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The potential of comics in science communication

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Abstract

Visual narratives, such as comics and animations, are becoming increasingly popular as a tool for science education and communication. Combining the benefits of visualization with powerful metaphors and character-driven narratives, comics have the potential to make scientific subjects more accessible and engaging for a wider audience. While many authors have experimented with this medium, empirical research on the effects of visual narratives in science communication remains scarce. This review summarizes the available evidence across disciplines, highlighting the cognitive mechanisms that may underlie the effects of visual narratives.

Keywords

Public engagement with science and technology; Science communication: theory and models; Visual communication

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Introduction

Science and engineering affect most aspects of our lives, making public understanding of science a priority for any democratic society. However, factual knowledge and reported interest in science and technology remain relatively low amongst the public [NSF, 2016] and the internet is increasingly reported as the main source for scientific information [NSF, 2016]. This is reflected by a proliferation of online platforms dedicated to science education and communication, which often rely on comics, animations and other visuals storytelling techniques to engage with their audience. Despite their popularity these kind of visual narratives aimed to the general public remain poorly studied in terms of their design and efficacy.

Both narrative and visual communication have been independently studied, but it is difficult to predict how their effects combine into visual narratives. While some scholars [McCloud, 1994; Sousanis, 2015] argued that the juxtaposition of words and pictures in comics achieve effects larger than the sum of its parts, it is not clear if combining storytelling and visualisation techniques is indeed more effective, from a communication perspective. Moreover, while comics have been studied as a tool for classroom education [Aleixo and Norris, 2010; Hosler and Boomer, 2011; Short, Randolph-Seng and McKenny, 2013; Spiegel et al., 2013; Weitkamp and Burnet, 2007], their application to the specific challenges of science communication remain largely unexplored. One of the reasons behind this scarcity of research is probably the lack of an accepted definition of what constitutes a 'comic'. As many authors have pointed out, while most comics share some unique recognizable features, they are also an extremely malleable medium which heavily borrow from other forms of visual communication, making any strict definition either too limiting or too porous [Cohn, 2013; Eisner, 1996; Groensteen, 2007; McCloud, 1994; Varnum and Gibbons, 2007]. For the scope of this essay, we will focus exclusively on the sub-genre of *science comics*, broadly defined by Tatalovic as "comics which have as one of their main aims to communicate science or to educate the reader about some non-fictional, scientific concept or theme" [Tatalovic, 2009] — although these 'aims' may not always be so clearly defined, as revealed by the study of Collver and Weitkamp (in this same issue). We will review qualitative and quantitative studies in the fields of education, psychology and cognitive science to explore how 'science comics' may affect the understanding, perception and engagement with science.

Current research on educational comics

In the past decades comics have emerged as an increasingly popular form of communication, able to engage readers of different age groups and cultural backgrounds. Despite some early resistance [North, 1940; Wertham, 1954], the potential of comics as an educational tool has always been recognized by teachers and psychologists alike [Sones, 1944]. From an educational perspective learning from comics may offer several advantages [Jee and Anggoro, 2012]. First of all, most comics are built on the integration of text and pictures, which has been highlighted by Mayer and colleagues as a guiding principle of textbook illustrations [Mayer and Gallini, 1990; Mayer et al., 1995]. Moreover, the multimodal nature of comics [Sousanis, 2015] has the potential to increase readers engagement and facilitate learning [Eilam and Poyas, 2010]. Finally, comics often rely on the use of characters and situation models, which provide the basis for emotional attachment and self-reference, which can also facilitate the formation of new memories [Symons and Johnson, 1997].

Building on these intuitions, many teachers and educators have experimented with comics in their classroom, mostly to support students with low literacy skills [Aleixo and Norris, 2010; Crawford, 2004; Frey and Fisher, 2008; Schwarz, 2006]. However, comics adoption on a larger scale has been hindered by the 'perennial disorganisation' of educational comics [Rifas, 1991], which makes them extremely difficult to find, and the lack of clear models for how comics may be integrated in classroom practice [Lapp et al., 2011]. These issues are particularly relevant in the field of 'science comics' or 'graphic science'. Although many comics covering STEM subjects (Science, Technology, Engineering and Mathematics) have been published over the years [Tatalovic, 2009] and the format has become increasingly popular with online science communication platforms, the effects of comics on public engagement and perception of science remain poorly understood [Jee and Anggoro, 2012]. Most literature on science comics consists of qualitative reports, often by teachers and educators who are also the authors of the comics themselves, therefore providing a small and possibly biased sample [Toledo, Yangco and Espinosa, 2014; Kaptan and İzgi, 2014; Kennepohl and Roesky, 2008; Kim et al., 2016; Nagata, 1999; Naylor and Keogh, 1999; Rota and Izquierdo, 2003].

Some useful insights may be drawn from the field of Graphic Medicine [Czerwiec et al., 2015; Green and Myers, 2010] in which several empirical studies on the use of comics have been conducted. When compared to traditional text-based material, comics appear to significantly improve understanding and recollection of medical conditions [Diamond et al., 2016; Tekle-Haimanot et al., 2016], compliance with medical instructions [Delp and Jones, 1996; Tjiam et al., 2013], promote informed consent [Furuno and Sasajima, 2015; Kraft et al., 2016], facilitate interactions between patients and doctors [Anderson, Wescom and Carlos, 2016] and between patients and their communities [McNicol, 2014; McNicol, 2017], and generally improve community engagement with medical issues [Leung et al., 2014; Wang, Acevedo and Sadler, 2017]. However, the health-related information presented in these comics clearly has a different emotional value than generic scientific knowledge. Moreover, graphic medicine often deals with personal narratives, which better lend themselves to visualization, and are probably easier for the readers to identify with. Therefore, the promising effects observed in Graphic Medicine may not extend to science comics, which often deal with non-human, abstract subjects.

Few studies so far have attempted to quantify the effects of comics on the communication of science (see Table 1) The goals and settings of these studies were extremely heterogeneous: Hosler and Boomer used comics in place of textbook in evolutionary biology classes for non-majors (N=98) [Hosler and Boomer, 2011]. Spiegel and colleagues compared the effects of comics and essays in teaching concepts of virology to high-school students (N=873) [Spiegel et al., 2013]. While Short and colleagues, used comics as additional material in a class for business students (N=114) [Short, Randolph-Seng and McKenny, 2013]. Keeping in mind these important differences, it is interesting to note how all these studies have reached somewhat similar conclusions. The effects of comics and text were equivalent in terms of knowledge acquisition, but comics were consistently more effective at improving students engagement and motivation. Interestingly, these results are in line with anecdotal evidence from other studies, in which participants 'prefer' comic presentation, even if they do not necessarily improve their knowledge [Aleixo and Norris, 2010; Kim et al., 2016]. While these studies provide a promising first step toward the understanding of comics as a tool for science education, they all have the limitation of being conducted in classroom settings. Some of the authors rightfully observed that the effects of comics in the classroom may be biased by the novelty effects of comics [Hosler and Boomer, 2011], therefore it would be important for future studies to measure comic literacy and predispositions amongst readers [Caldwell, 2012; Tatalovic, 2009]. More importantly, the goals and settings of science communication are often different from those of classroom education. Therefore, more studies are required to understand how the effects of comics may extend beyond the classroom, to informal learning settings, with more diverse audiences (both in terms of age, ethnicity and motivations) and with the goal of public engagement, rather than education [Meyer, 2016]. Indeed, the effects of comics may be equivalent to text when readers are required to memorize the material (regardless of the format) but comics could prove to be more effective at engaging occasional readers. This seems a particularly promising application for comics, considering that the few existing studies revealed that students with no prior knowledge of the subject were those who mostly benefited from their use [Hosler and Boomer, 2011; Spiegel et al., 2013] and the suggestion that comics "may enable a wider audience of non-specialists individuals, who do not typically seek out science information, to engage with science-related topics, thus fostering scientific literacy" [Spiegel et al., 2013].

Only two recent studies appear to have explicitly addressed the role of comics in science communication to the wider public. Amaral and colleagues collected feedback from 206 participants (age from 14 to 85 years old, 54.9% female) as part of a Portuguese governmental initiative aimed at improving public understanding of stem cell research [Amaral et al., 2015]. Unfortunately, the participation to the study was purely voluntary, therefore the sample was biased, and it involved exposure to a mixed repertoire of materials (including comics but also illustrated texts, newspaper articles and posters). Although it is difficult to draw any firm conclusions from such studies, it is interesting to note that comics were rated as the most effective material by 46% of participants (followed by illustrated texts 21.5%). Another empirical study was conduced by Lin and colleagues on 194 participants in the Taiwan region (age from 20 to 65 years old, 45% female), which investigated the effects of a comic book on knowledge and attitudes toward nanotechnologies [Lin et al., 2015]. The study found that comics were not significantly more effective than text at improving understanding and attitude (although they were just as effective as text) but "more comic readers (83%) were interested in using their assigned media to learn more about nanotechnology than the text readers (71%)". Once again, the study seems to confirm the potential of comics for promoting public engagement with science. However, it is important to note that the comic used was 109-pages long, while the text booklet was only 10-pages, and the information contained was reported to be similar but not identical. In fact, the authors explicitly state that the comic was designed with the goal to "contextualize" the scientific information with real-life scenarios, and they speculate that the effect of the comic may be linked to emotional factors such as interest and enjoyment, which have been previously highlighted as key factors in science learning [Falk, Storksdieck and Dierking, 2007; Lin, Hong and Huang, 2012]. Therefore, while these pioneering studies provide encouraging results, more rigorous experimental designs are required to establish the true effects of science comics.

Another important aspect that most of these studies failed to address is the extreme variability of styles and formats within comics. As previously mentioned, the term 'comics' has been used as an umbrella term to refer to a wide range of different formats, spanning from newspaper strips to long-form graphic novels. The advent of web comics, which incorporate motion, sound and interactive elements, complicates the matter even further, blurring the boundaries with animations and videogames [McCloud, 2000]. Given this heterogeneity it would be a mistake to draw general conclusions from the existing studies. In fact, most of the initial research in educational comics focused on short strips or single panel cartoons [Toledo, Yangco and Espinosa, 2014; Kaptan and İzgi, 2014; Kim et al., 2016; Nagata, 1999; Naylor and Keogh, 1999] and their results may be ascribed to the general effects of visualisation, rather than comics *per se*. On the other end of the spectrum, the results of studies comparing graphic novels with textbooks or essays [Spiegel et al., 2013; Hosler and Boomer, 2011; Lin et al., 2015; Short, Randolph-Seng and McKenny, 2013] could be attributed to the narrative component of the graphic novel, compared to the expository structure of the textbook. Indeed, Hosler and Boomer express this concern when discussing their results: "Would embedding content in a prose story be as effective or is there something inherently motivating about comics that engage students?" [Hosler and Boomer, 2011]. In this regard, science comics may have more in common with other forms of visual narratives, such as animations and videogames, than single panel cartoons and comic strips (which even when concerning scientific subjects often have the main goal of humour, rather than education or communication).

For all these reasons, instead of treating comics as a separate well-defined genre, it may be more productive for future studies to ask what strategies do comics and other visual narrative have in common? How can we use these tools more effectively in the field of science communication? Following this approach, the study of science comics could benefit from research in the field of education, cognitive psychology, information design and literary studies, which already explored some of the fundamental elements of visual narratives.

Year	Authors	# participants	Age	Setting	Format	Control	Subject
1999	Naylor and Keogh	113	?	public	concept cartoons	NA	general science
1999	Nagata	22	?	classroom	manga strips	NA	biochemistry
2007	Weitkamp and Burnet	150	7-10	classroom	comic book	NA	chemistry
2011	Hosler and Boomer	98	?	classroom	comic book	texbook	biology
2013	Short Et Al.	114+139	?	classroom	comic book	texbook	economics
2013	Spiegel Et Al.	873	avg 15.3	classroom	comic book	text essay	virology
2014	Espinosa	78	14	classroom	concept cartoons	NA	enviromental science
2014	Kaptan and Izgi	60	?	classroom	concept cartoons	NA	general science
2015	Amaral Et Al.	206	14-85	public	mixed	NA	stem cells
2015	Lin and Lin	194	20-65	public	comic book	text booklet	nanotechnologies
2016	Kim Et Al.	215	6-27	classroom	comic book	no stimuli	human anatomy

Table 1. Empirical studies on science comics and relevant details.

Potential benefits of visual narratives

Visual design

Illustrations have always played an important role in scientific writing and communication. Over the centuries, early decorative illustrations evolved into highly formalized diagrams and data visualizations. These 'visual explanations' [Tufte, 1997] evolved an elaborate vocabulary of marks and symbols [Tversky, 2011] which reflect basic cognitive principles, such as space and events segmentation [Zacks, Tversky and Iyer, 2001]. Indeed, carefully designed scientific visualizations have been shown to improve both knowledge acquisition and problem solving skills [Carney and Levin, 2002; Kools et al., 2006; Levie and Lentz, 1982; Mayer and Gallini, 1990; Pastore, 2009]. However, when it comes to science communication, these visuals may not be particularly useful, as they often require high degrees of expertise in order to decipher the information contained. Visual narratives, such as comics, may offer a way to bridge this gap. Just like diagrams, info-graphics, and other forms of science visualizations, comics use words and pictures to convey information, however they also divide the information into panels [McCloud, 1994] which can facilitate the reading experience and highlight important information, such as parts and processes [Mayer and Gallini, 1990]. Furthermore, comics not only break down the information into more digestible units but can also reassemble them into meaningful compositions, through the process that Thierry Groensteen defined as 'braiding (*tressage*)' [Groensteen, 2007]. Indeed, the content of each panel acquires its meaning not only from its text and visual content but also from the trans-linear relationships with the surrounding panels and the overall page composition. Therefore, just like diagrams, comics can be used to "combine assorted images of real objects into concocted universes, showing all at once what has never been together" [Tufte, 1997]. As summarized by comic scholar and educator Nick Sousanis: "the spatial interplay of sequential and simultaneous, imbues comics with a dual nature — both tree-like, hierarchical and rhizomatic, interwoven in a single form" [Sousanis, 2015]. In other words, comics can be read linearly, panel by panel, but also lend themselves to non-linear explanations, encouraging the reader to constantly reassess earlier panels in the light of new information. Similarly, science often requires readers to make connections between multiple scales and domains of knowledge, not necessarily arranged in a hierarchical, linear order. In conclusion, while comics are often perceived as an easy and playful format, they may be exquisitely suited at presenting complex information in a rigorous yet accessible way. In this regard, it would be interesting to explore the application of comics patterns to data visualizations and other types of scientific visualization [Bach et al., 2016; Bach et al., 2017].

However, besides the design of the individual panel or page, comics are often defined by the sequential relationship between panels, so much that after long deliberations Scott McCloud embraced Eisner's definition of 'sequential art' for the medium [Eisner, 1996; McCloud, 1994]. The storytelling component is what mostly distinguishes comics from other forms of science visualization, and their use should be informed by the extensive research in narrative communication.

Narratives and characters

Storytelling is a universal form of communication which has been studied from several different perspectives [Chatman, 1980; Fisher, 1985; Gerrig, 1999; Oatley, 1999; Toolan, 1988]. Beyond the field of literary studies, in cognitive psychology narratives have been considered as a fundamental structure of knowledge [Bruner, 1986; Schank and Abelson, 1977], a model for memory acquisition [Zacks et al., 2007], a simulation of social experience [Mar and Oatley, 2008] and a powerful tool of persuasion [Green and Brock, 2000]. In contrast to traditional persuasion models, which require active cognitive elaboration [Petty and Cacioppo, 1986], narrative communication seems to rely on emotional mechanisms such as 'transportation' into fictional worlds [Gerrig, 1999; Green, 2004] and identification with characters [Slater, 1997]. Therefore, narratives have been proposed as a useful tool to address sensitive subjects, which may otherwise resist cognitive elaboration because of conflicting beliefs and/or lack of interest amongst the audience [Avraamidou and Osborne, 2009; Mazzocco et al., 2010; Slater and Rouner, 2002]. Moreover, because their cause-effect structure, narratives are intrinsically easier to remember than expository arguments [Dahlstrom, 2014; Graesser, Olde and Klettke, 2002] and the changes of beliefs induced by narratives appear to increase over time, the so-called 'sleeper effect' [Appel and Richter, 2007]. Finally, several studies show that these effects are resistant to various forms of manipulation [Appel and Richter, 2007; Green, 2004; Green and Brock, 2000]: unless the persuasive intent of a narrative is made explicit [Moyer-Gusé, 2008] or the message is subjected to an active scrutiny [Marsh, Meade and Roediger, 2003], narratives seem to be largely assimilated as 'facts' even when explicitly labelled as 'fiction' [Gerrig and Prentice, 1991; Gilbert, 1991; Green and Brock, 2000; Marsh, Meade and Roediger, 2003], and the message they carry can have long-lasting effects on the beliefs and behaviours of the reader.

Despite this mounting evidence, narratives are still rarely employed in scientific communication, which usually prefers to adopt an impersonal expository/argumentative structure [Bruner, 1986; Norris et al., 2005; Wellington and Osborne, 2001]. This is due to social traditions [Ziman, 2002] as well as ethical considerations, since the persuasive power of narratives can also lead to the spread of misinformation, with potentially harmful consequences [Dahlstrom and Ho, 2012]. Nonetheless, narrative explanations may be extremely valuable when it comes to communicating science to the general public [Negrete and Lartigue, 2004]. For example, when discussing issues of science policy or health communication, where personal and cultural values often prevent other forms of engagement [Dahlstrom, 2014]. Narratives may offer a way to overcome these barriers, by engaging readers on both a cognitive and affective level [Green and Brock, 2000; Hinyard and Kreuter, 2007]. Empirical research in this field remains scarce and the effects of narratives on health-related decision appear inconsistent [Winterbottom et al., 2008], but these discrepancies may be partially accounted by the variability in the format and the structure of narratives [Dahlstrom, 2015; Nan et al., 2015].

Once again, comics may be able to build upon this evidence, combining the effects of text narratives with those of scientific visualization. In this context it is important to distinguish between science comics that still rely heavily on the expository/argumentative structure of traditional scientific texts [Cunningham, 2013; Gonick, 1991; Hosler, 2011; Wicks, 2016], and others which include more dynamic, character-driven narratives [Farinella and Roš, 2013; Hosler, 2000; Weitkamp and Burnet, 2007]. In light of existing research, it would be interesting for future studies to compare these different approaches and investigate how the benefits of narrative communication may extend to visual narratives. In particular, given the central role that characters play in literary narratives, the potential of comics to create relatable characters should be carefully considered. In *Understanding Comics* McCloud highlights how some of the most popular comic characters are extremely simplified (i.e. 'cartoony') and to some extremes anthropomorphic animals or objects [McCloud, 1994]. McCloud argues that one of the reasons behind the popularity of these characters is that they exploit our innate *pareidolia* and allow a broader audience to identify with their stories, possibly increasing narrative transportation [Green and Brock, 2000], regardless of gender, age or ethnicity. This theory remains yet untested, but if confirmed could have important implications for the way we choose to visualize scientific information. The use of cartoon characters may enable readers to engage with subjects which are otherwise perceived as too abstract and detached from everyday life. This approach seems particularly promising in the light of findings [Hosler and Boomer, 2011; Spiegel et al., 2013] which suggested that comics are more effective at engaging readers that do not perceive themselves as having a 'science identity'. Fictional characters who do not conform with the current stereotype of scientists portrayed in films and other mediums [Kirby, 2011] may allow comics to reach broader and more diverse audiences, who do not necessarily engage with other forms of science communication.

Metaphors

One final aspect, common to many visual narratives, is the frequent use of metaphors. Far from being a mere literary device, metaphors have been recognized as an important cognitive tool, that allows us understand and interact with the world around us [Lakoff and Johnson, 1980; Gentner, 1983; Giora, 1999; Bowdle and Gentner, 2005]. As such, metaphors have been shown to be central in guiding scientific research [Brown, 2003; Hoffman, 1980; Leatherdale, 1974] and shaping the way scientists think and manipulate their object of study [Keller, 2009; Gentner and Grudin, 1985]. Metaphorical thinking can also play an important role in scientific education and communication [Collins and Gentner, 1983; Gentner and Gentner, 1982], providing mental models for invisible entities (e.g. the flow of electricity as the flow of water). Therefore, when writing about science for a general audience, metaphors can be useful to establish a common ground and allow readers to use their own domains of knowledge to approach new abstract concepts. However, the improper use of metaphors can also have counterproductive effects on our attitudes and behaviours toward science. For example, in health communication the choice of metaphors can have repercussions on the way we think of diseases [Sontag, 2001] and engage with preventive behaviour [Hauser and Schwarz, 2014]. Similarly, metaphoric framing has been shown to affect attitudes toward climate change [Flusberg, Matlock and Thibodeau, 2017].

This line of research could be particularly fruitful for comics, which have been described as an intrinsically metaphoric medium [Wolk, 2007]. Because everything is filtered through the eyes of the artist, comics and animations constantly require the reader to actively interpret their content. Even in more 'realistic' comics nothing is meant literally. Starting with the balloon, which has to be interpreted as speech, everything in a comic is essentially a metaphor or a symbol for real world entities [McCloud, 1994; Sousanis, 2015]. For this reason, comics and other visual narratives are able to seamlessly blend metaphors and explanations, without interrupting the flow of narration, which risks to disrupt transportation [Green and Brock, 2000]. Therefore, one of the main benefits of comics in science communication could be the mapping of abstract scientific concepts on to everyday objects and experiences, helping the public to engage with the material at a more personal level. At the same time, it is also important to consider the potential downsides of metaphoric framing [Hauser and Schwarz, 2014] and the risk of metaphors overextension [Baake, 2003; Leydesdorff and Hellsten, 2005].

Conclusions

The research reviewed here strongly suggests that comics have great potential for engaging wide and diverse audiences with STEM subjects. However, carefully designed empirical studies are required to understand the full effects of comics on learning, engagement and attitude toward science. Until now the creation and study of science comics has been driven by the intuition of few individual scientists, artists and educators (see Collver and Weitkamp, in this same issue), who often also use the material in their own practice. These pioneering efforts are commendable but their quality is extremely variable and the analysis of the results may lack objectivity. Moreover, existing studies have focused excessively on stereotypical perceptions of comics, such as their 'humorous' nature and their appeal to children (partly because many studies were conducted in the classroom). While interesting, this approach ignores the rich and diverse tradition of comics of the past 30 years, which have adopted a wide variety of registers and styles and successfully engaged audiences of all ages. Therefore, one of the main appeals of science comics is the potential to engage audiences who are currently underserved by other channels of science communication. With these considerations in mind, instead of treating comics as a unified genre, future research should aim to distil the fundamental components of visual narratives, and explore how each of them can benefit the communication of science. Three lines of investigation seem particularly promising:

Visual research. The comic page offers almost endless design possibilities, and many authors have praised the ability of comics to organise information in innovative ways [McCloud, 2000; Sousanis, 2015]. At the same time, a rich tradition of visual design already exists in the field of scientific visualization and illustration [Tufte, 1997; Tversky, 2014]. In order to facilitate the adoption of comics as a tool for science visualization, it is important to draw connections between these two fields. How can comics incorporate and elaborate the marks and symbols of scientific visualizations? Which strategies are unique to comics and how can they be benefit the communication of science?

Narrative research. Few of the existing studies explicitly address the role of storytelling in science comics, which has been often highlighted as a defining feature of the medium [McCloud, 1994; Wolk, 2007]. Given that narratives are also powerful tools of engagement and persuasion [Green and Brock, 2000] future studies on educational comics should compare the effects of comic books and graphic novels with equivalent text narratives, and explore the differences between visual narratives and visual explanations. On a related note, it is important to consider the role of fictional characters and the use of anthropomorphism in comics, which may facilitate readers engagement with scientific subjects but also potentially promote a false sense of understanding [Epley, Waytz and Cacioppo, 2007].

Metaphoric research. Comics make extensive use of symbols and metaphors [Wolk, 2007] especially in character design [McCloud, 1994]. At the same time, metaphors also play a major role in scientific research and communication [Brown, 2003], especially when dealing with abstract concepts outside of our sensory experience [Lakoff and Johnson, 1980]. Despite the potential downsides, such as distortion, simplification and overextension, the role of visual metaphors in making abstract scientific concepts more relatable to the wider public deserves further consideration [Baake, 2003]. What are the advantages/disadvantages of visual metaphors in science comics? What constitutes a ‘useful’ visual metaphor in science communication?

Finally, it would be interesting to compare different types of visual narratives. In particular, comics and animations are often associated in popular culture but they probably rely on different cognitive mechanisms. Animations are a passive medium, in which the flow of information is not controlled by the receiver and this may be a disadvantage from an educational perspective [Tversky, Morrison and Betrancourt, 2002; Yang, 2008]. Only a recent study directly compared comics and animation as medical informational aids, finding that animated videos (or slideshows with voice-over narration) are more effective than comics in explaining medical practices, although both were more effective than text alone [Kraft et al., 2016]. More studies of this kind will be required in order to determine which visual strategies are more effective, on which topics and for which audiences. Integrating this kind of empirical evidence with the insights of visual communicators, educators and cognitive scientists will facilitate the creation and adoption of comics for science communication, allowing the emerging field of 'graphic science' to reach its full potential.

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