Interactive Digital Narratives to Represent Complexity: A Review

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Abstract. Interactive Digital Narratives (IDNs) have been long considered potential solutions to the issue of accessibly representing complex topics in a cognitively manageable way. This review article is aimed at investigating the affordances IDNs offer for representing and making complex issues accessible, as discussed in the relative academic literature. This review analysed the entirety of the proceedings of the International Conference on Interactive Digital Storytelling (ICIDS) and related texts, for a span of 28 years. From the analysis of the 126 selected publications, 10 macro-topics emerged, namely: Participation, Model complexity, Increased engagement and motivation, Multi-user capacity, Narrative, Adaptability, Multimodality, Structuring thinking, Replayability, and Caveats. These topics are discussed in relation to what they entail for the accessible representation of complexity through IDNs.

Keywords: Systematic literature review · Interactive Digital Narratives · Representation of complexity · Complex issues · Climate change · Cultural heritage · Mental health · Education · Democracy

1 Introduction

The complexity of pressing issues we face daily is increasingly overwhelming. Societal challenges like the ecological crisis, migration, or situations of conflict present themselves as wicked problems, with too many forces at play, too many interests, perspectives, and realities being intertwined with one another. Due to their complexity, such topics can easily provoke frustration, confusion, sadness, or disengagement, refusal, and even active contrast. The complexity of these issues becomes ever more problematic when people are required to cast votes in democratic institutions. Complexity in these cases may lead to detrimental cognitive shortcuts in problem-solving, and to potentially problematic linear thinking that may ultimately jeopardize democracy itself.

Interactive Digital Narratives (IDNs) have been long considered potential answers to the question of how to accessibly represent complexity in a cognitively manageable way. This review article is aimed at investigating the affordances offered by IDNs for representing and making accessible complex issues as discussed in the relevant academic literature.

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In order to include all pertinent academic discourses and provide a more holistic view of the subject matter, this review collects works dealing with the representation of different kinds of complexity, including but not limiting to issues like climate change, conflict situations, cultural heritage, education, and mental health. The reason for this choice lies in the fact that many of the representational issues that arise when trying to make accessible different kinds of complexity are similar, and the findings of different fields are often transferable at least to some extent. Such a transfer has been seldom operated, thus slowing down an otherwise very vivid field of research. This work hopes to strengthen this interdisciplinary exchange on how IDN can be used to represent a plethora of complex issues.

2 Method

The review has been conducted following the method outlined in [136], which presents a variation of the Grounded Theory methodology to systematically analyse the literature on a given topic in a specific field of research. The topic of this review is the accessible representation of complexity, and the research field is IDN studies. The main publication venue for the field is the proceedings of the International Conference on Interactive Digital Storytelling (ICIDS) and the newborn Journal of Interactive Narrative. Recently, the project COST Action – 18230 Interactive Narrative Design for Complexity Representation (INDCOR) investigated the topic in depth and produced a considerable body of research, which provides another pivotal collection of works in IDN research. ICIDS proceedings have been selected as the starting basis for the review given their wide time span (2008 to 2024). The proceedings collectively count 790 publications.

The procedures of selecting the relevant publications have been conducted manually (i.e. by reading the relevant material) rather than through automatic keyword filtering as outlined in [136]. The manual approach has been preferred due to the pervasive yet context-dependent nature of complexity: rigid a priori criteria might have excluded relevant works. This process has been deliberately inclusive, and papers were retained if they exhibited any engagement with the representation complex issues, whether in terms of theoretical discussion, of implementation of technical solutions for a related scope, of evaluation or anyway analysis of existing artefacts, of socio-cultural contexts surrounding IDNs for representing complexity, or of any combination of the previous.

The ICIDS proceedings underwent a first selection based on titles, discarding all papers that clearly did not pertain to the representation of complexity (e.g., papers narrowly focused on technical solutions not related to complex issues; papers focused on theoretical aspects unrelated to representation affordances, etc.). A second selection process has been conducted by reading abstracts and keywords to select publications that address or implicitly engage with the representation of complex issues. These two initial filters provided 73 publications.

Following the guidelines by [136], the sources cited by these 73 publications were manually scrutinised to detect additional related literature, following the same 2-steps procedure outlined above. This provided 46 additional publications (3 books, 43 articles). To this list were added works related to the COST Action INDCOR (2 books, 1 white paper, 4 articles), as anticipated. The final corpus on which this review is based counts 126 publications (5 books, 117 articles, and 4 white papers) between 1997 and 2025.

These publications have been analysed following the procedure established in [136]: an initial coding for the corpus has been identified by examining 15 of the identified publications (10 articles, 4 white papers, 1 book). Excerpts have been extracted from these publications to identify patterns through the procedure of "open coding" [136]. This initial coding has guided analysis of the rest of the corpus, as provided by the methodology employed. After extracting excerpts and iteratively completing the open coding of the entire corpus, axial coding [136] provided clusters of data and their relationships. Through selective coding [136], 10 macro categories and a number of sub-categories emerged.

As the reader will notice, the identified thematic categories at times follow well-known typologies developed in theoretical discussions (e.g., Murray's four properties of digital media [81]) but at other times divert from them, depending on how they are discussed in the reviewed literature.

This article presents and discusses the result of the review, highlighting the most advocated affordances of IDN for representing complexity, but also unearthing under-explored directions of research and contrasting voices in the academic discourse on the topic.

3 Results

A few general trends can be identified in the reviewed corpus of publications. First, and perhaps unsurprisingly, the technical solutions discussed closely mirror broader advancements in digital technologies. Over time, this has led to the adoption of increasingly sophisticated prototypes, improved graphics, more credible adaptive agents and scenarios, as well as the use of virtual and augmented reality and, more recently, generative artificial intelligence. In this way, IDN research has continuously evolved in parallel with technological progress, ensuring that IDNs remain at the forefront of innovation.

Secondly, the number of publications examining IDNs as tools for representing complex issues of various kinds shows a clear upward trend [1]. This growth can be attributed, at least in part, to advances in the underlying digital technologies and to the gradual consolidation of IDN studies as an academic field in its own right, which was at its (contested) origins in the late '90s and which is now gaining increasing recognition. Additional contextual factors are likely to have contributed as well, such as a broader societal concern with and awareness of global challenges. For instance, a marked increase in publications on IDN representations of complex issues can be observed in the aftermath of the Covid-19 outbreak. It is plausible to suggest that such a complex, divisive, polarising, and cognitively unmanageable situation such as a pandemic highlighted the limitations of established media in capturing complexity, thereby prompting researchers to explore alternative representational forms.

Lastly, two considerable shortages can be identified in the literature, namely the relatively low number of empirical studies evaluating the effectiveness of IDNs as representations of complexity, and the (related) considerable deficiency in frameworks for evaluating IDN efficacy - notwithstanding some notable exceptions (e.g. [9, 50, 101, 105]). These gaps will be highlighted more in details in the next pages as relevant.

Additional specific observations can be drawn. In the upcoming pages, I will discuss them following the 10 identified thematic clusters. These themes will be presented in

order of frequency of appearance (or alphabetically when the frequence is equal), with the exception of the caveats, that are left at the end.

3.1 Participation

The participatory property of digital media [81] can be broadly defined as the possibility given to interactors to have a part in the representation, and it constitutes one of the distinguishing traits of interactive media and IDNs. Participation is the affordance of IDN for accessibly representing complexity appearing most often in the reviewed corpus (56 over 126 reviewed publications, 44.4%) (Table 1).

Table 1. "Participation" cluster summary.

Affordance	Publications	Number
Participation	[4, 6, 9, 11, 12, 16, 22, 23, 29, 30, 32–36, 38, 43, 44, 46, 48, 49, 51, 56, 59, 62–72, 79, 84, 85, 88–92, 94, 100, 104, 110, 112, 113, 115, 117, 128–131, 137]	56
Consequences of choices	[4, 22, 32, 46, 48, 62–65, 68, 70–72, 90, 91, 94, 104, 115, 117, 131]	20
Different points of view	[6, 12, 16, 23, 29, 32, 38, 43, 48, 59, 67, 71, 89, 94, 104, 110, 130]	17
Dramatic agency	[9, 12, 46, 48, 66, 67, 71, 72, 88, 100, 104, 115]	11
Safely investigating options	[4, 23, 33, 49, 56, 72, 94, 104, 112]	9
Immersion and empathy	[29, 30, 44, 51, 69, 112, 128]	7
Spatial exploration	[4, 22, 46, 71, 88, 94, 100]	7

Participation is frequently discussed for its ability of making visible the consequences of choices, which also entails the possibility for interactors of safely investigating alternatives and their potential outcomes without real-world repercussions. Participation is also widely discussed in relation to perspective-taking, as it enables interactors to adopt alternative points of view on the represented phenomena. Furthermore, several publications discuss dramatic agency, or the power of shaping the narrative development, as a considerable facilitator of the representation of complex issues. Researchers further highlight that participation facilitates freedom of exploration, and immersion and empathy with characters, dimensions considered effective for the accessible representation of complexity.

Notwithstanding the widespread consideration of participation as a main affordance of IDNs for representing complexity, doubts arise on its actual usefulness to a closer investigation. For instance, the empirical studies conducted in [110, 129, 137], found that variation in interactivity levels correspond to no significant variation in persuasion and learning regarding the information represented, respectively. However, [110] shows that

a more organic embedding of learning content into the participatory process of IDNs does positively affect transformative learning (although not cognitive learning). This organic embedding is achieved by making choices meaningful and actually impactful for the narrative (through dramatic agency [81]), or for the representation more in general [11, 67]. It is crucial that this impact is clear and visible to the interactor [129]. Making interactivity more directly related to the content of the representation also avoids a ludo-narrative detachment that is detrimental to the effectiveness of the representation. Exceptions to this general guideline exist, but they must be carefully designed for specific purposes [1, 38] (see also section "3.10 Caveats").

While perspective-taking is often discussed as having a positive impact on the understanding of complex topics, too, the question of how to actually achieve meaningful perspective-taking is often untapped. Sometimes, it is assumed that embodying characters equals taking their perspective through empathy. [106] discusses the issues presented by this assumption and proposes a more considerate and inclusive approach. On the other hand, [59] suggests that the interactor is not actually put in the shoes of the character but rather is asked to *imagine what it would be like* to be in the shoes of the character. This imaginative process can significantly shift the interactor's perspective and may even undermine the meaningful representation of a phenomenon. For instance, an able-bodied interactor is unlikely to fully grasp the challenges faced by a person with a disability, even when mediated through an IDN, which could result in a partial trivialisation or dismissal of the issue. For this reason, perspective-taking has to be carefully managed (see "3.10 Caveats"). Furthermore, while researchers argues that interactors usually take responsibility for their choices in an IDN, [113] empirically found that operating choices did not increase the perception of accountability for one's decision: as the interactors are "imagining" to be in the characters' shoes, in a safe environment that cannot produce real consequences, perceived accountability is actually minimised. Whether accountability is actually beneficial to the accessible representation of complexity remains an open question.

Furthermore, participation is discussed as able to emotionally involve interactors, which is considered useful to avoid detachment from the represented issue [128]. However, emotional investment can lower critical thinking and rational awareness [27, 122], a phenomenon that can be mis-designed or even misused (see also sections "3.5 Narrative" and "3.10 Caveats").

3.2 Model Complexity

Providing a simplified representation of a complex phenomenon in order to analyse it, explain it, or lay bare in a more accessible way its behaviour is a further discussed affordance of IDNs (see the definition of "model" in [40]). The affordance of modelling complexity is cited in 54 of the 126 publications (42.9%) (Table 2).

The modelling of complexity is achieved in several ways according to the reviewed literature. These include three of the four properties of digital media [81], i.e.: the spatial property, or the ability to represent a navigable space; the encyclopaedic property, or the ability to include a wealth of details, data, and different semiotic modes; and the procedural property, or the ability to execute a set of rules. The ability to include multiple perspectives within a single artifact, too, is often discussed as one of the ways for IDNs

Table 2. "Model complexity" cluster summary.

Affordance	Publications	Number
Model complexity	[4, 6, 8, 9, 11–13, 15, 27, 29, 31, 32, 38, 43–47, 52, 56, 61–65, 67–69, 71, 72, 80–83, 86, 88, 90–92, 94, 103, 110, 112, 115, 117, 119, 122, 123, 127, 130–132, 138, 139]	54
Multiperspectivity	[4, 6, 11–13, 32, 45, 47, 52, 62–65, 68, 71, 72, 82, 88, 90–92, 110, 112, 115, 119, 122, 130, 131]	28
Procedural property	[44, 61, 71, 82, 83, 86, 88, 127, 138]	9
Spatial property	[6, 43, 86, 123, 139]	5
Encyclopedic property	[32, 62, 90, 130]	4
Also achieves: authentic representation	[8, 11, 38, 69, 71, 80, 88, 90, 115]	9

to model complexity. Several publications also mention that by modelling complexity IDNs can provide a more authentic view over the represented topic.

Multiperspectivity (sometimes termed plurivocality or pluralism [52], and sometimes discussed as itself enabled by participation – see "3.1 Participation") is explored in the literature as a way to model complexity by showing different points of view on the phenomenon at hand. However, [130] empirically found that while multiple perspectives might achieve enhanced realism, they do not necessarily entail deeper understanding of the subject matter for the interactor, as much depends on the design of the IDN and on the resulting user experience. More broadly, researchers mention that a strict adherence to verisimilitude is not a must, and sometimes fiction is useful in representing complex issues even if it means deviating from scientific accuracy [11, 31, 49]. Sometimes, fictional elements are even seen as necessary to tie together the experience into a coherent whole [131].

While possibly achieving a more authentic, realistic, or accessible representation, the modelling of complexity can also have severe ethical implications. As a model is a simplification of the phenomenon of reference [40], the ways in which such simplification is operated can present a distorted view of reality that might misguide the interactors' understanding. Therefore, it is paramount to operate a careful modelling, and to double-check the result with experts of the modelled phenomenon and with interested parties (see "3.10 Caveats").

3.3 Increased Engagement and Motivation

IDNs are discussed as able of providing a more engaging experience for their audiences, and thus to foster their motivation to deal with the material presented and to invest time in its understanding. This affordance appears in 41 of the 126 publications (32.5%) (Table 3).

The increase in engagement and motivation has been connected to various aspects of IDNs, including the engrossing power of narrative (which is itself linked to empathic

Table 3. "Increased engagement and motivation" cluster summary.

Affordance	Publications	Number
Increased engagement and motivation	[2, 21, 24, 25, 33–35, 37, 45, 47–49, 55, 56, 58, 59, 67, 72, 74, 77–79, 88, 92, 94–96, 99, 108, 113, 115, 120, 121, 123, 124, 128, 129, 132, 134, 135, 137]	41
Narrative	[24, 25, 47, 49, 56, 95, 123, 128]	8
Interactivity	[49, 124, 128, 129, 135, 137]	6
Game elements	[21, 25, 33, 74, 88]	5
Multimedia content	[33, 115, 128, 134, 135]	5
Interaction with physical artifacts	[2, 21]	2
Empathic attachment	[21, 128]	2
Novelty	[95, 121]	2
Entertainment aspect	[48]	1
Immersiveness	[49]	1

attachment), the possibility of interacting with the IDN artifact or with in-room objects (particularly in XR), and the multimedia, immersive, game-like, or entertainment aspects that sometimes characterise IDNs. This affordance often appears in evaluation questionnaires of IDN representations of complexity, with outcomes confirming IDNs power of enticing interactors (see e.g. [135]).

It might be possible to argue that the idea behind this affordance is relatively commonsensical: the employment of new technologies and methods in teaching or in information dissemination can be considered inherently appealing *per se*. [95] and [121] indeed connect the detected increase in engagement and motivation to the "novelty effect" of new technologies and methods, but they also warn about potential resulting issues. Among these are how to obtain durable, sustainable, and scalable research outcomes, and how to measure the success of an IDN representation of complexity given that data might be biased by this novelty effect. These questions remain underexplored, yet addressing them could greatly enhance the long-term value of IDN research. Notwithstanding some exceptions ([95] and [121]), in the reviewed literature empirical evaluations in this direction are scarce, too.

This is not to say that it is not possible to leverage on the increased engagement and motivation – and on the novelty effect – and exploit them for good. In fact, empirical studies detect a positive relationship between increased motivation and learning outcomes of an educational experience [77, 95, 108, 113, 120, 134]. At the same time, the novelty effect is discussed as able to support initial engagement [67] or even unintentional learning [55, 74]. Notwithstanding these findings, the central challenge remains to identify the conditions under which engagement fosters learning rather than becoming an end in itself [124], while also ensuring that creators and researchers are not compelled to prioritise motivation at any cost [45].

Furthermore, future studies should be mindful that an emphasis on engagement, fun, or spectacularisation in IDNs may divert the (researchers' or creators') attention away from other factors that can influence the accessible representation of complexity [39, 45] (see also "3.10 Caveats"). The reviewed literature already shows signs of this issue, as increased engagement and motivation are occasionally advanced as sufficient grounds for pursuing and IDN-based representation of complexity. Such cases are more common in publications focused primarily on the design of digital artefacts.

It should be noted that empirical findings challenge some of the theoretical assumptions about engagement and motivation. While narrative is generally considered a major factor in enticing interactors, [93] showed that children were more engaged by game-like than story-driven content, with learning outcomes nearly doubling in the game-based version. Yet, choices in the design of the narrative and of the game aspects, as well as contextual factors like experiment design and participants' age, can strongly affect these results. Exploring these factors could considerably advance our knowledge on how to effectively represent complexity through IDNs. Additionally, gamified and narrativized approaches have been shown as able to reinforce each other if well integrated [110] (see also "3.1 Participation").

3.4 Multi-User Capacity

IDNs can connect multiple users in various ways. This includes not only the capability of incorporating multiplayer functionalities, but also the possibility to be employed in social settings in order to engage interactors in shared activities contextual to the IDN itself, like dialogue or co-creation. This affordance is considered by 29 of the 126 reviewed publications (23%) (Table 4).

Table 4. "Multi-user capacity" cluster summary.

Affordance	Publications	Number
Multi-user capacity	[5, 16, 26, 32–34, 49, 52, 57, 64, 67, 73, 75–78, 94, 97, 99, 102, 111, 112, 115, 117, 121, 125, 126, 132, 138]	29
Discussion starter	[5, 16, 32, 49, 57, 64, 77, 94, 99, 111, 121, 125, 132]	13
Multiplayer features	[33, 78, 117, 126, 138]	5
Co-creation of content	[73, 75, 76, 97, 115]	5

Researchers have discussed the value of IDNs as starting points of discussion in settings such as classes, workshops, or museum visits. A number of publications consider the multiplayer features built within an IDN artifact as a great facilitator of complexity representation, too, particularly through interpersonal exchanges. Some works also propose ways to allow users to contribute to the representation of complexity with their own content. An interesting related approach is using an IDN to simulate interpersonal interaction without actually affording it, as proposed by [128].

Interpersonal interaction allows enriching exchanges. Several works (e.g., [33, 94]) regard fostering interpersonal discussion as useful for making complexity accessible

both directly (e.g. by collecting multiple perspectives on a topic - see the section on Modelling complexity) and indirectly (e.g., by preventing polarisations that are detrimental to the nuanced thinking necessary for understanding complexity). The use of IDNs for representing complex issues in conjunction with in-room instructors and exercises has been identified by the OSCE Office for Democratic Institutions and Human Rights as the best strategy to maximize learning outcomes for their capacity building practices, outweighing both the IDN and the in-room exercises in isolation, although no data are available to support this finding.

Evaluations along these lines are indeed missing in the reviewed literature, and with them an inventory of effective ways to support interpersonal interaction both within an IDN and outside of it, e.g. in classrooms, online forums, or other social contexts.

3.5 Narrative

Narrative is one of the defining terms of IDNs and as such it always appears in the reviewed literature. However, often narrative is overlooked in its power to facilitate the comprehensible representation of complex issues, or it is simply considered a way to maintain engagement (see "3.3 Increase engagement and motivation"). Only in some cases narrative is discussed as itself able to facilitate the representation of complexity (21 of the 126 publications – 16.6%) (Table 5).

Table 5. "Narrative" cluster summary.

Affordance	Publications	Number
Narrative	[4, 9, 12, 27–29, 35, 44, 48, 66, 67, 72, 78, 88, 91, 104, 115, 120, 122, 128, 140]	21
Emotional attachment	[4, 28, 35, 72, 88, 104, 115, 120, 122, 128, 140]	11
Situate learning	[28, 78, 88, 91]	4

Narrative is discussed in mainly two ways in the reviewed literature. One regards narrative as a meaningful sequence of events (e.g. [29]) and therefore aligns more with classical views of narratology, from Aristotle [3] to Genette [41]; the other considers it a *forma mentis* and a primary thinking function of the human brain (e.g. [4, 45]), in line with postclassical views of narratology, often referring to Bruner [19, 20] Ricoeur [98], Gerrig [42], or Herman [53].

Narratives are discussed as tools to emotionally connect the audience to the represented phenomenon, with sometimes the declared scope of getting the message across more easily by being more personally touching (e.g. in [104, 122, 128, 140]). This use of narrative can present considerable ethical concerns, as emotional attachment can impede or even disconnect the interactors' analytical thinking and critical stance over a topic [88], which make them more vulnerable to manipulation. Emotional involvement can also become overwhelming for interactors themselves, for instance when representing violence or human rights violations. Experimenting with different points of view and

focalisations, with different types of narrators, different narration times, with various configurations of story and discourse, or with different formal organisations of the narrative, could provide valuable insights into how to exploit the power of narrative while avoiding undesirable side effects.

A further usefulness of narrative identified in the reviewed literature is in providing a context in which to situate the representation of complex issues [28, 78]. This arguably supports the credibility of the modelled complexity (see "3.2 Model complexity") and facilitates the comprehension of diachronic developments. In these regards, narrativization through linear causality should be avoided as much as possible, to minimise improper structuring of thinking (see "3.8 Structuring thinking").

3.6 Multimodality

IDNs can make use of multiple semiotic modes (audio, visuals, haptics). This multimodality – sometimes termed multimediality – is usually seen as one of the main characteristics of the medium, but its usefulness in representing complexity appears only in 20 of the 126 reviewed publications (15.9%) (Table 6).

Table 6. "Multimodality" cluster summary.

Affordance	Publications	Number
Multimodality	[2, 4, 6, 13, 15, 21, 25, 29, 31, 33, 43, 52, 64, 67, 86, 96, 99, 115, 117, 128]	20
Include data	[52, 64, 67, 117]	4
Xr	[2, 6, 21, 25]	4

Multimodality is mainly discussed in its own capacity as facilitating the representation of complexity. Nonetheless, two related affordances are also discussed: the IDN ability to seamlessly include and present real (and even live) data, and their ability to resort to reality as a somehow additional semiotic mode through extended reality.

The main pattern regarding this affordance that emerges literature review is that it is often unclear how multimodality in its own capacity actually supports the representation of complexity. Usually, it is called into question as "enhancing the experience" or "making it more immersive", which relates to the increased engagement and motivation (see "3.3 Increase engagement and motivation"). In particular cases, multimodality is considered helpful when the represented phenomenon is itself multimodal (e.g., for cultural heritage [13], or for simulating a dialogical exchange [128]). [15] presents neurocognitive evidence connecting multimodality to strategies of cognitive economy that facilitate the processing of information, but it admits the little empirical evidence for the claims. A more in-depth understanding of how and under which circumstances multimodality can be harnessed to accessibly represent complex issues is critically needed, and it could benefit from an interdisciplinary exchange with information design research.

A further gap identified in the reviewed corpus concerns the underexplored informational potential of diverse semiotic modes in the representation of complexity. Establishing a typology of how distinct modes contribute to complexity representation in IDNs could constitute a valuable resource for practitioners. Nevertheless, such an endeavour should be approached with the understanding that the overall meaning of an IDN is an emergent, more-than-combinatorial construct; and that the simple juxtaposition of modes risks failing to produce the intended outcomes [14, 15].

3.7 Adaptability

The procedural and participatory properties of digital media make them able to change in relation to mutated conditions [81], allowing a considerable adaptability. This allows IDN creators to tailor experiences dynamically, while non-interactive media are forced to employ a "one experience fits all" approach [59]. Adaptability is discussed in 19 publications of the 126 reviewed (15.1%) (Table 7).

Table 7. "Adaptability" cluster summary.

Affordance	Publications	Number
Adaptability	[4, 11, 25, 35, 54, 59, 60, 62, 64, 67, 78, 88, 90, 94, 114, 117, 122, 126, 133]	19
To individual interests	[11, 78, 88, 94]	4
To individual values	[35, 88]	2
To match competence	[62, 126]	2
To community interests	[35]	1

According to the reviewed literature, the adaptability of IDNs can be used to show the relevance of the represented topic for the specific interests of the target interactor or community (see also the ability to include data in "3.6 Multimodality"). This allows IDNs to support the cognitively requiring effort of understanding a complex topic by leveraging the internal motivation of the individual audience member (see "3.3 Increased engagement and motivation"). Similarly, IDNs are described as capable of adjusting to the competence level of each interactor, tailoring their content to engage the audience in a topic without being overly simplistic (and thus boring) or too complex (and therefore overwhelming). This helps aligning with interactors' expectations in terms of content, but it also allows a more efficient use of the time dedicated to the experience. For example, it makes it possible to skip introductory explanations for an expert audience. Adaptability is considered particularly useful during the onboarding phase of the IDN [94], but testing the impact of its widespread use in IDNs for representing complexity would considerably advance the knowledge in the field.

Researchers also mention the alignment with the personal socio-cultural values of the interactor as an advantage of the adaptability of IDNs. While this might allow improved audience engagement, it also presents ethical concerns as it can reinforce individual

viewpoints and possibly extremise polarisation. As IDNs are carrier of values themselves [45] it is the designer's responsibility for these values to be ethically represented and treated with the appropriate care [10, 39, 62] (see also "3.10 Caveats").

3.8 Structuring Thinking

The ability of IDNs to structure thinking is a further factor in their ability to represent complex issues. This refers to the capability of guiding thinking and learning towards specific directions or of prompting specific thinking modes. Structuring thinking is examined in 16 of the 126 works (12.7%) (Table 8).

Table 8. "Structuring thinking" cluster summary.

Affordance	Publications	Number
Structure thinking	[8, 15, 44, 52, 64, 65, 67, 70, 88, 90, 92, 94, 96, 112, 113, 131]	16
Systemic thinking	[15, 64, 65, 67, 88, 90]	6
Critical reasoning	[67, 70, 88, 92, 96, 112]	6
Holistic view	[8, 15, 131]	3
Scaffold learning	[94, 113]	2
Awareness of additional paths	[8, 65]	2

Several are the shapes that structuring thinking can take. These include scaffolding learning, facilitating systemic thinking, prompting critical reasoning, providing a holistic view of the phenomenon of interest, and making the interactor aware of possible alternative developments.

The ability of IDNs to structure thinking is often connected to the creation of wide possibility spaces for interaction [17] and narrative development [67], which are then restricted through design choices and narrative vectors [44]. In this way, IDNs can at the same time present a holistic view over the represented phenomenon and delve deeper into one strand, while also making the interactor aware of the presence of alternative paths (even without exploring them individually). This structuring is based on the modelling of complexity [67, 94] (see "3.2 Model complexity").

By reacting differently to different choices (see "3.1 Participation"), IDNs can guide the interactor's thinking with a soft touch, providing a scaffold on which the understanding of the represented phenomenon can take shape, arguably activating critical reasoning and fostering systemic thinking. However, this guiding with a soft touch entails a scarce awareness from the interactor's side, which might have ethical implications (see "3.10 Caveats"). On the other hand, some researchers discuss exactly the breaking of the scaffolding or of the narrative layer as a way to spark critical thinking [1, 112].

Determining whether IDNs can effectively structure thinking remains especially difficult to establish empirically, particularly concerning long-term impacts on modes of thought (like systemic thinking), but research in these directions could produce extremely insightful results.

3.9 Replayability

The entirety of the IDN content is often not exhausted after one playthrough. A replay is generally possible and often even encouraged. For instance, when interactors are given the possibility to choose between different options, they can replay the same IDN artifact and take different routes to discover where they would lead. Replayability appears in 14 of the 126 publications surveyed (11.1%) (Table 9).

Table 9. "Replayability" cluster summary.

Affordance	Publications	Number
Replayability	[4, 8, 11, 32, 38, 61, 63–65, 68, 90, 91, 104, 115]	14
Different outcomes	[8, 32, 63, 64, 68, 91, 104, 115]	8
Different perspectives	[32, 38, 64, 104]	4

The possibility of replaying IDNs is generally deemed useful for their accessible representation of complexity as it helps understand the modelled complexity (see "3.2 Model complexity"). Replay is discussed in relation to two opportunities it gives: the opportunity of seeing mutated outcomes in relation to mutated choices (which connects to the exploration of choices and outcomes - see "3.1 Participation"), and the opportunity of seeing different perspectives over the represented topic (which connects to multiperspectivity - see "3.2 Model complexity").

In order for the affordance of replay to work optimally, the IDN should not only *allow* replay, but *support* and *encourage* replay through its design [67]. However, it does not currently exist in the reviewed literature a set of guidelines on how to support and encourage replay. [67] suggests making interactors aware that additional information is available beyond what they encounter in an initial run, and disclosing new information at each replay, as ways to encourage repeated engagement. Other methods could be found in further literature. A tool for analysing the effectiveness in terms of narrative consistency of replays exists [9], but actual empirical studies of the effectiveness of replays for the representation of complexity are currently lacking.

3.10 Caveats

The community of researchers in the field has also highlighted important caveats that must be taken into account when representing complex issues through IDNs. Caveats find their way in 36 of the 126 reviewed publications (28.6%) (Table 10).

Two caveats appear in particular, namely an ethical concern that is often considered inherent in the IDN representation of complex issues, and the necessity to channel the interactor's attention in the right direction to avoid meaningless or unproductive engagement.

The ethical concerns surrounding the use of IDNs for representing complexity reflect a growing recognition within the community that such persuasive representations can be employed with both positive and negative intentions. For this reason, researchers are

Table 10. "Caveats" cluster summary.

Affordance	Publications	Number
Caveats	[1, 6, 7, 10–12, 18, 31, 38, 39, 44, 48, 62, 72, 79, 86, 87, 90, 91, 93–95, 103, 104, 106, 107, 109, 110, 115–118, 121, 122, 129, 131]	36
Ethical concerns	[10, 18, 38, 39, 48, 62, 93, 103, 107, 109, 115–118]	14
Managing the experience	[1, 6, 11, 72, 86, 87, 90, 91, 94, 95, 104, 110, 121, 122]	14

progressively highlighting the potential ethical concerns connected to IDN representation, to guide designers towards avoiding malpractices. Several ongoing attempts to define IDN ethical frameworks exist (e.g. [10, 39, 62, 107]). As this review highlights, any feature of IDNs that can lower the critical attention of the interactor (e.g., the use of narrative as an emotional driver, the implicit dynamics of a model of complexity, or the polarisation that might come from the reinforcement of personal values) is potentially problematic and must be treated with appropriate care. In addition, IDNs themselves must be as unbiased as possible – or their biases must be as visible as possible [67]. To achieve this, scholars propose to involve the communities interested by the represented phenomenon and experts of the phenomenon itself in the IDN design phase [10, 39, 62, 107].

It is also considered crucial to ensure that the interactors engage with the presented material as intended. The user experience of an IDN must highlight the important aspects and underemphasize the irrelevant ones. For instance, the gamified aspects of IDNs can help foster engagement but must be designed in a way that does not shift the interactors' attention away from the point of the representation [12]. The scarcity of evaluation studies and frameworks in the reviewed literature makes it difficult to provide generalisable guidelines on how to effectively represent complexity through IDNs, not least because the process of creating an IDN experience has to considers a vast number of factors [15].

4 Conclusions

This article presents a review of the literature on the affordances offered by IDNs for the accessible representation of complexity. From the analysis of 126 publications, ten macro-themes were identified. These themes are examined in terms of their implications for accessible complexity representation through IDNs and, where relevant, further subdivided into sub-topics. Cross-references between categories are also highlighted, illustrating intersections among different affordances and findings—some mutually reinforcing, others generating tensions that further research will need to address. In addition, the review identifies gaps in the existing literature and outlines promising directions for future research.

On the outset of this work, I should note that while digital media might be seen as spaces of globalising homogenization, individual creativity can still counter these trends. Often, digital media appear in global platforms and are based on tools that are similar for all cultures. This risks to reinforce cultural hegemonies while silencing minorities.

However, IDNs can "on the one hand, build on local and less known traditions and modes of expression, maintaining them in a dynamic cycle of transmission, and on the other hand, take advantage of the flexibility of the technology to remix, combine, rethink, and revive them, including through encounters with other traditions and modes of expression" [18]. Supporting the creative and ethical development of good representations of complex issues through IDNs is the hope of all publications that have been discussed here, and of this review, too.

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