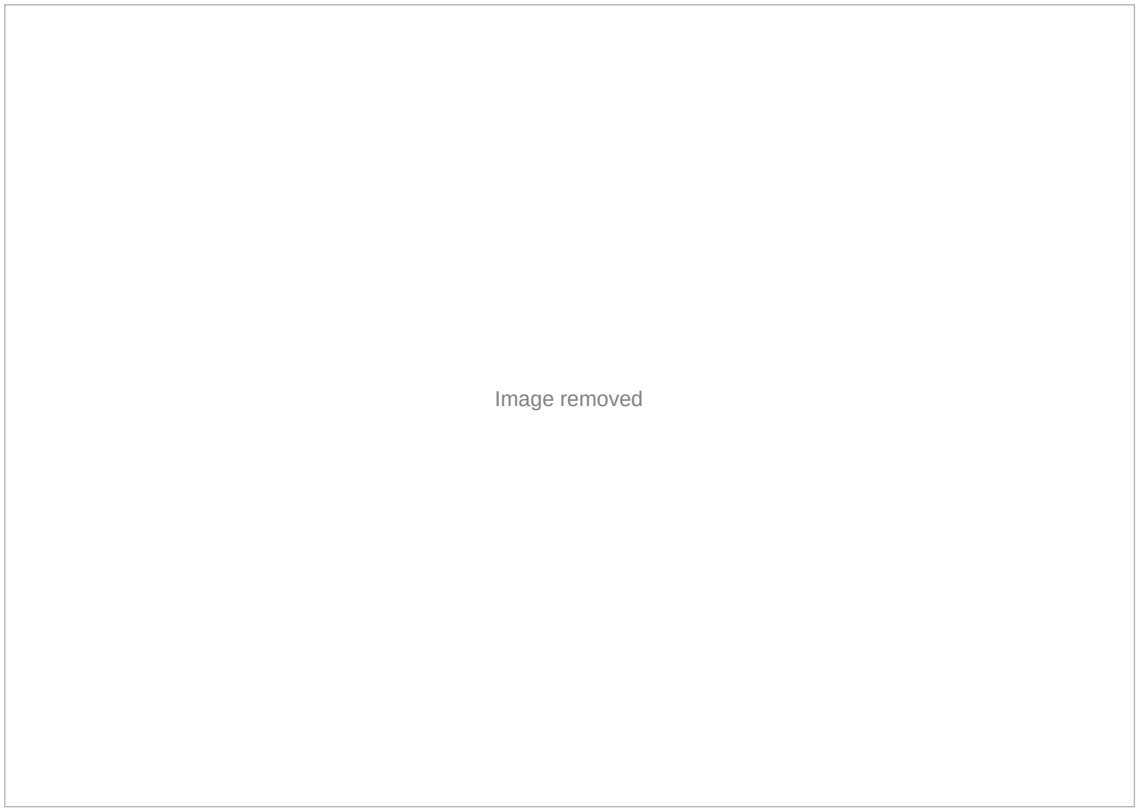


Figure 7-32: Kees Boeke, *Cosmic View: The Universe in 40 Jumps* (1957), pp. 8–16. This educational sequence uses scale shifts to explore spatial magnitudes from atomic to cosmic, exemplifying scalar mediation and inspiring later works like *Powers of Ten*.

[46] *Cosmic View* (Boeke, 1957) visualises scale through progressive zooming from the everyday to the cosmic and subatomic.

Concerning visualisations comparable to the third model, Dorrian (2012), focusing on *Powers of Ten* (Eames and Eames, 1977),[47] emphasises how these representations allow us to connect the micro and the macro in an observational continuum, changing the way complex phenomena are understood. DiCaglio (2020), on the same work, extends Dorrian's perspective, discussing scale's epistemological power and the risk of a totalising 'God Trick' (Haraway, 1988) vision. According to Di Caglio, *Powers of Ten* and similar works are not just scientific explorations but also narrative devices mediating between cognitive/post-human perspectives, problematising the observer/observed relationship.

Considering scale as a cognitive framework, the comics page-to-book transition represents a fundamental shift beyond mere representational space expansion. The book format fundamentally reconfigures comics' spatial/temporal logic. While single pages integrate multiple temporalities/scales via panel layouts (establishing simultaneous, relational, non-linear connections), the book format amplifies this capacity, introducing an extended narrative space for cross-page connections, accumulative structures, and trans-scalar relationships. This signifies an epistemic structure shift, enabling comics to model complex, non-linear phenomena. Horton's scalar models offer a framework for understanding how book-format comics integrate scales, suggesting further integrative possibilities.

These models, informed by space, cartography, and geography reflections, challenge space's static notion, favouring a dynamic and relational vision (Lévy et al., 2016; May and Thrift, 2001)—one particularly relevant for comics, where time is structured relationally through the interplay of time points, intervals, and planes, rather than purely sequentially.

The book's multi-page structure expands these possibilities further, introducing what might be described as a 'perpendicular axis' of temporal progression that transforms the book into a networked, stratified temporal cartography—one in which book-format comics construct relational knowledge systems rather than merely depicting sequential events.

[47] *Powers of Ten* project explores scale through a visual sequence. The 1977 short film depicts a journey from Earth to the universe's edge and then to the subatomic scale.

This epistemic reconfiguration of the book format is not merely an expansion of spatial scope, but a transformation in the way knowledge is navigated—through a dynamic interweaving of temporal and spatial dimensions. The shift from single page to book can thus be compared to representational models that embed temporality within spatial frameworks, such as multilayered cartographies or the Space-Time Cube (STC). Just as the STC allows states and transformations to coexist within geographic visualisation, the book-format comics constructs an interconnected system of relationships across pages, enabling layered and non-linear modes of reading. While the analogy is conceptually suggestive—and the STC also supports narrative data representation—the following examples will show how comics often pursue even greater dimensionality and complexity.

7.5.3. Comics As Multidimensional Peculiar Maps: The Book Form and *The Space-Time Cube*

Building on prior cartography and comics discussions (see Chapters 4 and 5), this section shifts from panel/page levels to the book format, exploring how trans-page connections and multi-scalar narrative layering enrich ECtC' representational strategies. It argues all comics, particularly book-format ones, function as complex, multi-layered *epistemic cartographies* structuring/representing spatiotemporal information analogously to, and even exceeding, advanced cartographic models. Spatial experimentation examples in comics further demonstrate this potential and comics' desire for additional dimensions.

This transition cautiously compares to two-dimensional cartography's evolution to advanced spatial/temporal models (e.g., STC, multi-layered cartographies). As Google Maps or similar interfaces allow navigation through geospatial information layers, book-format comics construct an interconnected relationship system, not a mere page succession. Readers can follow non-linear paths, jump between meaning levels, and establish networked connections between distant elements. Similarly, STCs integrate temporal dimensions into cartographic representation, allowing simultaneous state/transformation visualisation over static snapshots. In comics, page-to-book shift is not just spatial organisation expansion but a time/space-time management and navigation transformation. Like multi-layered cartographies, comics offer fluid, stratified, non-hierarchical exploration.

Developed in time geography, the STC model (mid-20th century) studies human interactions within inherently interconnected spatiotemporal contexts (Kveladze et al., 2019, p. 1; Kraak and Kveladze, 2017, p. 57). It uses two spatial dimensions (x, y) for location, and a third (time) for temporal data organisation (see Figure 7-33). The temporal dimension adds a narrativizing/historicising element to spatial data (Kraak and Kveladze, 2017; Mayr and Windhager, 2018).

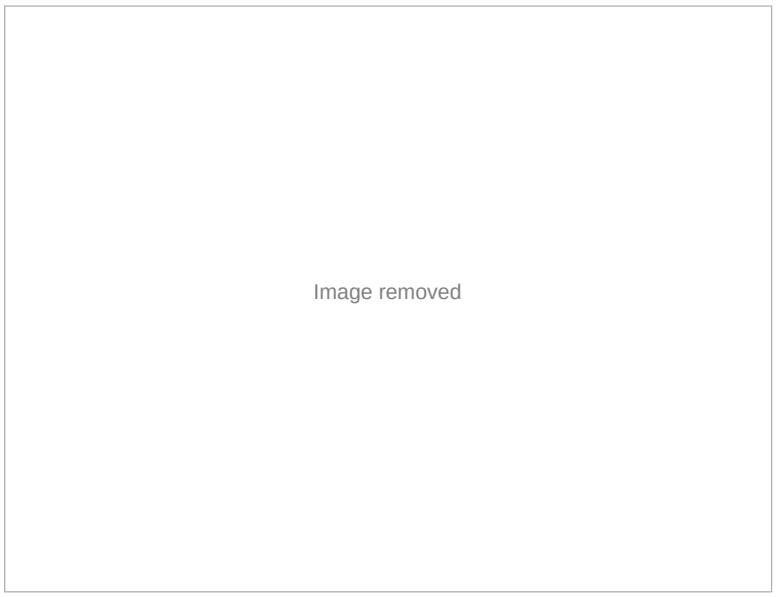


Figure 7-33: 'The time geography aquarium, or space-time cube'. In Moore et al. (2018, p. 6). A diagram illustrating the STC model: two spatial dimensions (x, y) and one vertical temporal axis, used to represent trajectories in time-space visualisation.

Possible comics/STC interactions have been suggested. Moore (2009) and Moore et al. (2018) discuss how comics visually organise spatiotemporal data, representing sequential events via panel arrangements akin to STC structure. However, comics' function remains primarily strip-model anchored, appearing more as a visual aid/graphic notation than a complex spatiotemporal medium. Its informative/engaging function is emphasised, without significant deviation from previously noted DC limitations (see Section 5.4). Le Mao and Touya (2024), comparing comics and multilayered maps, highlight progressiveness's role in constructing maps for intuitive, immersive navigation. They note multi-scale maps share comics' layered structure (information organised via visual hierarchies guiding users across detail levels), comparing map scale transitions to sequential comics reading (whole/unit perception coexisting). Their urge 'Explore maps as you read a comic book', invites the reply 'Explore comics as you read a map.'

Many comics artists have attempted to transcend page planarity within its two-dimensional limits. Shintago Kago's *Abstraction* (Kago, n.d.)[48] explores content/form relationship via progressive 3D panel structure expansion. Initially, a conventional layout depicts a man diving for a ring (Figure 7-34). Instead of a traditional page turn, composition rotates, revealing panels on a cube's surface, disrupting expected flow and emphasising spatial construction. Further rotations expose more panels, gradually replacing character-driven

[48] Source: https://didjelirium.wordpress.com/2011/02/19/abstraction-by-shintaro-kago/ (accessed 17 May 2025).

narrative with numbered sequences guiding readers through increasingly abstract composition. Finally, the original scene dissolves into a fragmented tableau of simultaneous events, suspending narrative coherence for structural exploration.

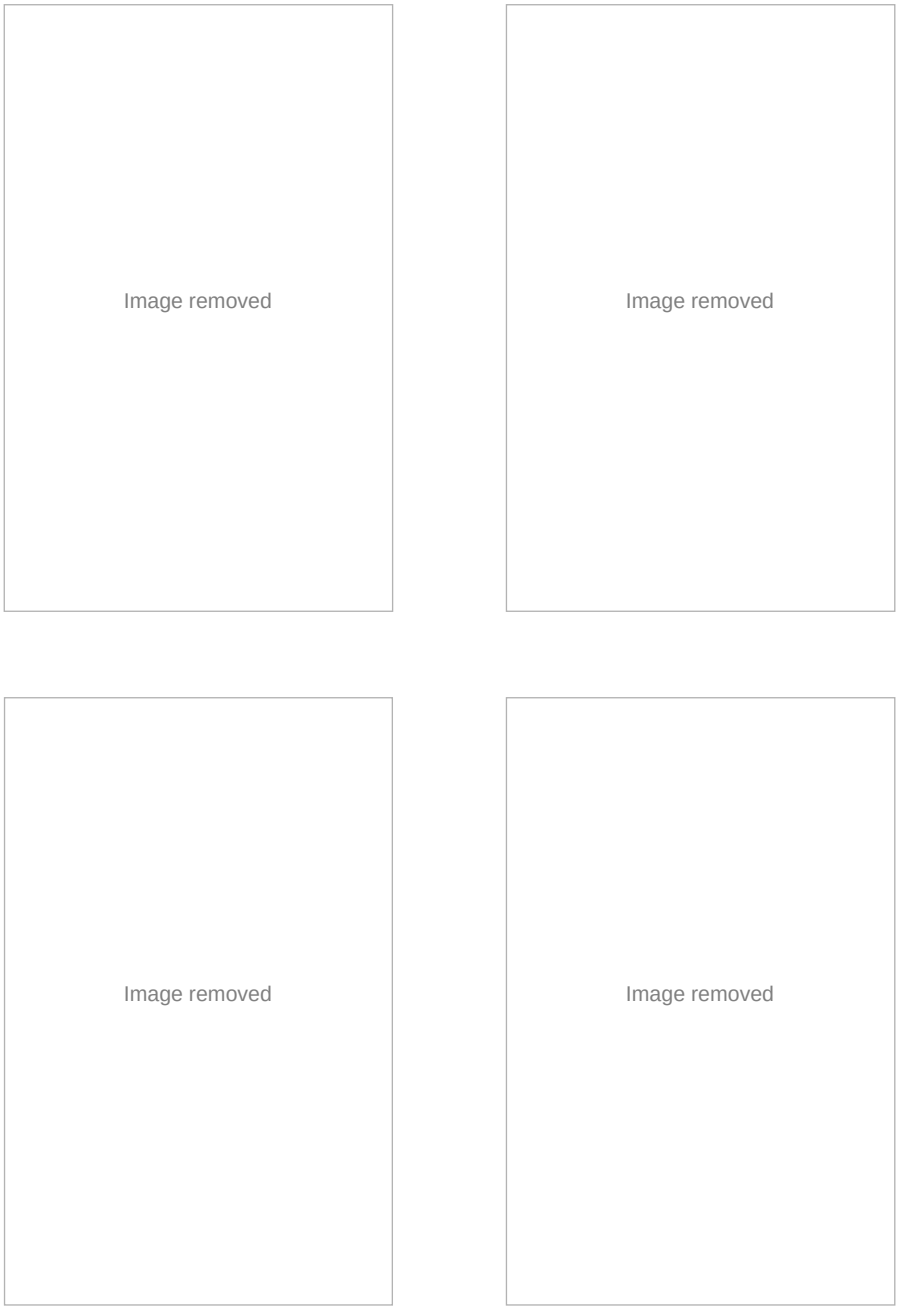


Figure 7-34: Shintaro Kago, *Abstraction* (n.d.), pp. 1–4. Panels unfold along the surface of a rotating cube, shifting from narrative to structural logic. The work explores spatial depth and abstraction, deconstructing conventional page organisation.

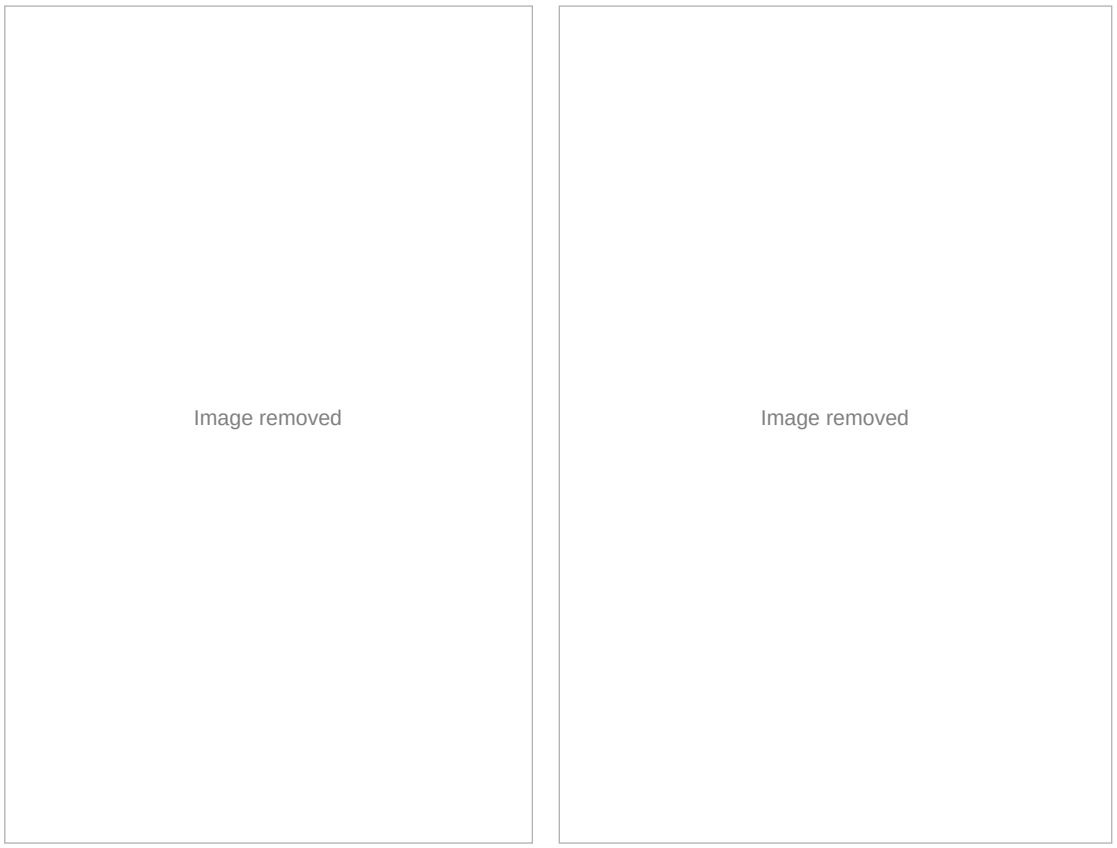


Figure 7-35: Patrice Killoffer, 'Tripoutre' (from *OuPus* 1, 1997, pp. 66–67). This cube-based structure allows multiple reading paths (linear, multiplicative, cyclical), transforming the comics into a combinatorial narrative system.

Structuring comics as a cube is notably explored by Patrice Killoffer in *Tripoutre* (1997).[49] Killoffer employs a non-linear, cyclical structure, mapping narrative panels onto a cube. Reading follows three numerical sequences: first traverses all panels; second selects multiples of 3 (3–6-9–12–15–18); third narrows to multiples of 6 (6–12–18). This generates combinatorial, modular narrative; meaning shifts with chosen path (Figure 7-35).

Marc-Antoine Mathieu's *L'Origine* (1990), (Julius Corentin Acquefacques series) introduces a physically missing panel on p. 37 (Figure 7-36), allowing readers to access past or future information depending on reading direction, justifying dialogue. This 'anti-panel' *(anti-*

[49] The Penrose Triangle (*Tripoutre* in French) is a geometric paradox that produces the illusion of a coherent 3D form while being physically impossible. Composed of beams seemingly connected at right angles, it challenges spatial perception and has been widely used to depict impossible architectures in both art and theory.

case) is explained by a character as 'quelque chose comme "une fenêtre" pour lire le passé ou le futur…' (Page 38, top right panel).[50]

The examples briefly analysed here not only challenge the two-dimensionality of the page by introducing spatial depth and alternative narrative structures, but also encourage a reinterpretation of the panels, allowing for new meanings beyond a linear and sequential reading. Particularly in Mathieu's and Kago's works, panels gain new significance based on viewed page or how new panels recontextualize prior ones. Authors sometimes transcend page physical limits, as Killoffer and Mathieu do literally.

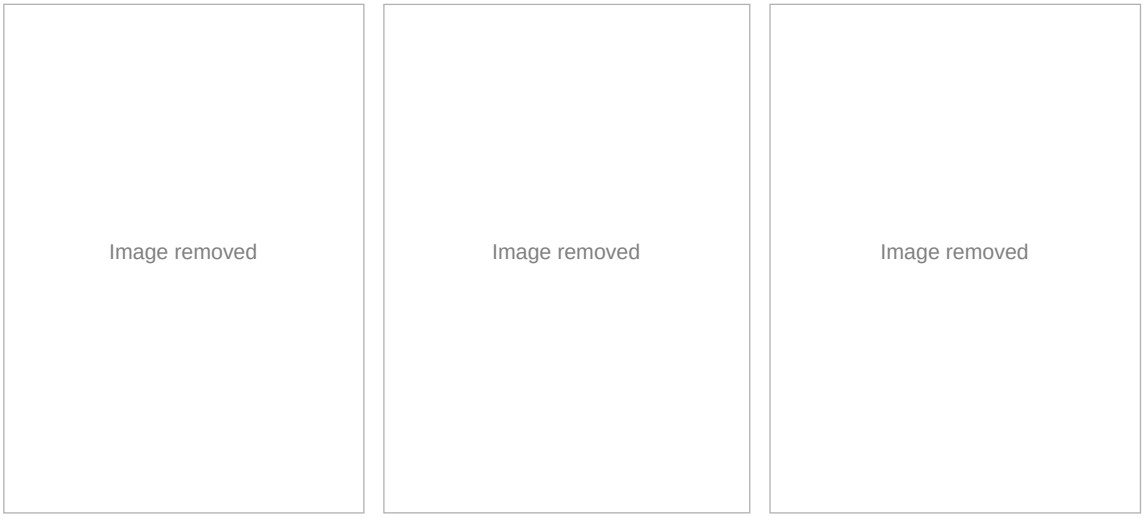


Figure 7-36: Marc-Antoine Mathieu, *L'Origine* (1990), pp. 36–38**.** The central panel on page 37 has been visually altered to suggest its absence—an *anti-case* that reconfigures temporal perception by enabling access to past or future information depending on reading direction, thus integrating spatial manipulation into both diegetic structure and metatextual reflection.

For HE educators and researchers, the significance of these experiments extends beyond formal curiosity. Each demonstrates that comics artists have independently developed strategies for representing layered, non-linear, and multidimensional knowledge structures—strategies that anticipate the representational demands of post-digital pedagogy without having been designed for that purpose. This convergence suggests that the comics medium possesses structural affordances for knowledge organisation that have been largely overlooked

[50] *L'Origine* integrates book materiality into its narrative, making page-turning integral to reading and thus highlighting comics' physical manipulability. Although this thesis only briefly explores physical manipulation in comics—a topic deserving greater attention—del Rey Cabero (2021) offers a detailed analysis.

in educational contexts, and that the ECtC framework proposed in this thesis can build directly on an existing, if underexplored, formal tradition. Kago demonstrates that panels can unfold on non-planar surfaces, decoupling the reading sequence from the page's flat geometry; Killoffer that the reading path itself can become a combinatorial structure, transforming the comics object into a navigable system of meaning; Mathieu that the panel can operate as a temporal portal, making absence and physical manipulation constitutive of the reading experience. Together, these constitute an informal repertoire of spatial strategies that ECtC can consciously inherit and operationalise.

Beyond visual similarities, STC comparison further shows comics' complex spatiotemporal information organisation, even without axonometric precision. Consider *One Soul* (Figure 7-7): each panel on a double-page spread represents a time point in the life of a different character, with each successive page depicting them in a different setting. Excluding the actual or perceived duration of individual panels, each double-page spread can be seen as a frozen moment in time, presenting *time slices* or *snapshots* of a single data state—analogous to an atemporal GIS, which omits past and future records and therefore obscures the processes linking successive states (Langran, 1992, pp. 4–5). Narrative time unfolds via comparisons and inferences from thematic visual parallels; historical time (progression) occurs along the book's perpendicular dimension, activated by page-turning.

Multi-page comics' inherent spatial/temporal layering is radically manifested in *Here* (McGuire, 1989, 2014), reconfiguring comics' space, time, and narrative relationship. Collapsing sequentiality into spatialized simultaneity, Here exemplifies a model where past, present, future coexist in one location, transforming the book into a stratified mnemonic map. The next section explores *Here* (McGuire, 1989, 2014), positioning it as a key reference for comics, time-space representation, and posthumanist epistemologies.

7.6. Here as a *Hyperobject*



Figure 7-37: Richard McGuire, *Here* (1989, pp. 69-74). This is the six-page version published in *Raw*. The black-and-white composition employs a strict 2×3 grid where each panel depicts a different moment in the same spatial location. Smaller inset panels introduce coexisting temporalities, visually articulating the simultaneity of events across epochs within a single frame.

Richard McGuire's *Here* (1989, 2014)—originally a six-page black-and-white story in *Raw* (1989) (Figure 7-37) and later expanded into a 304-page full-colour book (2014) (Figure 7-38)—depicts a single location's history through a fragmented, multi-temporal narrative. While both versions share this core concept, their execution differs significantly. The 1989 original is starkly minimalist, using a rigid six-panel (2×3) black-and-white grid. Each main panel

represents a distinct moment in the same room corner, with smaller, freely arranged inset panels introducing further time shifts, creating a layered effect of coexisting temporalities. These insets act as 'windows' into alternate timelines, visually conveying past, present, and future simultaneity within a fixed spatial setting. Dates, usually inscribed in panels' upper-left corners, act as temporal anchors, encouraging readers to connect disparate moments based on visual, thematic, or emotional resonance, rather than enforcing chronological order. Some dates recur, highlighting motifs; others appear once. The 1989 version's timeline spans 500,957,406,073 BC to 2033 AD.

The 2014 version expands *Here* to 304 full-colour pages, significantly enhancing temporal layering. The original rigid grid is replaced by a more fluid layout; the background merges seamlessly with the page, and gutters are largely absent (except for thin lines framing insets), creating openness and interconnectedness. Panels vary greatly in size, number, and placement, making the narrative more dynamic and immersive. The timeline is also extended (3,000,500,000 BC to 22,175 AD). This expanded format allows greater narrative density, with multiple events from different eras often coexisting on a single page, reinforcing time's non-linear nature within the fixed space.

In the 2014 *Here*, colour and graphic style are crucial for distinguishing eras. Historical scenes use soft watercolours, mid-20th-century moments employ vector graphics and flat colours, and futuristic scenes are depicted with a sketchier style. Colour acts as an indexical sign, guiding readers through the non-linear timeline. Dominant colour palettes facilitate quick visual clustering of co-present events from the same period (e.g., yellowish tints for the 1960s, reddish for the 1950s; see Figure 7-38). The codex format, as Bekavac (2022) notes, plays a crucial role in this dynamic. In Here, the act of turning pages does not merely advance the narrative—it performs time itself, making the reading experience a tangible enactment of temporal progression. This material structure reinforces the book's core logic: that space and time are not sequential but intertwined, layered, and relational.

Enormously influential, *Here*, in Steven Heller's (2014), 'a meditation on "impermanence", which is what makes it emotionally compelling yet unsettling—as though every moment in time is preserved in some random playback mode'. The work can also be interpreted as a reflection on how present, past, and future reverberate continuously, becoming physically intertwined within the same space—geographically and narratively—both on the page and *throughout the book*. Starting from a premise similar to that of *ASHoA*—that of observing a fixed vantage point as a space evolves in complexity over time—*Here* (1989, 2014) radically departs from conventional linear comics narratives, offering a fragmented, multi-temporal depiction of a single location through a rhizomatic and diagrammatic approach. Its critical reception highlights its openness to multiple theoretical interpretations.

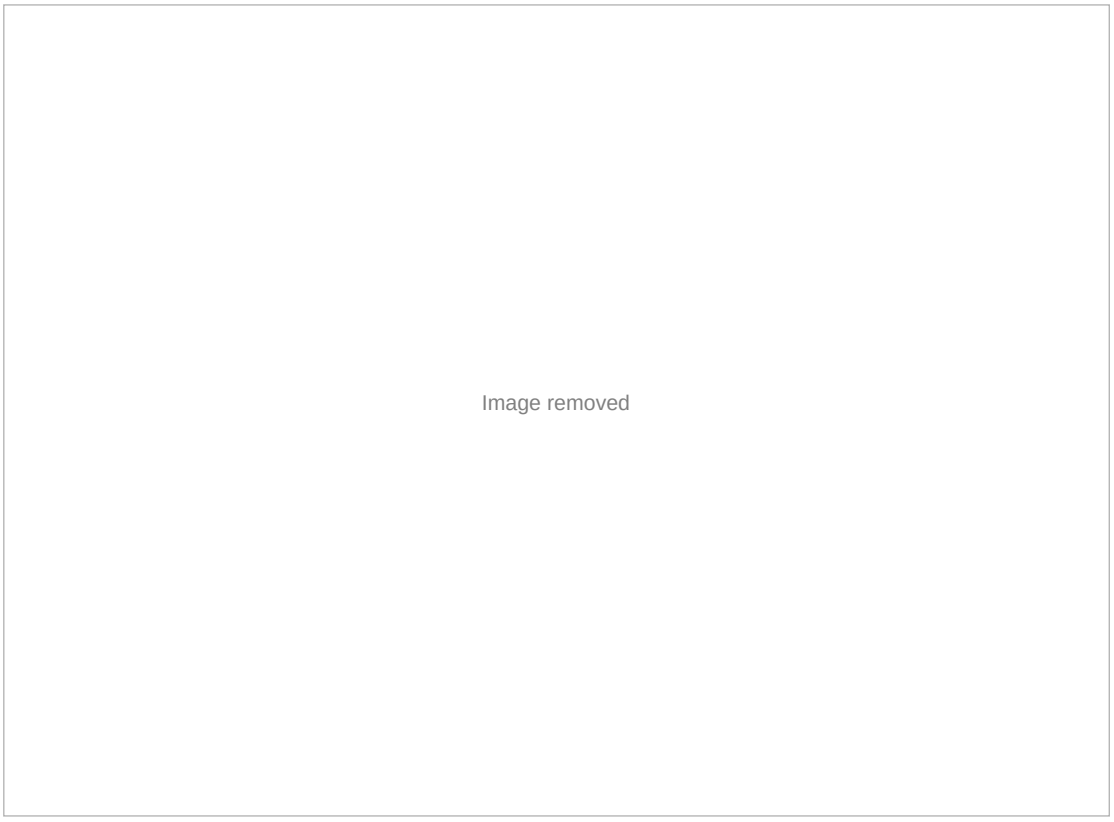


Figure 7-38: Four double-page spreads from Richard McGuire, *Here* (2014), pages 6, 57, 69, and 72. The layered, nonlinear narrative structure highlights the book's capacity to represent complex, multi-scalar phenomena through visual simultaneity and spatial continuity.

Bekavac (2022) suggests the narrative approach of Here is fruitfully analysed through multiple theoretical lenses: Bakhtin's *chronotope* (illuminating how *Here* subverts traditional spatial/temporal narrative structures, transforming the page into a layered archive of overlapping temporal moments), Derrida's *espacement* (highlighting how writing itself becomes a temporally fragmented process, visualized through coexisting epochs), and *ergodic text theory* (underscoring the reader's active role in deciphering connections and constructing meaning from *Here*'s non-linear arrangement). This radical form subverts expectations, offering simultaneous time representation. Balestrino (2018) interprets this as Deleuzian deterritorialization, where time becomes non-linear ('a square or even a cube', p. 77) and space is temporally projected, creating a *network of relationships* and transforming the environment into a layered mnemonic archive where heterogeneous temporal layers overlap like geological strata (Balestrino, 2018; see also, Busi Rizzi, 2023; Moncion, 2017; Dynkowska, 2023). This spatialization of time visualizes stratified, multi-scalar phenomena (Moncion, 2017; Menga and Davies, 2020; Rossetto, 2019; Perry, 2018; Sou, 2023). Moncion (2017) for example, perceives a critique of linear historiography through *Here*'s coexisting temporal snapshots.

Beyond its historiographical dimension, *Here* invites broader reflection on representing time in complex phenomena like climate change and the Anthropocene, whose intrinsic complexity and human-perspective impenetrability make them challenging to visualize. Sou (2023) highlights how comics, particularly *Here*, effectively represent multiple temporal scales simultaneously, making them especially suitable for depicting systemic, stratified phenomena. Menga and Davies (2020) see *Here* as exemplifying non-linear narrative deconstruction of environmental crisis, capable of exploring inter-epoch connections. Both perspectives recognise comics' unique potential for visualizing Anthropocene/climate change complexity while challenging apocalyptic/deterministic narratives. This aligns with Curto (2020), who situates *Here* within biocentric narratives challenging anthropocentric perspectives, depicting humanity as one temporal layer in a broader ecological continuum.

Menga and Davies (2020) further expand discussion to posthumanism and the Anthropocene, arguing the latter challenges human temporalities/subjectivities. Applying assemblage theory, they demonstrate how comics construct new knowledge forms and

time/space representations, articulating non-linear temporalities and multi-scalar visual/narrative element relationships. In this framework, narrative fragmentation in comics is a resource enabling greater human/non-human element fluidity, allowing visualization of ecological networks/environmental dynamics differently from traditional discursive/textual tools. Assemblage thus emerges as effective for exploring natural/human-made environment complexity, making comics ideal for Anthropocene epistemological challenges.

In the OOO context, Peterle and Rossetto (2023) emphasise *Here*'s narrative/visual structure functions as an onto-cartography privileging human/non-human entity horizontal relationships; objects themselves become protagonists constructing reality, deconstructing traditional anthropocentric perspectives. This onto-cartographic approach displaces human viewpoint, dismantling human temporality control illusion. Similar perspectives emerge from Perry (2018), linking *Here* to the more-than-human by examining its deconstruction of human subject to highlight broader ecological/temporal forces, and Smith (2018), analysing *Here* as cli-fi challenging dominant climate change narratives and situating human subjectivity within larger historical context.

Critical literature generally identifies *Here* as exemplary for representing complexity and encouraging active reader participation in meaning-making, fostering agency/problem-solving (Busi Rizzi, 2023; Perry, 2018; Balestrino, 2018; Moncion, 2017; Groensteen, 1991). *Here*'s narrative/visual fragmentation, while generating a tension between the experience of loss and the potential for reconstructing meaning (Busi Rizzi, 2023)—requires active narrative reassembly, filling inter-panel gaps and mentally reconstructing connections between temporally distant events from fragmented clues. This active participation takes the form of ludic exploration, as reading becomes an exercise in deciphering/reorganizing visual/textual material. Traditional narrative progression's absence forces an interpretative process oscillating between hypothesis/verification, leading readers to play with inter-panel connections. As Groensteen (1991, p. 101) notes for the first version, an exclusively narrative approach would be limiting; a topological strategy allows meaning emergence through interactions between seemingly incongruous panels. *Here* not only demands but actively emphasises this reconstructive attitude: fragmentation is a narrative device stimulating

ongoing cognitive re-elaboration. *Here*'s dual structure (chronological logic via panel dating; spatial logic via image arrangement generating new juxtapositions/relationships) reinforces reading as an experience where meaning is constructed, not given. Narrative becomes explorable territory, inviting readers to move, experiment, and redefine their interpretative path in continuous interplay and retracing between on-page panels and those scattered throughout the book.

7.6.1. Here and the Comics-Fact: A Model for Visualising *Hyperobjects*

The conceptualisation of the comic book as both a potential *hyperobject* and a multi-layered epistemic cartography—capable of representing complex and transdisciplinary knowledge systems (as discussed in Sections 7.5.2 and 7.5.3)—is powerfully exemplified in Richard McGuire's *Here* (2014). This work can be effectively interpreted through the conceptual lens of hyperobjects as defined by Morton (2013a): entities that are spatially and temporally extensive, massively distributed, and ontologically elusive. The comics' fragmented and coexistent representation of time resonates with this notion, particularly in its capacity to visualise multiple epochs simultaneously and to reflect the persistence and entanglement of events across extended temporal scales. Such a reading supports both posthumanist and object-oriented ontological perspectives. Indeed, scholarly analyses have similarly explored *Here*'s engagement with such vast temporalities and its alignment with posthumanist thought, offering valuable perspectives on its complex narrative architecture (e.g., Menga and Davies, 2020; Perry, 2018).

In this context, Peterle and Rossetto (2023) frame *Here* as a form of onto-cartography, which displaces human perception and aligns—at least analogically—with Morton's concept of the *strange stranger*: a radically non-human entity that remains irreducibly other, resisting full comprehension, yet persistently entangled with human existence (Morton, 2010, 2013a, 2013b).

Building upon Peterle and Rossetto's characterisation, this analysis further posits that *Here* does not merely visualise relationality or interdependence (as in the *mesh*) but structurally enacts the co-presence of entities whose temporalities are misaligned, non-contiguous, and asymmetrically legible. In its continuous traversal of these misaligned times and spaces, the structure of *Here* compels the reader to confront a stratified constellation of disjointed temporalities which, while potentially familiar in isolation, remain collectively irreducible and elusive. In doing so, it induces in the reader an experiential tension analogous

to an encounter with the strange stranger, echoing the ontological strangeness and persistence typical of hyperobjects.

Such a reading finds further support when considering the visual and temporal architecture of *Here* as a site of distributed knowledge construction. The page—and more broadly, the book—becomes a medium through which time is not simply narrated but diagrammed across multiple scales, sequences, and interruptions. This diagrammatic quality aligns with the notion of the comics-fact introduced in Section 4.8: a situated epistemic event that arises from the interaction between the visual organisation of comics and the interpretative labour of the reader. Like the comics-fact, *Here* generates a form of cognition that is both inductive and spatially distributed, emerging from pattern recognition, juxtaposition, and inferential association across non-linear narrative paths.

In this sense, the reader's engagement with *Here* mirrors the epistemic operations activated by comics conceived as exploratory interfaces: temporal inference, multi-scalar comparison, and the active reconstruction of relational meaning. By refusing narrative linearity in favour of recursive structures and temporal overlays, Here not only serves as a model for complex visual representation but also exemplifies a cognitive mode suited to phenomena, such as the Anthropocene, that resist linear or statistical depiction.

This structural and cognitive complexity also finds resonance in contemporary cartographic frameworks, particularly in the post-digital turn, where maps and visual systems evolve from static records to dynamic epistemic environments. As observed (Section 5.5), digital mapping technologies altered time concept, transforming maps into dynamic narrative tools, not static records—an issue also affecting traditional cartography. The same applies to *Here* and comics more broadly, a medium oscillating between an archival, immediate, demonstrative dimension and a subterranean, multilinear one, operating as an induction/storytelling machine. Despite differences, both systems—cartography and comics—propose, envision, or attempt a nonlinear temporality model, where separate moments coexist within a single spatial framework. While multi-scale mapping tools like Google Maps allow macro-to-micro transitions, *Here* adopts a similar, though non-interactive, principle. Readers

navigate different epochs within the same space, connecting past, present, future. Unlike Google Maps' hierarchy, *Here* presents temporalities rhizomatically/non-hierarchically.

Assemblage and complexity theory offer another interpretative framework for *Here*. For instance, Dittmer's (2014) vision of geopolitics, moving beyond scalar hierarchies and emphasising interconnectedness, aligns with *Here*'s posthumanist approach, distributing agency across elements. *Here* generates/structures time, illustrating small-scale events' large-scale consequences. Complexity reflects emergence logic—complex systems/patterns arising from multiple simple interactions—where system behaviour is not understood solely via individual components. This suggests comics' effectiveness for exploring dynamic phenomena. Dittmer's (2010) reading of comics aligns with his geopolitical views, emphasising that both meaning in comics (through reader engagement with panels and gutters) and geopolitical events (through assemblage interactions) emerge relationally and non-linearly.[2] This micro/macro transition ability, establishing connections, aligns with creative teaching/learning approaches challenging status quo and cultivating ability to 'zoom on minute detail and link it to something large-scale', fostering interconnectedness understanding 'between human and non-human things, and among people' (Lacković, 2020, p. 38). Furthermore, Lacković argues images can function as relationality maps across space, time, matter—akin to Benjamin's constellations—linking global systems to local practices, promoting inter-/transdisciplinary perspective (pp. 36–37). This reflects broader post-digital pedagogical needs (see Chapter 3, particularly Section 3.6).

Here engages directly with Horton's (2017) three scalar models discussed in Section 7.5.2. Its microcosmic dimension emerges in the way each temporal fragment connects to a larger whole without imposing hierarchical order, allowing scale to be navigated relationally. Its serialized logic manifests in the rejection of linear progression: meaning arises through the reader's pattern recognition across juxtaposed epochs rather than authorial sequencing. And while *Here* lacks the overt educational trajectory of Boeke's resolved cosmos, its layered temporal architecture invites precisely the kind of active cross-scalar reconstruction that model describes..

Regarding pluridimensional (+2D) representations, *Here* expands upon the Space-Time Cube (STC) model discussed in Section 7.5.3. By overlaying multiple timelines within a single narrative structure and intersecting perpendicularly with the volume's plane, it enables trans-scalar, interconnected navigation. This multi-layered experience departs from the constraints of traditional STCs, allowing simultaneous multi-epoch movement beyond linear time.

In conclusion, *Here* effectively combines multiple functions, positioning itself as a phase space—also in Morton's (2013a, pp. 71–74) sense (simultaneous system state representation, including time/space as dimensions, not just containers). With its complex, nonlinear temporality, *Here* serves as an exemplary model for prototypes representing complex, multi-scalar, temporally distributed phenomena.

7.6.2. General Guidelines for *Here*-Based Prototypes

Building on the preceding analysis of *Here* and other examples, this section outlines general guidelines for developing ECtC prototypes that leverage comics' unique capabilities for representing complex spatiotemporal phenomena. These guidelines translate theoretical principles into practical design considerations for representing such phenomena:

- **Multi-Layered Temporality (Focus on Progression):** These prototypes move beyond simple linear timelines to explore how different temporal perspectives (past, present, future) interact and influence each other within the same visual space. Furthermore, the prototypes explore how the future can retroactively shape the reading of the past, operationalizing multidirectional temporality.
- **Diagrammatic Structure (Emphasis on Relationships):** Embrace layouts that prioritise relationships and connections between elements over strict sequential reading. As seen previously, this could involve non-linear panel arrangements, network-like structures, or the integration of visual elements that explicitly link panels across the page or spread. The prototypes move beyond traditional grid-based layouts and adopt a diagrammatic and reticular approach.
- **Strategic Use of Colour:** Employ colour both indexically (to distinguish categories, time periods, or data types) and quantitatively (to represent gradients of change, intensity, or other variables). Consider colour's impact on both readability and emotional impact, drawing inspiration particularly from examples of effective colour use discussed earlier. Colour can be used to ensure that representation remains clear, while conveying additional layers of meaning.
- **Scalability (Micro/Macro Transitions):** Design prototypes to accommodate transitions between micro-level details (e.g., individual experiences, specific

events) and macro-level overviews (e.g., overall impact, long-term consequences). As seen in previous examples, this might involve inset panels, varying panel sizes, or other visual cues that indicate shifts in scale. The prototype should integrate micro and macro perspectives, offering a structured transition between levels of detail.

- **Visual Metrics (Quantification):** These prototypes utilise *visual metrics*—systematic variations in panel size and spatial arrangement—to represent quantitative data. This, combined with the strategic use of colour outlined above, constitutes a key element for enhancing data-driven aspects within the narrative. Panel size, spatial arrangement and progressive colour schemes can reflect intensity, duration, or transformation patterns.

- **Balancing Detail and Abstraction:** Carefully consider the interplay between detailed representation (e.g., individual faces) and abstract quantification (e.g., empty panels). Use progressive abstraction to represent concepts like cumulative impact, long-term consequences, or the sheer scale of an event. This design merges qualitative visualisation with quantitative representation.

- **Explorative Navigation (Rhizomatic and Comparative):** The prototypes foster explorative navigation. Both the layout of the pages and the entire multi-layered structure should function as a temporal interface, fostering rhizomatic, associative, and comparative navigation. This design constitutes a framework for engaging with complex, distributed, and temporally layered phenomena.

The following section presents a conceptual prototype that embodies these guidelines, illustrating how they can be operationalised to model spatiotemporal complexity in a specific socio-environmental context.

7.6.2.1. Prototype 3. Temporal Landscapes: A Visual Model for Environmental and Cultural Change

This prototype visualises the interwoven development of an ecosystem and its socio-cultural context within a geographically fixed frame. Each page functions as a temporal layer, anchored by a large main panel that captures a historical moment (past, present, projected future), with inset panels providing windows into other temporalities or details. These inset elements support comparative reading, highlighting feedback loops and causal relations across time.

The layout enables the co-representation of ecological and cultural transformations, maintaining visual continuity while encoding change. Colour is used both indexically (e.g., greens = forest health; reds = conflict) and affectively. Panel size, position, and density reflect intensity, impact, and relative importance.

Example: A series of four pages presents the Amazon rainforest at key stages—from pristine pre-Columbian landscapes to projected dystopic or regenerative futures. The main panels anchor environmental states, while inset panels depict events like deforestation, species loss, resistance, or recovery.[51]

The prototype embodies the principles outlined in Section 7.6.2, particularly multi-layered temporality, diagrammatic composition, and micro/macro scalability. It supports ECtC designed to foster systemic thinking, cross-scale visual reasoning, and narrative-exploratory engagement.

In this respect, the prototype responds to the research question by demonstrating what comics can do that conventional DV cannot: represent phenomena that are temporally and spatially distributed beyond human-scale perception—such as ecological change or long-term environmental crisis—not by simplifying them into a single chart or timeline, but by making their layered, non-linear complexity navigable within a single book format.

[51] This prototype is based on purely fictional example data and simplifies complex and sensitive phenomena.

Implementation strategies, detailed page analysis of the 2024 scenario, and educational variants are provided in Appendix C, which documents motif transformation rules and ambiguity management protocols.

7.6.2.2. Final Considerations on the Here-Based Prototypes

The explored prototype demonstrates how multi-layered visualisation can effectively model complex, dynamic systems. Integrating different temporal scales, spatial relationships, and socio-material interactions enables a systemic, interconnected reading of phenomena. Its layered structure highlights local/global process interplay, fostering *transcalar* understanding of change over time. Elements like inset panels, panel density, colour coding, and border variations function as aesthetic tools and epistemic devices facilitating comparative analysis and hypothesis generation. *Feedback loop* use reinforces infrastructure, historical events, and ecological shifts' embedment in recursive cause/effect cycles. Presenting systems as evolving/contingent, not linear/deterministic, this prototype aligns with contemporary complexity theory, OOO, and post-digital pedagogies, addressing complex systems' effective visualisation needs.

While inspired by *Here*, this prototype is not rigidly bound to it, integrating additional strategies like panels for quantitative displays and multi-scalar representation. Unlike *Here*'s fixed zoom level for all temporal frames, this model allows panels to zoom on visual details while preserving geospatial correlation. This flexibility enhances adaptability for diverse representational/analytical needs, opening further conceptual expansion possibilities. Though applied to specific case studies, the prototype's structure is highly adaptable, extendable to model broader, interconnected phenomena, capturing complex interaction networks across disciplines/timeframes. Its scalability is valuable for visualizing large-scale, multi-causal systems in urban planning, climate science, epidemiology, policy analysis, and also biology, chemistry, physics (illustrating multi-step processes), or economics/political science (mapping global systems, statistical trends, case studies).

Educational Value in HE

Beyond representational function, this prototype holds significant HE pedagogical potential. Facilitating a multimodal complex systems approach encourages interdisciplinary learning, fostering ability to synthesize information across historical, scientific, socio-technical

dimensions. Qualitative/quantitative element integration supports data literacy; its nonlinear, interactive structure enhances critical thinking/interpretative skills. This model also aligns with student-centred, inquiry-based learning, allowing dynamic content navigation, cross-scale relationship tracing, and hypothesis-driven analysis. As such, it provides an innovative knowledge visualisation framework, positioning comics and visual narratives as active epistemic tools, not merely illustrative devices. Its adaptability suggests broader applicability beyond HE to research, policy-making, public communication, reinforcing effective complex system visual strategy needs. Crucially, this prototype fosters intra-/transdisciplinary engagement, particularly between humanities and STEM, visualizing historical/scientific processes within a shared framework, creating cross-disciplinary collaboration opportunities, bridging narrative, spatial, data-driven approaches. This humanistic inquiry reintegration with scientific/technical perspectives supports holistic knowledge production/problem-solving—an emphasis even more evident in the next prototype.

7.7. Alpha… Directions: The Atlas or The Inevitable Arrow of Time

This section connects Jens Harder's Alpha…Directions (2015, 2009) (Figure 7-39)[52] to themes such as multi-scalarity and composition. Unlike the examples analysed in this chapter, Alpha is conceptually distinct and arguably unique in its ambitions, style, and compositional choices. It is an imposing 360-page large-format volume with approximately 2,000 detailed drawings, packed with diverse graphic influences. Harder's narrative spans from the Big Bang to the Cenozoic era (≈65 million years ago), averaging one drawing per 7 million years (Lorah, 2015).[53] The work covers physics, art history, chemistry, and cosmology, creating a composite, fascinating fresco that is both chronological and transtemporal. It synthesises elements from different disciplines and periods, highlighting comics' relationship with assemblage—physical and conceptual—and demonstrating comics' potential as an archival and polygraphic medium.

Alpha is not merely a world history; it is also a history of the world's perceptions. Harder (Lorah, 2015) believes comics can contribute to scientific discourse and popularisation, stating:

> Concerning the images, no self-developed pictures of something that really existed. I always had the wish to show not only the development of the world, but also the development of our view on the world. I wanted to find out tracks or echoes of all beings and of all events, if not on Earth (as fossils or landmarks), then in our cultural awareness, in our fairy tales, religious stories, nightmares, paintings, sculptures, book illustrations, wherever.

The book includes an extensive array of reproduced works, from Hindu sacred icons to scientific diagrams, from comics to scientifically accurate illustrations and artistic interpretations. Additionally, it features explanatory images employing diagrams, astronomical illustrations, and temporal representations to convey scientific concepts (see Figure 7-39).

[52]In this section, reference will be made to the 2015 English edition, while the images are taken from the 2009 French edition.

[53] There is no claim to proportionality: events such as the Big Bang are spread over several pages, while millions of years are summarised in a few panels.

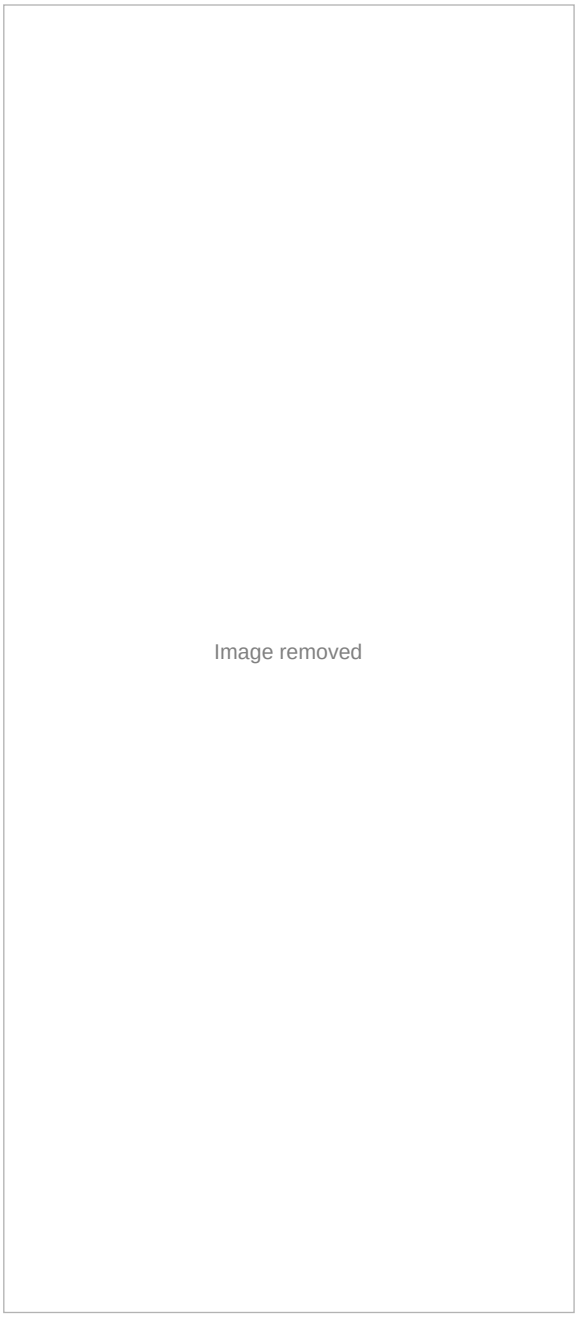


Figure 7-39: Pages 23–28 of Jens Harder's *Alpha…Directions* (2009). Sequence depicting the birth of the universe following the Big Bang. Scientific illustrations, symbolic diagrams, religious cosmologies, and conceptual tools are juxtaposed across the spreads, creating a visual assemblage that reflects both the physical origins of the cosmos and the evolution of human perception. The composition interweaves empirical, mythological, and epistemological layers, exemplifying *Alpha*'s transtemporal and transdisciplinary logic.

Consequently, *Alpha* is not a simple visual encyclopaedia but a modern—or postmodern—anthology reminiscent of those compiled between medieval and Renaissance periods. This comparison is pertinent: as Blair (2010, pp. 117–229) discusses, medieval compilation involved selecting and recontextualising existing material, while Renaissance approaches favoured less structured knowledge organisation. Harder similarly replicates images like a medieval copyist but presents them within an interpretatively open framework, akin to Renaissance texts.

Harder's approach to written text is also notable. *Alpha* contains very few words, mainly from the predominantly written tradition of scientific literature. These succinct sentences, in minimalist style and small font, serve as brief annotations to individual images. Addressing his 'textbook-like approach', Harder (Lorah, 2015) explains:

> Since I trust the scientific basis of the statements I wrote, I wanted to express it as precisely as possible [...] I wanted to keep the text as clear as possible, maybe also a bit dry sometimes, because the combined images are so versatile, sometimes also disturbing or chaotic. My comments should give the neutral red line through the whole-time journey. These one or two sentences per page plus the summaries of the single chapters shall provide all the important information needed.

Harder employs additional techniques for categorising knowledge. Each section is printed in a distinct two-colour tone, allowing readers to identify the corresponding time span by the book's edge. Furthermore, unlike *Here*, and more akin to traditional comic books, *Alpha* maintains a clear directional flow: page-turning from left to right inevitably moves the reader forward in time. Despite associative and temporal leaps from juxtaposing diverse historical/cultural images, reading direction follows time's arrow. However, this is not entirely prescriptive. One of the four 'notices to the reader' at the end of the volume—titled 'To the purist', 'To the faithful believer in God', 'To the Manga lover', and 'To the scientist'—offers a playful invitation to manga readers:

> Should you, out of habit, have opened 'Alpha' from this page you are hereby invited to continue your reading in the direction most familiar to you. You could well examine all the processes and developments illustrated in this book in a completely new way in a visually retrograde motion. It should also be noted that the pages can be considered not only from right to left but consequently, also from bottom to top (Harder, 2015).

Nonetheless, as Harder states (Heydenreich and Heydenreich, 2015), the book avoids a teleological narrative, presenting history as an intricate interplay of chance and natural laws. Thus, *Alpha* is not just a historical compendium but a dynamic epistemic framework. It

constructs a multi-layered system where knowledge is reconfigured through associations, juxtapositions, and visual recursions, rather than a fixed linear account. This interpretative flexibility allows analysing *Alpha* not merely as documenting past events, but as a conceptual model for knowledge visualisation.

Within comics—and other media—direct comparisons to *Alpha* are scarce. Perhaps only Larry Gonick's *The Cartoon History of The Universe* and *The Cartoon History of the Modern World* (21 volumes total) match its scope. Despite its ambition and accomplishment, *Alpha* has received relatively little critical and virtually no academic interest. Beyond the aforementioned interview (Heydenreich and Heydenreich, 2015), Groensteen (2017) offers the only substantial analysis of Harder's style, discussing image integration in biographical comics about painters.[54] Groensteen highlights Harder's recontextualisation and reframing of images to emphasise aspects beyond their original meaning, organising them thematically rather than by artistic value. Notably, sacred imagery is desanctified and treated as just another form of visual material.

[54] Groensteen is also editor of the *L'An 2* series of *Actes Sud* editions, in which the French version of Harder's work was published.

7.7.1. *Alpha* as Visualisation

Although *Alpha* lacks an explicit theoretical framework, it can be productively analysed through multiple lenses highlighting its role as a conceptual model for ECs. Its unique visual knowledge representation allows interpretations beyond its chronological structure, positioning it as a mapping system that organises, connects, and reconfigures knowledge across disciplines and periods.

One way to understand *Alpha* is as a *mapping of a knowledge domain*, akin to scientific mapping techniques like bibliometric and co-citation analysis. As these methods visualise scientific frontier structures by tracing citation patterns and thematic clusters (Chen, 2013), *Alpha* creates a vast association network spanning from the Big Bang. Its visual structure is reticular, not strictly linear, linking historical eras and seemingly separate disciplines—a principle central to conceptual association mapping.

Simultaneously, *Alpha* functions as a *transdisciplinary mapping*, integrating diverse fields like physics, biology, cosmology, mythology, and art history. Reflecting the transdisciplinary principles discussed in Section 3.6.2, it resists traditional compartmentalised disciplinary logic. Harder's assemblage of scientific diagrams, religious imagery, and artistic representations embodies the included middle logic, allowing seemingly contradictory epistemologies to coexist. This visual interconnection network transforms *Alpha* into a form of cognitive cartography, where images act as nodes in a broader conceptual grid revealing emergent relationships between distant knowledge fields.

The work also exemplifies *knowledge mapping*, a visual strategy for structuring and navigating complex information. Unlike conventional conceptual maps (hierarchical/nodal structures), *Alpha* adopts a more fluid, layered approach. Each page, image, and visual detail functions as an interconnected unit in a broader network where scientific knowledge intersects with artistic, mythological, and philosophical elements. This invites dynamic, non-linear knowledge engagement, with meaning constructed via active reader participation. Moreover, *Alpha* not merely organises knowledge; it actively reshapes its conceptualisation and

negotiation. As Lacković (2020, pp. 47–48) argues, images can only illustrate aspects or instances of abstract concepts, never fully encapsulating their complexity. *Alpha*, however, demonstrates visual representation can extend beyond illustration, facilitating active engagement with abstract ideas. Through its associative structure, *Alpha* constructs a conceptual network where ideas (evolution, universe origins, religious thought development) are visually/epistemically interwoven, not just depicted. This aligns with Lacković's argument that juxtaposed, collectively interpreted images enrich conceptual understanding and reveal abstract ideas' inherent multiplicity. *Alpha* embodies this by integrating scientific diagrams, mythological imagery, and artistic interpretations into a fluid, dynamic knowledge mapping. Its structure invites readers to navigate interconnections rather than offering a single, fixed interpretation, reinforcing knowledge's contingency on perspective, interpretation, and context. Consequently, the *knowledge atlas* concept (Section 5.5.2) is particularly relevant: *Alpha* builds a multidimensional cartography spanning disciplines, periods, and visual traditions, not just documenting a single knowledge domain.

Harder's visual strategy also engages the *epistemological sublime*—the overwhelming complexity sense arising from attempting to grasp vast interconnected knowledge. As Morton (2020) argues, sublime objects exceed cognitive capacity, producing wonder and vertigo. This notion is relevant to *Alpha*; its densely layered visual language attempts to render human knowledge immensity perceptible, mirroring sublime experiences' challenge to full comprehension. Kennedy and Hill (2017) examine how DV (especially with Big Data) evokes sublimity by confronting viewers with overwhelming information scale. Similarly, *Alpha*'s vast interconnected imagery network creates an experience where knowledge is structured yet sometimes overpowering, reinforcing knowledge visualisation's inherent order/excess tension.

A final interpretative lens is *Alpha* as a model for representing *nomadic concepts*—ideas traversing disciplines/historical contexts, adapting meaning across epistemic frameworks (Bal, 2002). The Moon concept, for instance, evolved from ancient mythological symbol to scientifically measured celestial body, poetic metaphor, and cultural reference (Blunden, 2012, p. 5). In *Alpha*, similar conceptual migrations occur ideas emerge, dissolve, and reconfigure through visual juxtaposition, creating a shifting meaning network. Harder's work visually

enacts these transformations, not just documenting them, emphasising knowledge's constant reinterpretation across reference frames.

For HE educators and researchers, Alpha's significance lies not only in what it represents but in how it is structured. A course, a research programme, or a transdisciplinary curriculum faces the same challenge Alpha addresses: how to make visible the connections between fields, periods, and frameworks that conventional textbook organisation—sequential, hierarchical, discipline-bound—systematically obscures. Alpha demonstrates that a comics volume, deployed as a polygraphic medium, can function as a curriculum-organising device in its own right: not illustrating knowledge but spatialising it, allowing readers to navigate conceptual relationships rather than merely absorb a fixed sequence of content.

By integrating these mapping forms—domain-specific, transdisciplinary, cognitive, conceptual—*Alpha* provides a compelling example of comics functioning as epistemic tools for structuring/visualising complex knowledge systems. While Harder's work presents an open-ended, associative model, the following prototype formalises/expands these principles into a structured knowledge visualisation framework, applying *Alpha…Directions*' mapping strategies to a practical model emphasising conceptual evolution, disciplinary interconnections, and knowledge spatialisation.

7.7.2. Prototype 4: Cartographic Atlas—A Visual Model for Mapping Knowledge Evolution

This prototype expands on *Alpha Directions'* ability to visualise the layered evolution of knowledge systems, ideas, and epistemologies across disciplines and historical periods. It operates as a cartographic palimpsest, where knowledge is mapped through visual juxtapositions, rather than following a linear or strictly sequential logic. Unlike *Here*, which anchors its narrative in a fixed spatial frame and tracks temporal shifts within it, *Alpha* constructs meaning through layered associations that transcend both time and space. Its compositional strategy is not based on a singular vantage point, but on the continuous recontextualisation of images, allowing multiple epistemic frameworks to coexist and interact. This fundamental difference informs the conceptual basis of the prototype, which prioritises a networked model of knowledge over a strictly sequential one

- **Fixed Spatial Frame**: Unlike traditional narratives, evolving through time, this model treats the page as a spatial map of knowledge—a layered representation where ideas, symbols, and scientific frameworks interact across time and disciplines.
- **Knowledge as a Landscape**: Instead of a purely chronological sequence, knowledge is spatialised, with panels and panels clusters, acting as conceptual windows into different epistemic frameworks, perspectives, or historical reinterpretations of the same subject.
- **Visual Cross-Referencing**: Concepts are visually recontextualised, mirroring how ideas evolve, migrate, and transform across disciplines and cultures.

Example Application:

This prototype explores the evolution of the concept of life across scientific and cultural epistemes. For example, one possible application visualises how the concept of 'life' evolves from origin myths to molecular biology and speculative futures, using visual layering and

epistemic juxtaposition. Panels might show ancient cosmologies, Darwinian trees, DNA strands, and synthetic organisms within a spatially navigable page sequence. This enables students to analyse paradigm shifts and disciplinary interactions through visual recursion and comparative cartography.

This prototype responds to the research question at the scale of the book as a whole: where Prototypes 1 and 2 demonstrated how comics can represent specific events and their human consequences, and Prototype 3 how they can map environmental change across time, this model shows how a comics volume can function as a transdisciplinary knowledge system—one in which the associative, non-sequential organisation of images enacts precisely the kind of networked, non-hierarchical knowledge construction that post-digital pedagogy calls for across disciplines.

A full implementation—including page-level scenarios, comparative strategies, and curricular applications—is elaborated in Appendix D, which provides discipline-specific scripting templates for epistemic cartography spanning STEM-humanities integration.

7.8. The Non-Linearity of Research: Using Comics to Map the Unpredictable

Comics' spatial multilinearity makes the medium particularly suited to incorporating branching narratives with multiple or uncertain endings—a capacity explored in Sections 4.3 and 4.7. Visualisations representing genuinely branching futures remain rare in DV—tools like flowcharts can indicate alternative outcomes (Rendgen, 2012, p. 210), but none make the research process itself navigable as a branching structure. This gap is compounded by a broader tendency: branching narratives often 'collapse' into linear forms (Hadler and Irrgang, 2014), reassembled into coherent sequences through subjective reading choices (Simons, 2008), with non-linearity frequently proving transitory. Despite their proliferation from the 1970s, branching narratives remain understudied in HE (Fenici and Mosca, 2024), though their potential benefits—exploring counterfactual scenarios, simulating complex decision-making, fostering collaboration—align well with post-digital educational frameworks.

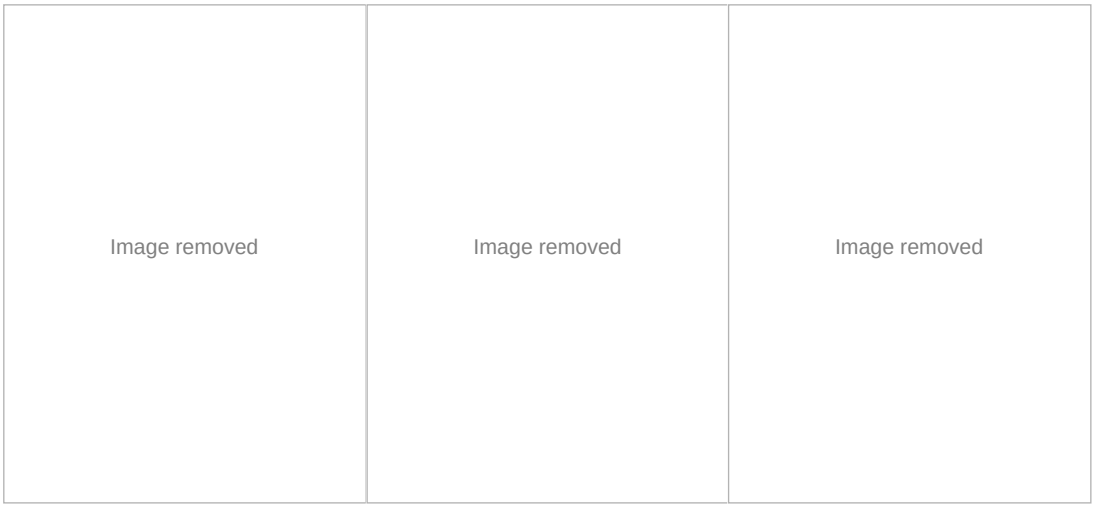


Figure 7-40: Pages 3–5 from *Rabbithead* (Dart, 2004). Fragmented and non-verbal sequence illustrating intersecting narrative lines that split and rejoin, forming a cyclical structure suggestive of branching time and multiple perspectives.

This potential is particularly relevant when applied to the research process itself. Although this thesis focuses on learning in HE, the upstream research phase cannot be overlooked. Research, dissemination, and education—understood explicitly as *re-search*, that is, 'searching

again'—can be considered a single flow requiring integrated skills, especially within a non-authoritative, inquiry-oriented model of learning. Students should be made part of the research design even when research has already been completed, encountering its turning points, upheavals, errors, and dead ends rather than a linear, finalist account. As Reyns-Chikuma (2019, p. 187) notes, 'experiential learning implies experimenting. Hence, failing is part of the process of learning.'

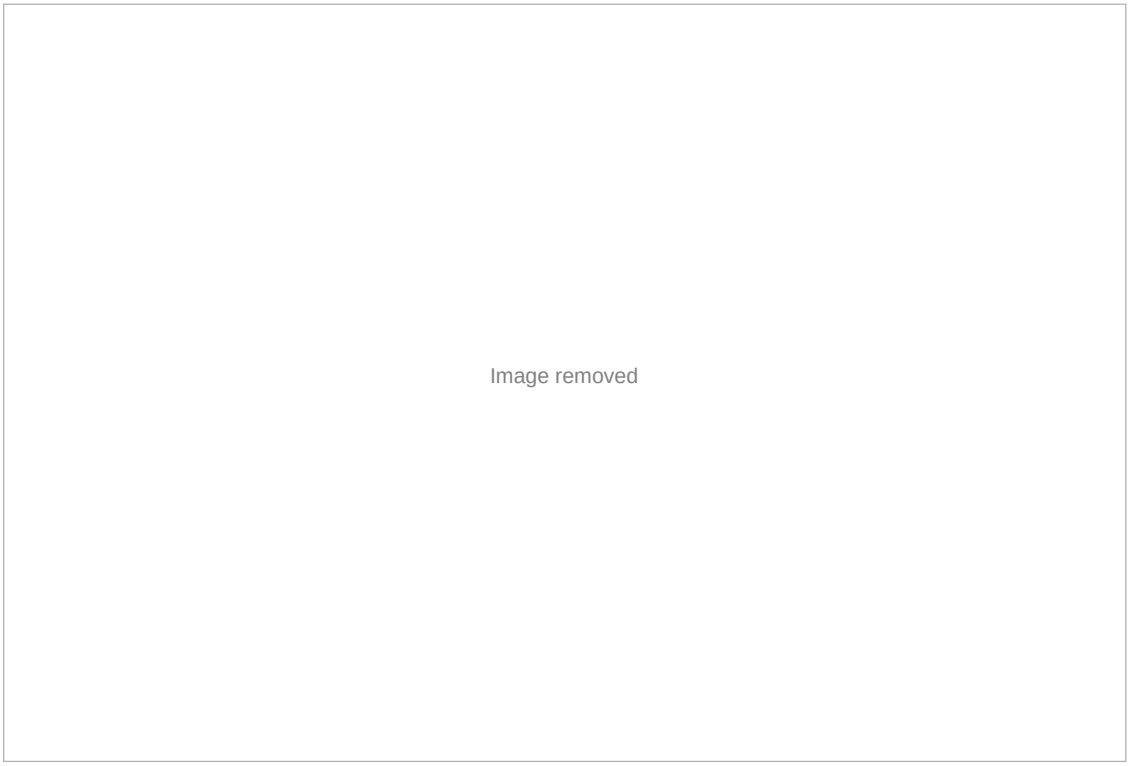


Figure 7-41: Double-page spread from *Les Trois Chemins* (Lewis Trondheim, writer; Sergio García, art, 2013). Three characters navigate distinct paths on a shared continuous background. Vertical implicit segmentations and interactions between paths evoke ordered time with intersecting perspectives.

Comics possess a structural advantage over other media in representing branching narratives. Lambert (2015), drawing on graph theory, distinguishes between planar structures—in which narrative timelines can be represented without intersections—and non-planar ones—in which intersections are inevitable and constitute the formal essence of the work. Comics demonstrate this spectrum concretely. Dart's Rabbithead (2004, Figure 7-40) operates as a non-planar cyclical structure—narrative lines split, intersect, and rejoin in a loop. Trondheim and García's Les Trois Chemins (2013, Figure 7-41) is planar, maintaining linear coherence within each path despite a continuous shared background. Jason Shiga's Meanwhile (2010,

Figure 7-42), by contrast, approaches a complex non-planar graph in which bifurcations are structurally inevitable—and partially visible to the reader.

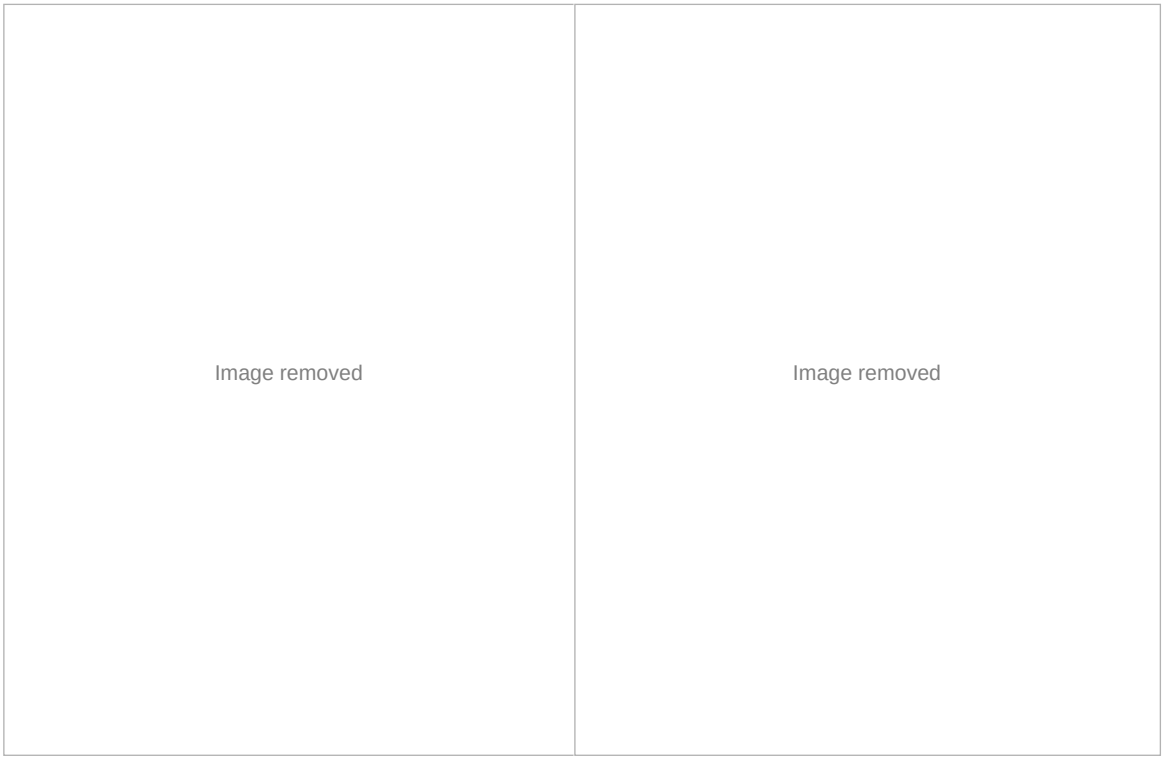


Figure 7-42: Branching page from *Meanwhile* (Shiga, 2010). Highly structured narrative architecture with tabs and coloured paths enabling reader-directed choices. The page makes visible a portion of the work's vast branching structure.

Subtitled 'Pick Any Path. 3,856 Story Possibilities', it presents an extraordinarily complex architecture in which the reader makes constant choices—leading through bifurcations, time loops, dead ends, and multiple endings—through a system of tabs and arrows spanning 80 pages. Unlike traditional gamebooks, *Meanwhile* allows the reader to see part of the map of possible paths, specific to the page they are on—which paradoxically increases rather than reduces complexity, given the vastness of possible connections.

Meanwhile stands out from other branching narratives for several interconnected reasons. It is the only example in which the reader actively makes choices that determine the narrative path—multilinearity is not potential or suggested, but implemented through an explicit choice mechanism. Its branching structure is partially visible rather than implicit, making the reader aware of the architecture they are navigating. The number of possible paths

is vastly greater than in comparable works, creating a radically non-linear reading experience. And unlike works with a purely narrative purpose, *Meanwhile* integrates a playful dimension that is intrinsic to its structure rather than incidental to it. The work is simultaneously a narrative, a game, and a complex information system—and it is precisely this triple function, combined with the partial visibility of its own architecture, that makes it the model for the following prototype.

7.8.1. Prototype 5: Research Unfolded—A Scientist's Journey Through Uncertainty

This prototype is designed to represent the scientific research process as a non-linear journey, characterised by revisions, errors, and unexpected discoveries. Unlike traditional academic narratives, which often emphasise the linear progression of knowledge, *Research Unfolded* uses comics to depict research as an open and iterative system.

The researcher-educator becomes both author and protagonist of the comics, illustrating their own research journey while engaging students in an interactive experience where they must make key decisions. Each choice leads to different consequences, making the reader an active participant in the scientific process.

- **Branching paths**: The reader explores multiple scenarios linked to methodological and interpretative decisions.
- **Errors and revisions**: Choices lead to different results, highlighting the necessity of reviewing and adapting strategies.
- **Active engagement**: Students experience research complexities first-hand, developing critical and decision-making skills.

Example Application:

The prototype centres on an experimental case study to demonstrate that research is not a straightforward, obstacle-free path but a dynamic system of exploration and adaptation.

This prototype addresses the research question from an angle the preceding four do not: rather than visualising an external phenomenon for HE students, it turns the medium on the research process itself. Comics' structural capacity for branching, non-linear navigation—demonstrated across this chapter—makes it uniquely suited to rendering visible what conventional academic writing conceals: that research is not a linear progression toward a conclusion but a system of decisions, dead ends, and revisions. In doing so, it offers HE

educators not just a representational tool but a pedagogical model for teaching research as a process.

A full breakdown of the four-page script, implementation strategies, and pedagogical applications is provided in Appendix E, which formalises branching logic into reproducible decision-tree architectures for research ethics training.

7.9. Final Considerations: Expanding the Role of Comics in HE

This chapter has explored the largely untapped potential of comics as a tool for DV and knowledge representation in HE. Moving beyond the limitations of traditional ECs and DVs, this chapter has proposed a series of conceptual prototypes that redefine the role of comics in managing, organising, and transmitting complex knowledge within a post-digital learning environment. As established in earlier chapters (Chapters 1-5), the theoretical discussions surrounding comics, DV, and post-digital learning environments have laid the foundation for the conceptual models proposed here.

These prototypes, far from being rigid models, are conceived as flexible starting points, encouraging further exploration and adaptation by designers and educators. They offer insights into potential educational and domain-specific applications while remaining open to continuous reworking. In essence, they serve as a flexible resource or conceptual toolkit for future ECs designers, offering selected configurations that highlight the diverse ways comics can be employed.

Beyond outlining new configurations for the use of comics in HE, the chapter has also introduced intermediate models that reconceptualise some of the fundamental characteristics of the medium—panels, grids, page layouts, and the book format itself—demonstrating how these elements can be repurposed for knowledge visualisation and data navigation. Through this analysis, the chapter has shown how comics can be leveraged to:

- Visualise temporal intervals and information density.
- Represent processes and transformations.
- Map complex and multiscalar knowledge.
- Explore alternative futures and decision-making processes.

These capabilities were demonstrated through five distinct conceptual prototypes (from temporal grids to knowledge atlases inspired by works like *Here* and *Alpha*) and intermediate models reinterpreting comics structures, developed according to the criteria established in Chapter 6 specifically to address the identified need (Chapters 1-5) for more complex, multi-scalar, and non-linear visual representations. Rather than merely replicating traditional DV techniques within comics, this chapter has investigated how ECtC can establish their own distinct representational potential, drawing parallels between established visualisation strategies and the unique approaches afforded by reconceptualised comics. A transversal comparison of these prototypes, highlighting their temporal models, epistemic focus, and educational affordances, is provided in Appendix F.

Ultimately, this chapter has contributed to a reconsideration of the role of comics in HE and transdisciplinary learning processes. By reimagining comics not merely as a narrative medium but as a flexible system for data, information, and knowledge representation, it has laid the groundwork for innovative methodologies that enhance engagement, critical inquiry, and knowledge visualisation in academic contexts. These prototypes, therefore, not only suggest avenues for future practical implementation but, more fundamentally, contribute to establishing the distinct visual epistemology of ECtC, as will be consolidated in the final chapter. Future research should focus on empirically testing these conceptual models, evaluating their effectiveness in various educational contexts, and refining their design principles through practical application.

8. Conclusions: Towards an Epistemology of Educational Comics to Come

8.1. Introduction: Reimagining Educational Comics—A Recapitulation

This doctoral thesis embarked upon a critical exploration of the role and potential of comics within Higher Education (HE), addressing the persistent underutilisation and reductive understanding of Educational Comics (ECs) and Data Comics (DC) within academic contexts. In an era grappling with information overload and the limitations of linear communication models (Chapters 3-5), traditional approaches often fail to capture the dynamic, interconnected nature of contemporary knowledge. These models, which reduce multifaceted phenomena to static and oversimplified representations, cannot adequately represent the complexity inherent in many modern challenges. This research critiques the reductive use of visual displays and proposes the framework of Educational Comics to Come (ECtC), embracing Lynch's (1988, p. 202) insight that visuals are not peripheral but 'essential to how scientific objects and orderly relationships are revealed and made analyzable'. By leveraging the unique affordances of comics, the thesis suggests a more integrated, multimodal epistemology that better aligns with the needs of HE in the post-digital age.

The subsequent investigation involved establishing robust theoretical foundations by reconceptualising comics beyond narrative (Chapter 4) and critically evaluating existing visual representation practices (MERs, DV, DC—Chapter 5). Building on this, specific criteria for Educational Comics to Come (ECtC) were formulated (Chapter 6), leading to the development of conceptual prototypes as initial epistemological testbeds (Chapter 7). This concluding chapter synthesises the core arguments, responds explicitly to the guiding research questions, evaluates the thesis's contributions, acknowledges limitations, and outlines future trajectories. It posits that the ECtC framework embodies a distinct visual epistemology. This epistemology, distinct from traditional academic models reliant on linear text and even from other visual approaches focused solely on representation or data clarity, is fundamentally characterised by its reliance on visuo-spatial cognition, its emphasis on meaning emerging relationally from multimodal synthesis, its embrace of productive ambiguity as a catalyst for

critical inquiry, and its demand for active reader engagement. Crucially, it also integrates aesthetics as a *way of knowing*—one that operates distinctly from pure logic through sensory perception and culturally embedded contexts, suffusing the reader's entire engagement with the medium (see Giddens, 2013, p. 209, for a discussion of Manderson, 2000, pp. 8–11). Indeed, the imperative to reconsider educational comics through this aesthetic lens, alongside other core affordances, necessitated looking beyond the often-limited scope of existing ECs and DC models towards the broader, more formally diverse landscape of comics history and practice for inspiration and conceptual grounding.

8.2. Answering the Research Question

The investigation was guided by specific questions outlined in Chapter 1. The findings and arguments developed throughout this thesis provide the following answers:

- **Central Question**: How and to what extent can comics support data visualisation for scientific discourse development to inform HE teachers and researchers on the potential of comics across disciplines?

  This thesis concludes that comics, specifically when reimagined as ECtC, can significantly support and enhance scientific discourse and DV in HE. The extent to which this potential can be realised depends on leveraging their distinctive affordances: their inherent diagrammatic capacity to map relationships (Section 4.8), their cartographic function in structuring knowledge landscapes (Section 4.9), and their meshwork potential inviting non-linear navigation (Section 4.9). By moving beyond simplistic models, ECtC offer sophisticated ways to integrate diverse data and information types, spatialize complexity, embody multiple perspectives, and foster critical inquiry, enabling both representation and critical analysis of data across disciplines.

- **Sub-Question 1**: How can data visualisation tools use comics' modalities to make data presentation, comparison, investigation and narration more efficient?

  DV practices can gain efficiency and conceptual depth by integrating comics' specific modalities (Chapters 3, 4, 5, and 7). This includes using spatial layout dynamically for relational meaning and comparison (as explored in Prototype 3, Section 7.6.2.1); employing synergistic text-image relationships where visuals carry

significant epistemic weight; utilising the medium's capacity for polygraphy for nuanced representation (as discussed in Section 5.3.5) and principles like concreteness fading (introduced in Section 5.2.1); leveraging the panel structure and gutters for controlled pacing and inferential engagement; and adopting diagrammatic logics to map complex systems (Prototype 2; Section 7.3.2). This suggests the potential for a fundamental shift from the container model of current DC (Section 5.4) towards exploiting the structure of comics as an active component of the visualisation itself, where narrative and data are interwoven in a way that allows for deeper engagement and dynamic, multi-dimensional understanding.

- **Sub-Question 2**: What are the arguments for comics being more widely accepted means of scientific communication and dissemination in the HE context?

  Arguments for wider acceptance rest on ECtC' capacity to address key contemporary needs (Chapters 3 and 5). These include potential for enhanced engagement; their role in cultivating essential visual literacy skills needed for post-digital ecologies (Chapter 3); their unique ability to represent complexity and productive ambiguity (Section 5.3.3); their alignment with post-digital pedagogical principles valuing multimodality and connectivity (Chapter 3, and Section 4.8); and their capacity to overcome the limitations of fragmented MERs and reductive DV, offering a more holistic approach, not only enhancing engagement and critical thinking but also fostering interdisciplinary connections by integrating diverse knowledge domains into a single, coherent visual framework.

- **Sub-Question 3**: Does any aspect of comics as a medium represent an obstacle to such development?

Yes, significant obstacles persist across cultural, epistemological, and practical domains. One of the key practical obstacles for ECtC lies in the scalability issue inherent to printed comics (Section 7.5). Unlike written texts or digital visualisations, which can handle large amounts of data with flexible zooming and scrolling, printed comics face limitations in the amount of visualised data they can present on a single page. This can lead to cognitive overload when too much information is compressed into a limited space, hindering the clarity of the message. Furthermore, the cultural perception of comics as non-serious hinders legitimacy (Chapter 1). A widespread limited understanding of the medium's affordances remains (Section 5.4). Production challenges (skills, costs, collaboration) are practical barriers (Section 8.6). The medium's inherent interpretive openness, while a strength, can clash with disciplines valuing univocal meaning (Section 5.3.3). Moreover, the lack of established evaluation metrics specifically for ECtC, mirroring broader challenges in DV assessment (Section 5.2.3), represents a significant epistemological and practical obstacle within traditional academic frameworks. Finally, institutional inertia and logocentric biases actively resist visual-centric epistemologies. While significant obstacles persist, solutions may be found through targeted educational programs and interdisciplinary collaboration, which can foster greater acceptance of comics as legitimate tools for scientific communication in HE.

8.3. Synthesis of Core Arguments: Articulating an Epistemology of ECtC

This thesis culminates in articulating an Epistemology of Educational Comics to Come (ECtC), a framework that moves beyond viewing comics merely as communication tools to recognizing them as active *epistemic interfaces.* Unlike traditional epistemologies privileging linear text or minimalist visuals striving for objective detachment, the ECtC epistemology is defined by a unique constellation of affordances, operationalised through the conceptual prototypes developed in Chapter 7.

Central to this epistemology, this thesis argues, is the foregrounding of visuo-spatial cognition. Knowledge is not simply conveyed through space; it is actively structured by the spatial relations on the page (Chapter 4). The prototypes illustrate this: Prototype 3 (Section 7.6.2.1), for instance, uses layered inset panels within a consistent geographical frame to map environmental and cultural change across multiple timescales, demanding that the reader synthesise information based on spatial juxtaposition and comparison rather than sequential exposition. Similarly, the branching structure of Prototype 5 (Section 7.8.1) spatialises decision-making processes, allowing readers to navigate the non-linear 'terrain' of scientific inquiry.

Consequently, meaning and understanding emerge relationally from the network of multimodal connections within the comics interface. This relationality is exemplified by Prototype 4 (Section 7.7.2) which maps the evolution of concepts across disciplines and history through associative visual links rather than linear argument. The reader must actively trace connections across temporally and conceptually distant elements, constructing understanding from the overall meshwork (Section 4.9). This relational mode of reading is equally central to Prototype 2 ('Contextual and Humanised Data Representation'; Section 7.3.2), which integrates quantitative grid sequences with panoramic layouts and individual character perspectives within a shared visual space, requiring the reader to move fluidly between registers of data, spatial form, and lived experience.

This necessitates a multimodal synthesis where readers dynamically integrate visual forms (drawings, diagrams, photographs as in Prototype 2 (Section 7.3.2), textual fragments, and spatial architectures (panel layouts, page design, book structure). This process engages embodied cognitive processes (with embodied cognitive processes explored particularly through schema theory in Section 4.5, and related cognitive aspects in Sections 4.2 and 4.8), moving beyond purely abstract or linguistic reasoning. Prototype 2 (Section 7.3.2), integrating quantitative grids with panoramic scenes and individual perspectives, explicitly requires the reader to synthesise statistical data with qualitative, experiential information presented multimodally.

Crucially, this epistemology embraces ambiguity as a productive space for critical interpretation and the generation of multiple meanings (Chapter 3, and Section 5.3.3). The interpretive openness inherent in comics—stemming from the visual polysemy, the text-image interplay, and the inferential demands of the gutter (Chapter 4)—is not treated as noise but as a deliberate feature that stimulates critical thinking. Prototype 1 ('Temporal Progression and Cumulative Impact'; Section 7.3.1) leverages the ambiguity of empty and abstract panels to represent cumulative loss at scale, forcing the reader to infer meaning from absence and structure alone—a strategy that transforms emotional representation into quantitative inference. The layered temporalities in Prototype 3 (Section 7.6.2.1) also introduce ambiguity, requiring readers to negotiate overlapping past, present, and future perspectives within a single visual field. This contrasts sharply with disciplines valuing univocal meaning, positioning ECtC as tools that foster tolerance for uncertainty and interpretive skill.

Furthermore, this epistemology acknowledges the constructed nature of representation (Section 5.3.5). The capacity for polygraphy allows ECtC to integrate diverse visual styles and perspectives within a single work (as suggested conceptually in Prototypes 3 and 4, Sections 7.6.2.1 and 7.7.2), foregrounding the subjective and situated aspects of knowledge visualisation, moving away from the myth of objective transparency.

8.4. Reading and Engaging with ECtC: Aesthetics, Inference, and Co-construction

Having articulated the core tenets of the ECtC epistemology in the preceding section, it becomes necessary to delineate the mode of engagement this framework demands. 'Reading' an ECtC is conceptualised not as passive reception of pre-packaged information, but as an active, embodied process of inferential meaning-making and co-construction. This process is crucially guided by an aesthetic stance, one that values the experiential and formal qualities of the medium alongside its informational content. The reader, adopting this stance, actively navigates the complex visual interface, bridging narrative, informative and spatial gaps (the gutters, ellipses), interpreting multimodal cues (text, image, layout), and engaging with the artefact's material presence.

This aesthetic engagement proves particularly vital because the ECtC, through its intricate visuo-spatial structuring theorised in Chapter 4 (as diagram, map, or meshwork), often confronts learners with complex relationalities or *threshold concepts* presented non-linearly. Overcoming these requires more than purely analytical decoding; it necessitates an appreciation of *how* the form itself shapes understanding. The aesthetic dimension, therefore, can be understood to function epistemically: the formal qualities—composition, line, colour, rhythm—guide the reader's attention, activate relevant cognitive schemas (cf. Section 4.5), and modulate the interpretive process, fostering the conditions for the emergence of the comics-fact (Section 4.8).

This comics-fact—that unique moment of insight, affective resonance, or conceptual connection afforded specifically by the medium—arises precisely from this synthesis of spatial structure (the diagrammatic or cartographic layout), multimodal content (the interplay of images and text), and the reader's active aesthetic and interpretive engagement. It differs fundamentally from what could be called a traditional 'data-fact' derived from the direct, often minimalist, decoding of conventional visualisations. The comics-fact is emergent, co-constructed through the interaction with the interface's specific affordances.

This view of comics as active environments for meaning-making aligns with the principles of Rhizomatic Learning and Edusemiotics established in Chapter 3. It also potentially informs Comics-Based Research methodologies by highlighting the cognitive work involved in reading and creating comics as knowledge artefacts. Furthermore, this complex process of co-construction, inherent in navigating the ECtC's spatial and multimodal architecture (e.g., tracing paths through the meshwork or deciphering diagrammatic relationships as theorised in Chapter 4), distinguishes it significantly from engagement with simpler multimodal interfaces which might rely more heavily on linear sequences or direct representational mapping, lacking the same degree of spatial inference and interpretive synthesis demanded by the ECtC.

Pedagogically, this emphasis on active, aesthetic, and inferential engagement points towards assessment strategies that value process over product. Rather than solely evaluating the 'correctness' of interpretation, assessment could encourage learners to articulate their interpretive journeys, map the connections they forged while navigating the ECtC's structure, and reflect critically on how the specific form facilitated (or complicated) their understanding. Such approaches would not only assess comprehension but actively cultivate the deeper visual, critical, and multimodal literacies essential for navigating contemporary knowledge landscapes.

While the potential of the ECtC framework is significant, acknowledging the methodological limitations of this study and the practical challenges for implementation is crucial for grounding future work

8.5. Methodological Reflections and Research Limitations

In evaluating the contributions of this thesis, it is essential to acknowledge its inherent methodological limitations. The dual methodology adopted—combining the flexibility of bricolage with the speculative nature of Proof of Concept (PoC, see Chapter 2)—enabled theoretical synthesis and conceptual design but necessarily limited empirical validation. Consequently, while this study establishes a robust conceptual framework for the ECtC epistemology, its practical efficacy and cognitive impact remain, at this stage, well-supported hypotheses rather than demonstrated outcomes. Systematic testing is required to confirm these potentials.

A second limitation is the research's focus on Western Higher Education (HE), which limits the diversity of pedagogical and narrative traditions considered in the ECtC framework. The immense variety and the fragmented availability of global material, particularly non-Western comics and pedagogical practices, pose a particular challenge to this research. While the Western focus provided a clear framework for this study, more inclusive sampling would offer a broader, more representative view of the potential for ECtC across cultures and educational contexts.

Finally, the nature of the PoC approach itself introduces limitations. As employed here, it primarily serves an illustrative and heuristic function, demonstrating the potential feasibility and conceptual richness of ECtC, rather than offering generalizable empirical proof. The design phase for the prototypes, while integral to conceptualisation, was not the primary research focus. While the design phase helped clarify the conceptual foundations of ECtC, it does not provide the empirical validation required to fully assess their educational impact or their practical implementation. The prototypes serve as valuable conceptual tools, but their effectiveness in real-world educational settings needs further systematic testing and refinement. Appendices A–E (prototype frameworks) and F (comparative taxonomy) mitigate this limitation by providing reproducible design frameworks that bridge theoretical concepts

and practical implementation. Appendix G offers an overview of selected studies related to comics in education.

Ultimately, these limitations highlight the conceptual and exploratory nature of this thesis. The potential of the ECtC framework is substantial, but it is crucial that future empirical research focuses on validating and expanding its findings through real-world application in diverse educational contexts, ensuring its global relevance.

8.6. Practical Implementation Challenges

Successfully implementing ECtC within HE faces significant practical challenges that extend beyond methodological considerations. Creating high-quality ECtC, capable of realizing the epistemic potential outlined in this thesis, demands considerable transdisciplinary expertise. This requires merging deep subject-matter knowledge with sophisticated pedagogical design and accomplished comics artistry—a confluence of skills rarely found in a single individual and often necessitating funded collaborations between academics, educators, and creative professionals.

Furthermore, effective integration into curricula hinges upon robust educator training, equipping instructors with the visual literacy and pedagogical strategies needed to guide students through these complex multimodal interfaces. In practical terms, this means designing training programs that not only introduce educators to the technical aspects of creating or utilizing ECtC but also show how to seamlessly integrate them into their existing teaching practices. This could involve workshops, peer-to-peer learning, or ongoing professional development that specifically addresses how comics can be used to foster engagement, critical thinking, and interdisciplinary connections within the classroom.

Beyond human capital, tangible hurdles include production costs—which vary significantly based on complexity, length, and artistic requirements—and strategic decisions about format. Both print and digital modalities present distinct affordances and challenges relevant to ECtC. Digital formats, for instance, offer enhanced accessibility features and potential for interactivity (e.g., embedded links, non-linear navigation structures, multimedia integration), which resonate well with the dynamic nature of post-digital learning environments (Chapter 3). However, they can also introduce complexities regarding interface design and consistent user experience. Print comics, on the other hand, leverage specific material and tactile affordances; the physical page allows for a particular type of spatial overview and embodied navigation (see Sections 4.3 and 4.9) that facilitates sustained engagement and potentially different modes of cognitive mapping. Yet, print formats

inherently face limitations in scalability for very large datasets (see Section 7.5) and present unique accessibility challenges. While many examples explored in this thesis draw from print traditions, reflecting the current state and accessibility of the corpus (Section 2.2.3), a comprehensive implementation of ECtC would likely benefit from critically evaluating and potentially integrating the strengths of both print and digital formats depending on the specific pedagogical goals and context.

Potential pathways forward include fostering transdisciplinary collaboration frameworks (as discussed in Section 3.6.2); strategically leveraging specific medium affordances identified herein (Chapters 4 and 7)—such as using comics' inherent multimodal integration to reduce reliance on dense text blocks or employing their spatial/diagrammatic capabilities to visualize complex relationships, thus potentially lowering certain production burdens or expertise demands. The development of supportive communities of practice, where educators, researchers, and creators can share expertise and resources, would also be invaluable in overcoming these challenges. Additionally, modular design principles could enable the creation of adaptable and reusable ECtC components suitable for various contexts, ensuring sustainability and scalability in the long term.

Such approaches could collectively pave the way for wider, sustainable implementation of ECtC across educational institutions. While this thesis focuses on Higher Education, the proposed strategies may also hold promise for adaptation in K-12 education and professional development contexts, pending further exploration and empirical validation.

8.7. Future Directions: Expanding the ECtC Framework

This research opens multiple pathways for future inquiry. Building on the conceptual groundwork laid out in this thesis, the next phase of work will require integrating empirical validation, design innovation, theoretical refinement, and community engagement to fully realise the potential of ECtC.

- **Empirical and Pedagogical Research** emerges as the most pressing area. Systematic testing of ECtC prototypes—such as comparative studies evaluating Prototype 3 (Section 7.6.2.1) versus traditional text-based resources in representing ecological change—can shed light on their impact on learning outcomes, engagement, and visual literacy in diverse HE contexts. In parallel, there is a need to develop and validate assessment strategies that reflect the process-oriented and interpretative nature of ECtC. This may involve experimenting with a *Proof of Teaching* (PoT) model, which would shift the focus from demonstrating conceptual possibility (PoC) to demonstrating pedagogical transferability and educational impact. Additionally, qualitative reception studies are crucial to better understand how readers engage with and interpret ECtC structures, especially across disciplines and learning profiles.

- **Design, Materiality, and Technological Research** is another key avenue. Future work could focus on developing discipline-specific ECtC, tailored to the epistemological styles and representational needs of fields such as climate science or engineering. A critical line of inquiry concerns the affordances of print versus digital formats. While this thesis has privileged print comics for their spatial and tactile coherence, future studies could explore how interactive modalities (e.g., AR/VR, responsive layouts) might extend or transform ECtC' epistemic potential in different contexts. Furthermore, empirical design research grounded in Schön's (1983, 1992) reflective practice model could help refine visual design principles, ensuring that layout, composition, and multimodality function pedagogically as well as aesthetically.

- **Theoretical Development** will also be essential in advancing the ECtC framework. This includes refining key constructs such as the comics-fact, potentially exploring their cognitive correlates and how they differ from interpretation models used in traditional data visualisation. ECtC could also be used to visualise difficult concepts—such as non-human temporalities or ecological causality—especially those resistant to linear or linguistic representation. Building on examples cited in Chapter 5.5.3 (e.g., Niendorf et al., 2020; Ruktanonchai et al., 2018), future work could align ECtC with Object-Oriented Ontology (OOO) and posthumanist visual cultures. In addition, further exploration of critical cartography and post-digital learning theories—such as seamless learning—may deepen the epistemological reach of the ECtC model, connecting it to broader educational and philosophical discourses (Wong and Looi, 2011; Milrad et al., 2013).

- **Implementation and Community Building** represents a strategic frontier. To enable meaningful adoption, future work should develop pedagogical frameworks and training resources that help educators integrate ECtC into their curricula with confidence and creativity. This includes not only technical training but also support in visual literacy development and interpretative pedagogy. At the same time, establishing interdisciplinary communities of practice—involving educators, artists, cognitive scientists, data designers, and domain experts—can foster sustained collaboration, resource-sharing, and iterative innovation. These communities could also contribute to building open-access ECtC repositories or collaborative authoring platforms, enhancing accessibility and scalability.

Ultimately, expanding the ECtC framework will require a multi-faceted effort that bridges theory, practice, and pedagogy. It is a project that calls not only for empirical rigour and design excellence, but for **epistemic openness**—a willingness to rethink how knowledge can be constructed, visualised, and shared. The ECtC, as a model, holds transformative potential: not only as a representational tool, but as a **cultural and educational shift** toward relational, multimodal, and participatory ways of knowing.

8.8. Final Word: Comics as a Necessary Epistemology

This thesis concludes by arguing that Educational Comics to Come (ECtC) can be seen not just as an innovative teaching tool, but as embodying a crucial epistemology. This epistemology may prove particularly valuable because, as argued in Chapters 3 and 5, traditional linear discourse and minimalist visualisations struggle to adequately represent the systemic complexity, non-linearity, and interconnectedness defining many contemporary challenges, often sacrificing the contextual richness crucial for holistic understanding. ECtC offer a unique synthesis, integrating reason and aesthetics, spatial reasoning, and multimodal interaction. This framework addresses the limitations of fragmented MERs and reductive DV (Chapter 5) by offering an inherently integrated and relationally structured interface for knowledge exploration. Wider adoption of this visual epistemology within HE could foster not only more engaging and effective learning environments but also cultivate graduates better equipped with the multimodal critical literacies needed to navigate and shape an increasingly complex visual world, potentially catalysing new forms of interdisciplinary research and collaborative knowledge creation. Reimagining comics is, ultimately, about reimagining how we come to know.

Appendices

Notes on the Appendices

These appendices provide technical expansion of Chapter 7's prototypes through three documentation formats, alongside a study overview supporting Chapter 1's literature review:

- **Design Specifications** (Appendix A): Visual encoding systems, implementation matrices
- **Narrative Scripts** (Appendices B-E): Temporal sequencing, interactive pathways
- **Analytical Taxonomy** (Appendix F): Comparative framework for cross-prototype adaptation
- **Study Overview** (Appendix G): Selected studies on Educational Comics in Higher Education

Each corresponds to a specific prototype:

- Appendix A: [Prototype 1] Cumulative Impact Encoding
- Appendix B: [Prototype 2] Hybrid Visual Narratives
- Appendix C: [Prototype 3] Temporal Landscapes
- Appendix D: [Prototype 4] Cartographic Atlas
- Appendix E: [Prototype 5] Research Unfolded
- Appendix F: ECtC Prototype Taxonomy
- Appendix G: Overview of Selected Studies on Educational Comics in Higher Education

This heterogeneous structure reflects ECtC's core epistemology: varied representational forms demand equally varied documentation strategies, as does the empirical grounding that precedes them.

Appendix A. [Prototype 1] Cumulative Impact Encoding: Design Strategies for Temporal-Scale Visualisation

A.1. Expanded Application Scenario

Industrial Disaster Context–Layered Representation of Impact Over Time

This prototype can be applied to represent the extended consequences of an industrial disaster, such as a chemical plant explosion. The first pages depict the immediate casualties, with each panel showing individual victims using detailed graphic representation. Subsequent pages transition into increasingly abstract and symbolic panels—blank, iconographic, or colour-coded—to visualise the deaths caused by long-term environmental contamination.

Such a representation fosters systemic thinking and supports the interpretation of long-term, delayed effects within environmental or public health curricula. This sequential structure offers a layered visualisation of the disaster's unfolding aftermath, enabling an understanding of indirect consequences beyond the initial event.

A.2. Implementation Strategies

A.2.1. Legend and Captions

- Introduce clearly labelled time intervals on each page (e.g., '5 years later', '10 years later', '25 years later').
- Use captions or extra-diegetic visual markers to provide readers with temporal orientation and semantic cues.

A.2.2. Gradual Abstraction

- Progressively reduce detail in human figures:
  - From realistic facial representation → simplified silhouettes → symbolic forms → blank panels.

- This transition visually encodes the progressive loss of individual visibility within systemic narratives, reinforcing the fading of personal agency in large-scale consequences.

A.2.3. Colour Coding

- Assign colours to specific types of long-term consequences:

  - **Red**: immediate trauma and injuries.
  - **Blue**: respiratory illnesses due to contamination.
  - **Grey**: social trauma or displacement.

- Apply colour as background fill, panel border, or full-panel tone depending on abstraction level.

A.3. Visual Encoding of Death Modalities Across Time

The table below (Table Appendix A-1) provides an overview of how different panel types and colour codes can be used to represent categories of mortality over extended timeframes. This visual strategy supports layered representations of environmental and systemic consequences.

Table Appendix A-1: Visual Encoding of Death Modalities Across Time

Panel Type	**Representation**	**Time Interval**	**Colour Code**	**Meaning**
Realistic Face	Immediate Victims	Year 0	Natural Tones	Direct Casualties
Simplified Icon	Indirect Victims	+5 years	Blue	Respiratory illness
Blank Panel	Data absence/Unknows	+15 years	Grey	Displacement, undocumented trauma

Appendix B. [Prototype 2] Hybrid Visual Narratives: Grid-to-Panorama Implementation

B.1. Narrative Structure: A Three-Phase Model

B.1.1. Phase One—Before the Disaster (Pre-Event)

- **Individual Perspectives** (*Strobe*-inspired):
  Panels depict various individuals—factory workers, residents, emergency responders—engaged in daily routines within a shared, synchronised timeframe. The focus is fragmented yet comprehensive, allowing interpretive exploration without narrative hierarchy.

- **Spatial Overview** (*The Great War*-inspired):
  A panoramic view of the urban setting maps key locations (homes, workplaces, public spaces), linking individual stories to spatial coordinates. The visual flow is left-to-right, establishing a cognitive map for later disruption.

B.1.2. Phase Two—The Crisis and Immediate Aftermath

- **Crisis Representation** (*Holy Terror*-inspired):
  Grids with increasing panel density represent the escalation of casualties and systemic stress.

- **Geographical Disruption** (*The Great War*-inspired):
  The panoramic layout fragments or distorts to show damage zones, emergency activity, and disrupted infrastructures. Visual ruptures metaphorically encode breakdowns in public order and social fabric.

B.1.3. Phase Three—Recovery and Long-Term Consequences

- **Return to Individuals** (*Strobe*-inspired):
  The original characters reappear in altered post-event contexts, their daily lives transformed. Emotional states, economic shifts, and community adaptations are portrayed.

- **Reconstruction Spread** (*The Great War*-inspired):
  The panoramic layout is reassembled to display rebuilt environments, population redistribution, and traces of past disruption. The before/after contrast is formalised through visual mirroring.

B.2. Implementation Strategies

- **Visual recursion**: Motifs, icons, and characters reappear across phases, altered by their experiences.

- **Narrative navigability**: Readers can follow either linear progression or thematic paths (e.g., by space, character, or structural change).

- **Format suggestions**:

  - *Print*: Fold-out leporello, triptych spread, poster format.

This structure can also be adapted to interactive environments, allowing users to toggle between narrative layers—individual, spatial, and statistical—or navigate dynamically through hyperlinks, maps, and sequential flows.

B.3. Educational and Epistemological Relevance

This prototype enhances:

- **Visual epistemology**, through comparative, recursive, and layered data structuring;

- **Empathy-based engagement**, by integrating affective and statistical information;

- **Critical spatial literacy**, linking lived experiences to systemic disruption;
- **Interdisciplinary applicability**, particularly in education on disaster response, public health, urban planning, and social stratification.

B.4. Visual Techniques by Phase

The following table (Table Appendix B-1) outlines the visual forms used in each narrative phase, tracing their functional roles and referencing their inspirational sources. This synthesis clarifies how distinct visual configurations and compositional strategies contribute to different narrative and epistemic functions within the prototype.

Table Appendix B-1: Visual Forms and Narrative Functions Across the Three Phases

Narrative Phase	Visual Form	Inspirational Source	Function
Pre-Event	Individual character panels	*Strobe*	Depict simultaneous everyday routines
	Panoramic urban layout	*The Great War*	Establish spatial context and orientation
Crisis / Impact Phase	Dense grid sequence	*Holy Terror*	Visualise escalation of casualties
	Fragmented panorama	*The Great War*	Show spatial disruption and systemic collapse
Post-Event / Recovery	Mirrored character panels	*Strobe*	Highlight transformation over time
	Reconfigured panorama	*The Great War*	Represent reconstruction and systemic shift

Appendix C. [Prototype 3] Temporal Landscapes: *Script* for Socio-Environmental Change

C.1. Design and Visual Encoding

This prototype operates on a fixed visual frame that evolves across pages, using inset panels and spatial cues to represent change over time and the entanglement of environmental and cultural dynamics.

Key strategies include:

- **Layered visualisation**: overlapping panels depict multiple temporalities simultaneously.
- **Inset panels**: serve as temporal windows and detail amplifiers.
- **Colour coding**: links time periods and event types (e.g., greens = biodiversity, browns = degradation, reds = socio-political conflict).
- **Panel size**: reflects event magnitude or thematic relevance.
- **Motif repetition and transformation:** shows symbolic continuity or rupture.

Example of integrated visual strategies: Cultural and environmental change can be represented through shifts in visual motifs and framing. For instance, the replacement of canoes with motorboats illustrates technological change; stylised human figures may signal cultural assimilation. The presence or absence of species (e.g., tapirs, monkeys) across panels highlights ecological transformation and long-term ecological loss.

These encoding strategies collectively form a temporal-cartographic interface, enabling the reader to navigate knowledge across both linear and rhizomatic dimensions**.** The result is a visual structure that supports systemic comprehension, interpretive flexibility, and comparative insight—essential for analysing layered socio-environmental transformations.

C.2. Detailed Page Analysis: 2024 Scenario (Page 2)

- **Main Panel**: Cattle pasture, sparse forest remnants, subdued colours.
- **Cluster 1–Memory of the Forest** (top-left): historic biodiversity (jaguar, sloth, canopy).
- **Cluster 2–Portents of the Future** (bottom-left): desertification, extinction, uncertain reforestation.
- **Cluster 3–Present Actions** (right): logging machinery, burned areas.

This configuration invites inferential reasoning, as readers reconcile ecological traces across contrasting temporalities. The spatial logic of the cluster arrangement activates a layered reading experience in which meaning is not linearly imposed but emerges through visual synthesis. Additional elements introduce interpretive ambiguity. The presence of a drone (Page 1), advanced technologies (Page 3), and the bifurcated future vision (Page 4) resist fixed readings. These ambiguous cues reflect the complexity of real-world change, prompting the reader to engage critically with uncertainty and potentiality.

C.3. Reading Strategies and Narrative Structure

The model supports non-linear, thematic, and comparative navigation**.**

Core design elements:

- **Temporal clusters**: multiple versions of the same place over time.
- **Cause-effect layout**: implied by spatial placement.
- **Detail vs. overview**: large panels for context, small for triggers or consequences.

Readers are encouraged to trace variables (e.g., biodiversity, technology, land use) and to develop their own interpretive paths. This process may unfold in four analytical steps: (1) identifying relevant variables (e.g., biodiversity, technology, cultural resilience); (2) tracing their visual representation across the four pages; (3) formulating critical questions; and (4)

developing arguments based on inferential and comparative visual analysis.
These operations align with HE goals of inquiry-based learning, critical multimodal engagement, and the development of visual reasoning across disciplines.

C.4. Narrative Script Overview (Pages 1–4)

Page 1–10,000 BC: Pristine Amazon

The main panel shows a lush, pre-Columbian forest in rich greens and deep blues. The landscape is uninterrupted, dense with biodiversity. Inset panels include a hunting scene with indigenous figures (11,000 BC), megafauna such as a mastodon (10,500 BC), and a degraded version of the forest in 2200 AD. This page acts as the temporal and ecological baseline for the prototype.

Page 2–2024 AD: Deforestation and Agriculture

The main panel depicts a vast cattle pasture with few remaining trees, dusty roads, and fencing—symbolising present-day deforestation. Inset clusters provide three viewpoints: past biodiversity ('Memory of the Forest'), near and far future outcomes ('Portents of the Future'), and stages of industrial land clearance. These elements form a dynamic field of tension between past loss, present degradation, and future risk.

Page 3–2074 AD: Hybrid Landscape and Recovery Attempts

The main panel portrays a mixed terrain: eroded zones, patches of reforestation, and rural communities integrating traditional and technological elements. Insets show long-term

ecological damage (polluted rivers, adapted species) and conservation actions (indigenous-led efforts, biodiversity reserves). The page interlaces fragility with signs of recovery.

Page 4–2100 AD: Diverging Futures

The main panel is split: the left side shows collapse—desertification, infrastructural ruins; the right side presents a hopeful future—dense reforestation, eco-cities. Insets reflect on past decisions (abandoned farmlands, ongoing drone monitoring), linking visual motifs across the timeline. The dual composition invites reflection on branching futures.

The following table (Table Appendix C-1) summarises the thematic and temporal structure of the four-page sequence, highlighting dominant visual elements and interpretative trajectories for each moment in the narrative timeline.

Table Appendix C-1: Page-by-Page Schematic Overview of the 'Pristine Amazon' prototype. This table outlines the main theme, dominant colours, and narrative trajectory for each of the four pages in the sequence.

Page	Time	Main Theme	Dominant Colour(s)	Narrative Trajectory
1	10,000 BC	Baseline biodiversity	Green / Blue	Origin
2	2024 AD	Deforestation	Brown / Grey	Decline
3	2074 AD	Mixed recovery	Mixed tones	Ambivalence
4	2100 AD	Diverging futures	Split palette	Uncertainty

C.5. Prototype Extensions and Variants

These extensions share the core compositional logic and temporal-spatial structure of Prototype 3, while recalibrating focus, timescales, and narrative granularity according to domain-specific requirements. Each variant expands the model's applicability by anchoring it in a different system of meaning.

Examples:

- **Prototype 3.1–Networked Futures**: infrastructure and environmental impact
- **Prototype 3.2–Infrastructure Mapping**: lifecycle of built environments
- **Prototype 3.3–Pandemic Chronicles**: cross-epoch comparative epidemiology

C.6. Academic and Educational Applications

This prototype is suitable for:

- **Environmental Studies**: climate change, feedback loops
- **Anthropology**: ecological knowledge, cultural adaptation
- **History / Geography**: landscape transformation, colonial impact
- **Data Visualisation & Communication**: narrative integration of complex systems
- **Public Communication**: policy and awareness tools

This visual framework enhances epistemic engagement across multiple audiences, bridging data-driven logic with culturally embedded narrative forms. Its multimodal nature makes it adaptable for classroom settings, public outreach, and interdisciplinary research alike.

Appendix D. [Prototype 4] Cartographic Atlas: Scripting Knowledge Evolution

D.1. Conceptual Overview

This prototype extends *Alpha Directions* by transforming it into a flexible framework for epistemic cartography. It visualises how concepts evolve across time, disciplines, and perspectives through spatial juxtaposition and visual recursion. Rather than offering a linear historical account, it constructs meaning through layered associations and epistemic cross-referencing.

The prototype avoids a singular vantage point. Instead, knowledge is shown as a landscape where distinct frameworks—scientific, mythological, philosophical—overlap, compete, or converge. This conceptual openness allows the same subject to be reinterpreted multiple times, from different cultural and disciplinary lenses.

D.2. Page-by-Page Scenario Breakdown

This section outlines a four-page scenario visualising the evolution of the concept of life across scientific, mythological, and artistic epistemes. Each page represents a different epistemic configuration, articulated through visual juxtaposition, layering, and recursive motifs.

Page 1–Origin Myths & Early Scientific Thought (Prehistory–16th Century)

- **Visual Elements**: Ancient cosmologies (Babylonian, Hindu, Greek), alchemical diagrams, Great Chain of Being, Islamic anatomical illustrations.
- **Structural Strategies**: Layered composition without strict panel boundaries; conceptual continuity is shown via repetition, recombination, and proximity.

Page 2–Mechanistic & Evolutionary Models (17th–19th Century)

- **Visual Elements**: Cartesian machines, Linnaean taxonomies, Darwinian trees; juxtaposed with theological critiques and political iconography.
- **Structural Strategies**: Visual opposition and blending; previous motifs from Page 1 return in altered forms; art-science dialogue foregrounded.

Page 3–Molecular & Cybernetic Perspectives (20th Century—Present)

- **Visual Elements**: DNA strands, Gaia theory, circuit diagrams, AI interfaces; integration of organic and synthetic aesthetics.
- **Structural Strategies**: Motif transformation (e.g., tree → neural net); fluid image transitions; use of negative space to suggest epistemic limits.

Page 4–Speculative Futures & Alternative Biologies (Future Concepts)

- **Visual Elements**: Synthetic organisms, extraterrestrial life models, speculative evolution charts, mandala structures.
- **Structural Strategies**: Symmetrical layout echoing Page 1; visual rhythm shifts (dense/minimal); conceptual open-endedness via unanchored panels.

The following table (Table Appendix D-1) summarises the temporal, conceptual, and compositional logics underpinning each page of the scenario.

Table Appendix D-1: Epistemic Progression and Visual Mapping Overview for the 'Concept of Life' prototype. This table summarises the temporal and conceptual logic for each of the four pages, outlining the corresponding epoch, epistemic configuration, and visual strategy.

Page	Epoch	Epistemic Configuration	Visual Strategy
1	Prehistory–16th Century	Myths, proto-sciences	Juxtaposition, layering
2	17th–19th Century	Mechanistic, evolutionary	Recursion, visual opposition
3	20th Century—Present	Cybernetics, AI, systemic views	Negative space, transformation
4	Speculative / Futures	Synthetic biologies, posthuman paradigms	Circular symmetry, minimalism

D.3. Implementation Strategies

- **Layered Visualisation**: Subjects are shown from multiple epistemologies via overlaid imagery and intertextual echoes.
- **Conceptual Cartography**: Temporal clusters replace linearity; inset panels highlight conceptual shifts.
- **Panel Juxtaposition**: Encourages epistemic comparison (e.g., DNA next to sacred iconography); enables multi-scalar thinking.

D.4. Pedagogical Applications

This prototype supports:

- **History & Philosophy of Science**: Mapping paradigm shifts.
- **Transdisciplinary Research**: Revealing conceptual migration across fields.
- **Epistemology & Visual Communication**: Understanding the structure and reframing of ideas.
- **Futures Studies**: Designing visual anticipations of knowledge futures.

This model encourages student-driven navigation, visual reasoning, and the development of critical epistemic awareness across fields.

D.5. Concluding Remarks

The *Cartographic Atlas* prototype models knowledge as an evolving landscape. It rejects linear causality in favour of spatial recursion, disciplinary dialogue, and conceptual fluidity. Visual meaning emerges through cross-reading, inversion, and reinterpretation—activating an exploratory form of cognition.

By merging visual patterning with epistemic inquiry, this prototype demonstrates the role of comics not just as representations of knowledge, but as active frameworks for its production, navigation, and transformation.

Appendix E. [Prototype 5] Research Unfolded: Branching Narratives for Scientific Uncertainty

E.1. Concept and Structure

This prototype adapts branching comics logic to visualise the scientific research process as a recursive, non-linear structure. Research is represented not as a neat, goal-oriented trajectory, but as a map of trial, error, revision, and re-evaluation. Students follow a protagonist-researcher through key decision points, experiencing how different strategies lead to different outcomes.

Unlike linear timelines, this structure supports multiple perspectives and counterfactual reasoning. Readers must evaluate choices, revise hypotheses, and negotiate uncertainty—mirroring actual research dynamics.

E.2. Scenario Script—Four Key Phases

The following four-page structure visualises a branching journey through a stylised research process.

This four-page model operates as a didactic simulation loop, enabling students to experiment with decision-making within a visualised research process—a structure particularly effective in HE and STEM training contexts.

Page 1–Hypothesis Formulation and Initial Methodological Choices

- **Visual Elements**: Methodological schematics, researcher weighing methods.
- **Structure**: Parallel panels display initial choices; no dominant path.

Page 2–Experimentation and Unexpected Challenges

- **Visual Elements**: Equipment failures, contradictory data, split-colour panels (red = error, blue = progress).
- **Structure**: Diverging panels and visual feedback loops simulate revision cycles.

Page 3–Data Analysis and Interpretation

- **Visual Elements**: Graphs, peer feedback scenes, conflicting outcomes.
- **Structure**: Panels recall past decisions; motifs repeat in new contexts.

Page 4–Review, Publication, and Reflection

- **Visual Elements**: Meta-visual map of decision paths, reflective narration.
- **Structure**: Non-hierarchical graph layout; multiple valid conclusions.

The following table (Table Appendix E-1) summarises the narrative flow, epistemic focus, and branching logic of each page.

Table Appendix E-1: Research Scenario Overview. This table outlines the four phases of a simulated research process, detailing the epistemic focus and the visual/narrative strategy employed on each page.

Page	Phase	Epistemic Focus	Visual/Narrative Strategy
1	Formulating Hypothesis	Method choice, uncertainty	Parallel layouts, comparative schematics
2	Experimentation	Setbacks, data conflict	Diverging paths, feedback loops, colour signals
3	Data Interpretation	Inference, revision	Recursion, motif repetition, peer interaction
4	Evaluation & Publication	Meta-reflection, outcomes	Decision map, non-hierarchical structure

E.3. Visual and Implementation Strategies

- **Use of Colour**: Distinct colour codes for outcome types (e.g., green = innovation, red = failure, yellow = uncertainty).
- **Panel Interlinking**: Arrows and recursive layouts allow readers to revisit or abandon branches.
- **Modular Layout**: Each 'choice cluster' is self-contained but semantically linked to others.
- **Interpretive Cues**: Graphic interface elements such as arrows, icons, or 'decision nodes' may guide interpretive paths without prescribing them, supporting interpretative flexibility and non-linear cognition.

E.4. Pedagogical Applications

- **Scientific Training**: Demystifies research as iterative and fallible.
- **Research Epistemology**: Promotes reflexivity and awareness of method-bound interpretation.
- **Decision-Making Skills**: Models risk evaluation and real-world complexity.
- **Ethics Education**: Embeds moral/ethical decision nodes within the research flow.

These applications foster research literacy not only as content knowledge, but as processual, reflexive, and ethical engagement.

E.5. Educational Variants and Adaptations

This prototype may be adapted for:

- **Historical Case Studies**: e.g., Pasteur, Curie, Turing, etc.
- **Interdisciplinary Inquiry**: Humanities and social sciences with interpretative forks.

- **Professional Training**: For strategy, project management, or policy reasoning.
- **Ethics Simulations**: Embedding dilemmas with real-world consequences.
- **Design Thinking and Innovation Labs**: Exploring iterative design, prototype testing, and reflective decision-making in creative industries and STEM innovation contexts.

Further variants could simulate contemporary research dilemmas, replicating dynamic learning scenarios in which students navigate uncertainty, ethical constraints, or innovation deadlocks.

E.6. Concluding Remarks

Research Unfolded reimagines scientific inquiry as an exploratory cartography of uncertainty. By activating reader-agency, it resists simplification and affirms the role of revision, failure, and reflection in the production of knowledge. It positions comics not only as pedagogical tools, but as cognitive environments in which research can be actively experienced, simulated, and critically reconstructed.

Appendix F. ECtC Prototype Taxonomy: Comparative Framework

F.1. Purpose and Scope

This appendix provides a comparative synthesis of the five ECtC prototypes presented in Chapter 7. While each prototype was developed to address specific representational and educational needs, taken together they form a flexible typology. This comparative framework enables transversal analysis across visual strategies, temporal models, epistemic configurations, and pedagogical functions.

The framework also offers a metareflection on how comics can operate as conceptual tools within higher education—positioning each prototype within a broader system of visual reasoning and design-based learning.

F.2. Comparative Table

The following table (Table Appendix F-1) synthesises the key dimensions of all five ECtC prototypes. It enables direct comparison across structural design, temporal modelling, epistemic orientation, educational function, and distinctive implementation strategies. This comparative layout supports both analytical insight and curricular planning.

Table Appendix F-1: ECtC Prototype Comparison Matrix. This table provides an overview of the structural, temporal, epistemological, and pedagogical dimensions across all five prototypes.

Prototype	**Visual Structure**	**Temporal Logic**	**Epistemic Focus**	**Educational Function**	**Distinctive Features**
1–Cumulative Impact	Static grids, progressive panels	Diachronic, interval-based	Quantitative accumulation, systemic scale	Risk awareness, memory work	Minimalist design; abstracted death representation
2–Hybrid Data Narratives	Panoramic + grid layers	Event-based, multi-scale	Multi-perspective, contextualised representation	Emotional insight, spatial mapping	Inspired by Strobe & The Great War
3–Temporal Landscapes	Layered insets + main panel	Non-linear, temporal recursion	Cultural-ecological entanglement	Systems thinking, scenario analysis	Feedback loops; visual density variation
4–Cartographic Atlas	Conceptual overlays	Associative + speculative	Epistemic migration, disciplinary cross-mapping	Transdisciplinary knowledge design	Recurring motifs; conceptual cartography
5–Research Unfolded	Branching graph paths	Decision-based, recursive	Reflexive epistemology, uncertainty navigation	Inquiry simulation, research literacy	Visualised research cycles; choice-driven learning

F.3. Commentary and Insights

Across the five prototypes, several transversal features emerge:

- **Panel modulation**: All prototypes manipulate panel size, layout, and density to encode information beyond narrative sequence.
- **Temporal abstraction**: Time is never merely chronological; it is diachronic (1), recursive (5), or reticulated (3–4).

- **Cognitive function**: The models invite pattern recognition, inferential reasoning, and decision-making.
- **Educational orientation**: The prototypes move from descriptive (1) to analytical (2–3), speculative-design (4–5).

Together, they constitute a flexible repertoire of visual strategies for knowledge construction—anchored in comics but extrapolable to other multimodal design contexts.

F.4. Application Scenarios

This comparative matrix can serve:

- As a **heuristic for prototype selection** in curriculum or research tool design.
- To guide **further empirical testing** of ECtC models in HE settings.
- As a **teaching aid** to support metacognitive awareness in visual studies, education, or design programmes.

For example, in a course on Visual Epistemology, the matrix can support prototype selection aligned with specific learning outcomes, such as visualising uncertainty, simulating decision-making, or comparing multi-scalar representations.

F.5. Concluding Remarks

By mapping the conceptual, visual, and pedagogical logics of each ECtC prototype, this appendix reinforces the idea that comics constitute not a single representational system but a modular epistemic architecture—capable of hosting, generating, and transforming complex forms of knowledge.

This metaframework not only enables comparison, but also lays the groundwork for future prototype development, empirical testing, and cross-modal integration.

Appendix G. Overview of Selected Studies on Educational Comics in Higher Education

Table Appendix G-1: Overview of selected academic studies on the use of comics in HE across disciplinary fields and geographic regions.

A	B	C	D	E	F
1.	(Nagata, 1999)	1999	Japan	Biochemistry	
2.	(Gerde and Foster, 2008)	2008	United States	Business Ethics	comic books, graphic novels, multicultural, narrative, pedagogy, teaching
3.	(Murakami and Bryce, 2009)	2009	Australia	Agriculture	educational manga, sēnen manga, moyashimon
4.	(Herbst et al., 2011)	2010	United States	Mathematic	
5.	(Hosler and Boomer, 2011)	2011	United States	Science Literacy	
6.	(Bolton-Gary, 2012)	2012	United States	Educational psychology	innovative pedagogy, teaching strategies, humour, comics, educational psychology
7.	(Keller and Oechslin, 2013)	2013	Switzerland	Synthetic biology	
8.	(Blanch and Mulvihill, 2013)	2013	United States	Cultural Anthropology	
9.	(Whitt, 2013)	2013	United States	Education Miscellanea:	

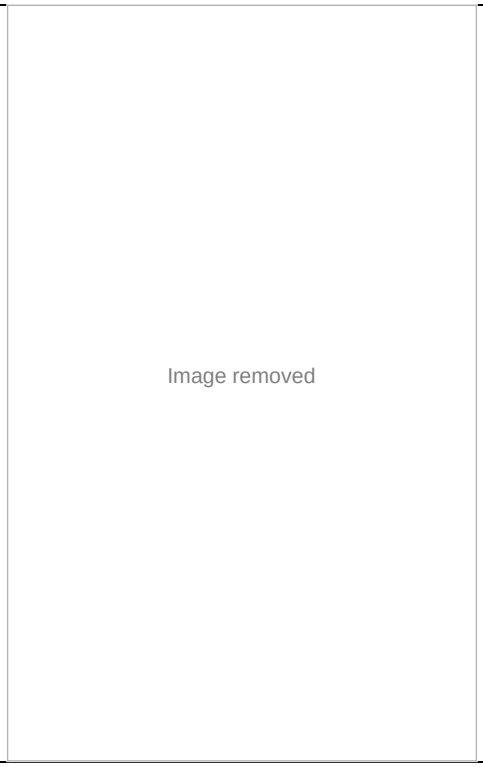
				physics, biology, literature, science fiction writing, film adaptations, philosophy, and religion	
10.	(Short et al., 2013)	2013	United States	Business Management	
11.	(Marrall, 2013)	2013	United States	Multicultural Education	
12.	(Weaver-Hightower, 2013)	2013	United States	Qualitative Research	
13.	(Green, 2013)	2013	United States	Medical Education	medical education, comics, graphic narratives, narrative medicine, humanities.
14.	(Shin et al., 2013)	2013	Republic of Korea	Anatomy	artistic anatomy, cartoons, humour, medical education, questionnaires
15.	(Irwin, 2014)	2014	United States	Library and Information Science	collection development, bibliographic essay, graphic nonfiction, graphic novels, nonfiction
16.	(Dahlan et al., 2015)	2015	Malaysia	Education	comic, education, academic, tool.
17.	(Humphrey, 2015)	2015	Australia	Academic Writing	
18.	(Farthing and Priego, 2016)	2016	United Kingdom	Medicine	graphic medicine, HE,

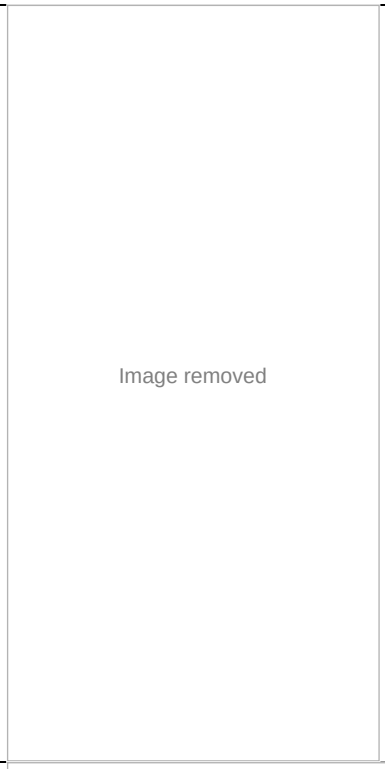
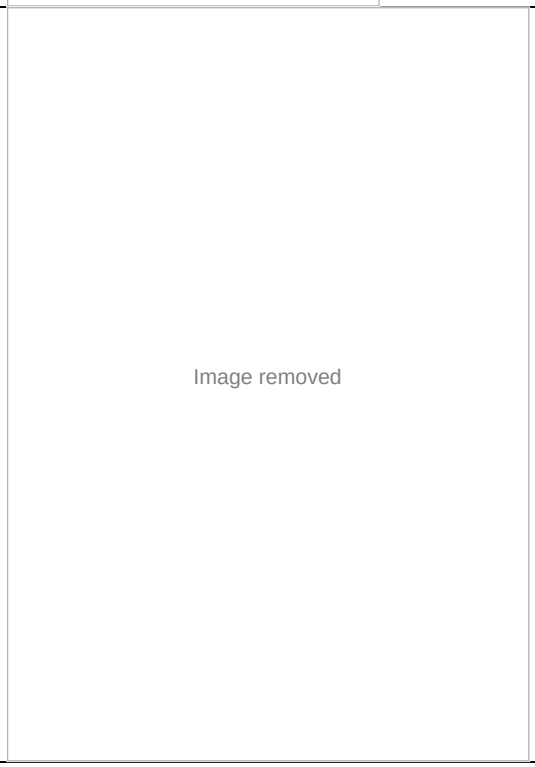
					interviews, mental health, social care
19.	(Muzumdar, 2016)	2016	United States	Pharmacy	comics, graphic novels, education, pharmacy, graphic medicine
20.	(Priego, 2016)	2016	United Kingdom	Finance	HE non-fiction comics, research, scholarly - communications, student finance
21.	(Manchester, 2017)	2017	United States	Queer Theory	
22.	(Silva et al., 2017)	2017	Brazil	Decision-Making and Managerial Development	teaching strategies; comics; learning; education in management; active learning strategies
23.	(Rocamora-Pérez et al., 2017)	2017	Spain	Physiotherapy	innovative teaching, HE, graphic novel, physiotherapy
24.	(Kim et al., 2017)	2017	Republic of Korea	Anatomy	gross anatomy education; anatomy cartoons; comics in education; science education; nonprofessional education; undergraduate education; medical education
25.	(Kumasaki et al., 2018)	2018	Japan / Taiwan / Thailand	Chemical Safety	
26.	(Landherr, 2019)	2019	United States	Chemical engineering	

27.	(Joshi et al., 2019)	2019	United States	Clinical Medical Education	comics, medical education, psychiatry clerkship
28.	(Lautesse et al., 2019)	2019	France	Quantum mechanics	quantum mechanics, HE, comic book, epistemology, fiction, counterfactual
29.	(Kara and Brooks, 2020)	2020	United States	Qualitative Research	comics, teaching, pedagogy, research methods, qualitative interviewing, qualitative research
30.	(Van der Sluis, 2021)	2021	United Kingdom	Education	
31.	(Robin et al., 2021)	2021	Canada	Teaching Science Communication	science communication, comics, postgraduate course, research dissemination, survey
32.	(Cabrera-Solano et al., 2021)	2021	Ecuador	EFL writing	digital comic strips; EFL writing; perceptions; Pixton; ICT
33.	(Topkaya et al., 2023)	2023	Turkey	Effectiveness of Using Comics in Education: Meta-Analysis	Educational comics, Meta-analysis, Meta-thematic analysis, Academic achievement, Attitude.
34.	(Santanna, 2023)	2023	Russian Federation	College students' perception of educational science comics	educational science comics, mixed-method approach, comics pedagogy, multimodal

				as multimodal texts	texts, college students
A: Reference number; B: Document; C: Year; D: Geographic origin; E: Field of research and application; F: Keywords (if applicable).					

Table Appendix G-2: Summary of selected studies on the use of comics in HE, distinguishing between self-produced and commercial comics, with specific examples when available.

* A	B	C	D
1.	(Nagata, 1999)	**c**	
2.	(Gerde and Foster, 2008)	c	
3.	(Murakami and Bryce, 2009)	c	

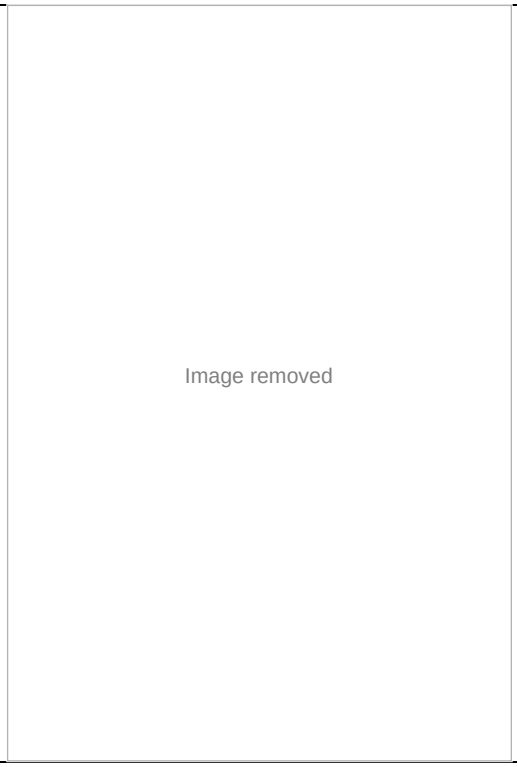
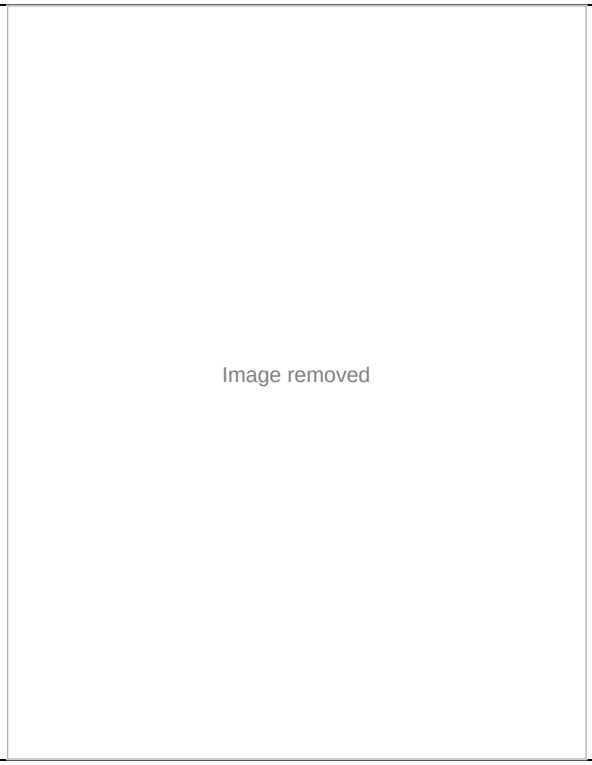
4.	(Herbst et al., 2011)	**s**		
5.	(Hosler and Boomer, 2011)	**s**		

6.	(Bolton-Gary, 2012)	**c**	Image removed
7.	(Keller and Oechslin, 2013)	c	Image removed
8.	(Blanch and Mulvihill, 2013)	**c**	
9.	(Whitt, 2013)	**c**	
10.	(Short et al., 2013)	**s**	Image removed
11.	(Marrall, 2013)	**c**	

12.	(Weaver-Hightower, 2013)	**s**	Image removed
13.	(Green, 2013)	**c**	
14.	(Shin et al., 2013)	**s**	Image removed
15.	(Irwin, 2014)	**c**	
16.	(Dahlan et al., 2015)	**s**	
17.	(Humphrey , 2015)	**c**	

18.	(Farthing and Priego, 2016)	**s**	Image removed	
19.	(Muzumdar, 2016)	**s**		
20.	(Priego, 2016)	**s**	Image removed	
21.	(Manchester, 2017)	**c**		
22.	(Silva et al., 2017)	**s**	Image removed	
23.	(Rocamora-Pérez et al., 2017)	**c**		

24.	(Kim et al., 2017)	**s**	Image removed	
25.	(Kumasaki et al., 2018)	**s**	Image removed	
26.	(Landherr, 2019)	**s**	Image removed	
27.	(Joshi et al., 2019)	**c**		
28.	(Lautesse et al., 2019)	**c**	Image removed	

29.	(Kara and Brooks, 2020)	**s**	
30.	(Van der Sluis, 2021)	**c/ s**	
31.	(Robin et al., 2021)	**s**	
32.	(Cabrera-Solano et al., 2021)	**s**	

33.	(Topkaya et al., 2023)	**s/ c**	
34.	(Santanna, 2023)	**c**	
A: Reference number; **B:** Document; **C:** Type of comics: **s**, self-produced (including reviews of academic comics), **c**, commercial.; **D:** Example (when available).			

Table Appendix G-3: Overview of reported advantages and disadvantages of using comics in HE, based on selected academic studies.

	Reference Numbers	Comment
ADVANTAGES		
- **Improving Engagement**	• 1; 6; 8; 10; 18; 20; 23; 26; 27; 29; 30; 33	Engagement is especially improved for "younger, more visually oriented readers (**20**, p. 2), for students who find traditional research and teaching methods boring and abstract (**29**) and for those who are uncomfortable with traditional textbooks (**8**).
- **Enjoyability**	• 1; 3; 8; 10; 19; 23; 26; 27; 33	**19** emphasises the relevance of this factor, especially for Generation Y.
- **Improving comprehension, memorability, and information retention.**	• 1; 3; 8; 14; 29; 33	
- **Simplifying complex concepts**	• 10; 26	
- **Making ambiguity tolerated and accepted**	• 13; 29	
- **Making abstract concepts more tangible and understandable**	• 6; 26; 29	
- **Promoting student self-identification**	• 11; 23; 26	
- **Low realisation costs**	• 19	
- **Ease of portability**	• 19	
- **Promoting critical thinking**	• 8; 13; 20: 21: 22	**21** specifically adds an improvement in 'critical looking'.
- **Reducing the gap between theory and practice:**	• 4; 8; 22: 25; 29	**8** specifies that this effect is increased when the student takes comics out of the classroom and into 'real life'.

- **Promoting equity and the inclusion and representation of minorities**	• 11; 21	
- **Facilitating skills development by contributing to the development of innovation and flexibility.**	• 22	
- **Improving long-life learning**	• 8	
DISADVANTAGES		
- **High costs and copyright restrictions**	• 18; 29	These factors are particularly influential in printed comics and not online comics.
- **Academic resistance to the use of the medium**	• 18; 19	This is an issue evoked in several sources.
- **Comics are perceived as childish or non-academic**	• 8; 12; 15; 21; 26; 29	
- **Oversimplification risk**	• 15; 27	
- **Difficulties for students with visual impairment**	• 29	
- **Students might not like comics**	• 29	
- **Lack of the necessary skills for the interpretation and creation of comics**	• 22; 31	

Table Appendix G-4: Terminological variation in academic literature on comics, based on study titles and abstracts.

	Year	Title	Abstract
1	1999	Manga	Comics, Manga, Cartoons
2	2008	Comic Books	Comic Books
3	2009	Manga	Manga
4	2010	Comics-Based Representations	Comics-Based Representations
5	2011	Comic Books	Comic Books, Comics
6	2012	Comics	Comics
7	2013	Comics	
8	2013	Comics	Sequential Art, Comics, Graphic Novels
9	2013	Comic Books	Sequential Art, Comics, Graphic Novels
10	2013	Graphic Presentation, Graphic Novels	Graphic Novels

11	2013	Graphic Novels	Sequential Art, Comics, Graphic Novels
12	2013	Sequential Art	Sequential Art, Comics, Graphic Novels
13	2013	Comics	Graphic Narratives, Comics
14	2013	Comic Strips	Comic Strips
15	2014	Graphic Nonfiction, Nonfiction Comics	Comics, Graphic Nonfiction
16	2015	Comics	Comics
17	2015	Comics	Comics
18	2016	Comics	Comics
19	2016	Comic Books	Comic Books
20	2016	Comics	Comics
21	2017	Comics	Comics
22	2017	Comics	Comics
23	2017	Graphic Novels	Graphic Novels, Comics
24	2017	Comics	Comics
25	2018	Graphic Novels, Manga	Graphic Novels, Manga
26	2019	Comics	Comics
27	2019	Comics	Comics
28	2019	Bande dessinée	Bande dessinée
29	2020	Comics	Comics
30	2021	Manga, Graphic Novels, Comics	Manga, Graphic Novels, Comics
31	2021	Comics	Comics
32	2021		
33	2023	Comics	Comics
34	2023	Comics	Comics

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