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Alter egos: an exploration of the perspectives and identities of science comic creators

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Abstract

While academic interest in science comics has been growing in recent years, the creators of these materials remain understudied. This research aimed to explore the experiences and views of science comic creators through the lens of science communication. Qualitative, semi-structured interviews were conducted with 14 science comic creators. Interviewees felt that the visual, narrative, permanent, and approachable qualities of comics made them particularly adept at explaining science and bringing it to new audiences. Science comic creators often had complex identities, occupying an ambiguous territory between 'science' and 'art', but were otherwise unconcerned with strict definitions. They emphasised the importance of balance between entertaining and informing, striving to create an engaging visual narrative without overcrowding it with facts or compromising scientific accuracy. This balancing act, and how they negotiate it, sheds light on what it means to be a science communicator operating in the space between entertainment and information/education.

Keywords Science and technology, art and literature; Visual communication

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Introduction

In recent years, both comics about science and scholarly research on comics have increased — particularly concerning their value to education. However, little research has explored the creators of these comics. This study contributes to the emerging field of comics scholarship by providing insights into the perspectives and identities of science comic creators.

Background

The reputation of comics has undergone many permutations, from trivial child's play, to dangerous corruptor of society [Hajdu, 2009; Williams and Lyons, 2010; Van Lente and Dunlavey, 2012]. Yet despite its chequered past, the comics medium is slowly being recognised as a legitimate art form as it moves into the cultural mainstream [Fisher and Frey, 2011; Weitkamp and Burnet, 2007; Tatalovic, 2009] — to the point where comics have received literary recognition, with awards like the Pulitzer Prize [Spiegelman, 1992]. As the acceptance and celebration of comics

continues to grow, experts are increasingly advocating for their use in education [e.g. Mayer et al., 1996; Morrison, Bryan and Chilcoat, 2002; Cheesman, 2006; Hosler and Boomer, 2011; Kobayashi, 2011; Ardasheva et al., 2015], healthcare [e.g. Austin et al., 1995; Houts et al., 2006] and libraries [Meier, 2012].

Defining 'science comics'

Comics that have a scientific focus can be considered a sub-genre of the comics medium [Tatalovic, 2009]. Tatalovic defines *science comics* (or 'sci-comics', for short) as follows:

> 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, even if this means using fictional techniques and narratives to convey the non-fictional information. [p. 3]

This contrasts with comics that may reference science "but have no intention, agenda or responsibility to educate their readers in science" [Tatalovic, 2009, p. 3]. Interestingly, this defining characteristic of *intentionality* is only assumed, relying on an interpretation of the creator's 'agenda'. It is conceivable, for example, that a comic may contain a substantial amount of science content as a creative decision only, without having any specific educational goals in mind. Therefore, by using the creators themselves as primary sources, this study seeks to develop this definition of the sci-comics genre by refining its claims to authorial intent.

The scientific community has also begun to use comics to explain their research to other experts. For example, Caudron & Barral's study [2013] in the journal *Cell* includes a "graphical abstract" (in this case a comic), and Briscoe et al. [2013] conclude their study in *PLoS Genetics* with a two-page comic summarising their findings in light-hearted tone. It is clear that the medium of comics presents many intriguing possibilities for science communication. Yet while much of the research on the benefits of comics in general may apply to sci-comics, there is little research specific to the form. Indeed, the medium's potential to engage the public(s) more broadly with science has remained largely unexplored.

Comics as sci-art

By blending scientific subject matter with the visual art and narrative attributes of the comics medium, sci-comics serve as an exemplar of the coalescence of science and art known as 'Sci-Art'. As such, the genre is also a lens through which to view the broader discourse surrounding C.P. Snow's perennial, albeit hackneyed, notion of 'Two Cultures' [Snow, 1993]. Snow regarded the sciences and the arts as two monolithic and antipodal disciplines that increasingly do not — perhaps cannot — adequately communicate with each other [Snow, 1993; Barash, 2005].

For this reason, Jee and Anggoro [2012] maintain that collaboration between scientists and comic creators — a common arrangement in sci-comics [Tatalovic, 2009] — is essential to creating comics that are both scientifically valid and artistically meaningful. And if something is to be considered a good example of Sci-Art, many argue that it should be both [e.g. Sørensen Vaage, 2016; Hilton, 2014; Wilkinson and Weitkamp, 2016]. In order to best achieve this, Sci-Art collaborations

should be 'two-way partnerships' [Gewin, 2013] based on mutual trust and respect, where both parties approach the project on equal terms, valuing the knowledge, expertise, and contributions of the other [Metcalfe, Riedlinger and Pisarski, 2008; Kirby, Chambers and Macauley, 2015; Wilkinson and Weitkamp, 2016].

Unfortunately, this is not always the case. Sørensen Vaage [2016] and Kirby [2008b] lament the fact that it is more common for scientists to take on a mentoring role or adopt a position of superiority over their non-scientist collaborators. Specific to sci-comics, Wysocki and Thompson [2014] note that collaborations where "both science and comics [are] equally valued" are less prevalent than "models in which comics are a vehicle for the delivery of science". This seems to be part of a broader tendency within the scientific community to view the arts as a "handmaiden" or "instrument" of the sciences [Wilkinson and Weitkamp, 2016, p. 105].

Sci-art — whose identity?

Contrary to some claims that "studies exploring the effects of comics are scarce" [Lin et al., 2014, p. 276], it is evident that studies of effects in fact represent the bulk of the literature concerning comics — usually with a focus on readers in a formal education setting [e.g. Weitkamp and Burnet, 2007; Lo Iacono and de Paula, 2011; Jee and Anggoro, 2012]. A better understanding of how sci-comics arise would deepen our understanding of the form, and it would thus be useful to know more about *who* is making these comics and *why*. Some interviews with creators are available in the literature [e.g. Meier, 2012; Wysocki and Thompson, 2014], but there has been little attempt to draw them together and synthesise their views and experiences. This study addresses the need for further investigation into the genre of sci-comics in particular, from the perspectives of the creators themselves.

Gewin [2013] highlights the fact that there are an increasing number of scientists with "hybrid interests" in both science and art who seek ways to unify their interests. Equally, artists may choose to pursue longstanding interests in science within their artistic practice. This raises interesting questions about identity. While there is considerable research on young people's identities in relation to science [e.g. Archer et al., 2010; Hazari et al., 2010; Bøe, 2011], and an emerging literature around scientists' identities in relation to their performance of science communication [e.g. Davies and Horst, 2016; Horst, 2013; Ritchie and Schell, 2009], we have not identified any such work exploring specifically those — whether scientist, artist, or both — involved in forms of science communication that combine science with the arts (i.e. Sci-Art projects). To explore the identities of comic creators, we have drawn on the work of Stryker and Burke [p. 284 2000], who explore identity from the perspectives 'of the meanings that persons attach to the multiple roles they typically play in highly differentiated contemporary societies'. These meanings are internal, relating to the expectations individuals attach to particular roles, and prescribed by social structures. Social structures can be institutional (e.g. settings such as schools or museums) or more conceptual groupings (science or art), as in social identity theory as outlined by Stets and Burke [2000]. We also draw on Stets and Burke's [2009] division of identity into three facets: role identities (e.g. parent, sci-comic creator), social identities (category memberships such as political parties, educator or entertainer), and personal identities (e.g. ethics, characteristics that are used to make claims to uniqueness as

an individual, such as proximity to science). In the context of this research, we briefly explore role-based identities as a sci-comic creator, but focus our attention on the impacts of social structures (i.e. how sci-comics creators' construct their roles as educators, entertainers or science communicators) and the roles that science and art play in the construction of their personal identities. Thus, we explore the identities of comic creators pertaining to a) their personal identities in relation to science and arts, and b) their roles as science communicators — that is, to what extent do they identify with these different roles? We also consider identity through the lens of the 'two cultures', specifically examining how comic creators navigate a space between what has been argued to be two distinct communities.

Aims and objectives

In light of these considerations, this study aims to explore the identities and perspectives of those who create sci-comics –scientists (past and present) and comic artists/writers. As such, we ask four questions:

- Why create comics?
- What identities do sci-comic creators adopt?
- How do they negotiate the tensions between science and art?
- What are the intentions and priorities of sci-comic creators in relation to education, entertainment and science communication?

Methods

Research approach

This study used a qualitative, interpretavist approach where the knowledge, experiences, and points of view of sci-comic creators were the primary data source [Mason, 2002; Kvale and Brinkmann, 2009]. These data were collected by conducting semi-structured research interviews in order to gain a nuanced "insider view" [Blaikie, 2000, p. 115] of the experiences unique to each participant [Mason, 2002; Dowell and Weitkamp, 2011]. A preliminary interview guide was devised relevant to the study's aims and objectives (adapted from Pinto, Marçal and Vaz [2015], and Dowell and Weitkamp [2011]).

Participant recruitment

Interview participants were identified purposefully, and selected based on their involvement with one or more sci-comics projects [Creswell, 2014]. Based on the definition of 'science comics' discussed in the Literature Review, the study focused exclusively on participants who have worked on comics with (apparently) explicit rather than incidental science content.

In order to establish a pool of potential interviewees, a list of sci-comic titles/creators referenced in the literature [Meier, 2012; Tatalovic, 2009; Spiegel et al., 2013] was compiled, followed by internet searches in order to determine the most prominent or well-known examples of available materials (e.g. most

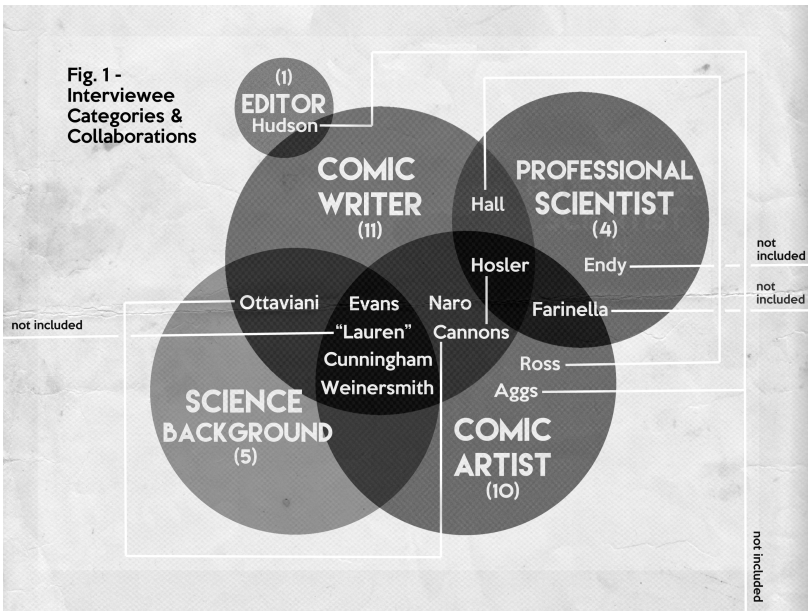

Figure 1. Interviewee Categories & Collaborations. This Venn diagram maps the identities of interviewees in relation to five comic production roles. White lines indicate instances of collaboration between participants (four of which were not included in this study).

frequently referenced, top-sellers, award-winners, high page views). 'Snowball' sampling was also employed in some cases, where participants would recommend other titles/creators known to them during the course of an interview [Mason, 2002]. This augmented the list of targeted, relevant interviewees by including the personal knowledge and connections of individuals involved in the field.

In an attempt to represent the diversity of the sci-comics genre, the study aimed to achieve breadth across several variables, including: a range of solo and collaborative roles (e.g. scientists, artists, writers, or a mixture); formats (e.g. graphic novels, webcomics, self-published/small press booklets, academic publications); sub-genres (e.g. biographical, historical, fiction/adventure); and scientific focus (e.g. biology, physics, astronomy). Single-frame cartoons and illustrated educational books were excluded since, while comic-like, they do not qualify as true comics [McCloud, 1993; Eisner, 2008; Tatalovic, 2009]. The study was also limited to English-language comics and participants. This left a pool of 21 potential interviewees all of whom were approached via email. Seven declined or did not respond, resulting in 14 interviewees. These can be grouped into five broad social roles (Figure 1): professional scientists (currently working as an academic researcher), those with a scientific background (e.g. science education/training, former professional scientist), comic artists, comic writers, and one editor/marketer. These groupingsare a useful way of orienting participants in relation to each other and provide a basis from which we can start to explore the identities of sci-comic creators.

Interviews

11 interviews were conducted via Skype and three via email correspondence. Skype interviews ranged from 47 minutes to 1 hour 35 minutes, and email

interviews were followed by one set of follow-up questions based on the initial responses. Skype interviews were audio-recorded and later transcribed verbatim. At the end of the interviews, all participants were also given the option of anonymity, following an explanation of how the information they provided would be used; all but one consented to having their statements attributed to them. This was done in accordance with ethics approval obtained from the University of the West of England Research Ethics Committee.

The interviews were semi-structured in that, while a list of pre-planned questions had been prepared, this was used as a guide from which to draw talking points, rather than a rigid script. This gave the researcher the flexibility to adapt the interview schedule based on the specifics of each interaction and gave interviewees some control over what they wanted to discuss and how they framed their responses. This method was chosen because the purpose of the interviews was to probe participants' *subjective* views on the process of creating sci-comics [Marshall and Rossman, 1999; Kvale and Brinkmann, 2009].

Data analysis

Data were analysed using an immersion/crystallisation style of analysis — an iterative technique whereby a period of close examination of a set of data was followed by a period of detachment from it in order to draw out key insights [Borkan, 1999]. This dual process yielded central themes and patterns within the data that in turn informed subsequent analysis of interviews [Miller and Crabtree, 1992]. This cycle was repeated until all transcripts had been thoroughly examined and all relevant quotations had been extracted and organised thematically.

Themes were generated from an initial close reading of each interview transcript, followed by the application of additional or modified codes to account for themes that might emerge from further scrutiny [Creswell, 2014]. If any emergent codes were added, previous data were re-evaluated to ensure that nothing was missed. Furthermore, after thoroughly interpreting individual interviews, transcripts were re-interpreted in light of the entire interview set. In all cases, the aim was to fit codes to the data rather than the data to set codes [Marshall and Rossman, 1999].

Results

In seeking to understand the identities of sci-comic creators, we explored a range of facets of identity, including externally defined roles (see Figure 1), their perceptions of sci-comics, the challenges they face in defining their internal identities, and their authorial intentions.

Perceptions

> *"I think there is something very particular about comics that works well for explaining complex subjects."* *Darryl Cunningham*

Overall, participants tended to regard comics as a medium that is well-suited to the communication of scientific ideas — to the extent that Farinella was "surprised we haven't used them more in science communication". Endy even recommended that "all PhD thesis should at least have a comic-based abstract".

Comics are visual — (AE, BH, ER, JHa, JHo, JO, K&ZC, L, MF, PA)[1]

Participants highlighted the inherent *visual* nature of science that comics are able to compliment (JHo, MF). As Lauren pointed out, "there's a long history of scientists making cartoon-like drawings to convey the facts (e.g. Galileo's sketches of Jupiter's moons)". Ottaviani similarly observed that "when you hear the great scientists talk about their ideas... the vast majority of the times, they'll describe things in ways that an artist could draw. It's word pictures happening inside people's heads".

Interviewees mentioned that visualisation in comics could clarify scientific thinking and lead to new insights (AE, BH, JHo, MF). Indeed, "the act of drawing and the act of drawing relationships between different things concretises them in a way that might not otherwise happen" (JHo) — a process that can result in "a sort of 'Eureka' moment" (JHo). Farinella suggested that this could happen "even if you've been working in the field for decades... *seeing* something can really change your understanding and maybe help you think about it in a different way".

Comics are also useful for increasing the visibility of research (BH, JHa, PA). Hudson specifically chose comics as part of a marketing strategy because "visuals really are key to making your work stand out from the crowd... and you can tell a lot more of a story than a paragraph and text can, in a more concise and engaging way" (BH). Aggs said that "attracting attention — getting people to look — is the first step... that's the point of doing it in a sequential comic way" (PA).

Comics are narrative — (AE, DC, ER, JE, JHa, JHo, JO, K&ZC, L, MF, MN, ZW)

Endy observed that comics and science are compatible at a basic level: "Both a written research paper and a comic are forms of narratives". Participants noted that, as a species of storytellers (AE, JO), "we are wired for narrative" (JHo). Thus, using narrative through comics "is a powerful way... of talking about science that... connects students and readers to it in a way that has a lasting effect" (JHo) — a notion Naro referred to as "science as storytelling":

> Comics, at their core, are a storytelling device, and I think that fits well with science because no discovery happens in a vacuum. Science is ultimately the story about how humans have come to understand the universe, and comics are a great way of depicting that story. (MN)

Furthermore, narrative can contextualise science (JHa, JHo) and "engage the reader on a personal level" (MF). Ross noted that it can be "alienating to jump straight into the science, so if you give a bit of context you can fade into the story and the struggle of the scientists" (ER). "Those human experiences offer a clear narrative" (JHo) that can "put the human face" (MN) on an otherwise abstract subject matter (DC). Given these benefits, many creators expressed the desire to experiment with using more storytelling elements in their future work (DC, ER, JE, JHa JHo, JO, MF, MN).

[1] Interviewees will be referred to by their initials; refer to supplementary material for an alphabetical list.

Comics are 'permanent' — (BH, DC, ER, JHo, K&ZC, MF)

Participants suggested that the permanent or fixed visual component of comics distinguishes them from other forms such as TV or film, where the medium determines the speed at which the viewer takes in the information. While these might be "great as delivery methods of information" (KC) in their own right, they are "often very fast" (MF) and "if you want to dwell on it you have to sit there and pause it" (JHo). With a comic, on the other hand, the reader has full control over how quickly the viewing progresses, and can interact with it as a physical artefact that can be held, flipped through, bookmarked, dog-eared, read and re-read. For this reason, participants felt that information presented in comics form could be "better absorbed" (MF) and have "more longevity" (ER) than some other forms of science communication.

Comics are approachable — (AE, ER, MF, JE, JH, JHa, JO, ZW)

Interviewees described how the "grass-roots, very popular, low-brow" (MF) association of comics was able to remove the "intimidation factor" (ZW) surrounding science for many people. Rather than being "put off by something looking like a scientific manuscript," (JHa) comics are "very disarming — people will expect to understand it" (JHa). As such, comics can confound readers' expectations of how they encounter science — as a form of entertainment.

However, this popular appeal of comics is not without its limitations. Because many people still view comics as a "childlike form" (JE), comics may not be taken seriously by academics or "very 'grown up' people" (JHo) who do not expect the medium to deal with more advanced information (AE, ER). Endy even concluded that "the research community is not well prepared to receive novel technical advances and ideas via comics".

Comics reach new audiences — (AE, BH, DC, JE, JHa, JHo, JO, K&ZC, MF, PA)

Underlying all these considerations was the hope that using comics would be a way to "reach out to people that might not normally engage with science" (ER) — or, indeed, with comics (DC, JO, MF). Cunningham felt that the explanatory power of comics could help "bridge" what he described as "a huge gulf between your ordinary man or woman on the street and their understanding of science". Hudson discussed tangible examples of how his company's promotional comics have been "bringing academic research to a new audience," and Farinella even switched from a career in science to cartooning because he felt that comics would have more impact "than just publishing another academic paper". As Ottaviani put it: "Narrative non-fiction reaches audiences that '*The Journal of Incredibly Difficult Differential Equations*', with a subscription list of 43 libraries worldwide, cannot and never will".

Drawing together these different facets of sci-comics, we summarise the ways that they contribute to science communication, as perceived by their creators, in Figure 2. This highlights the combination of visual and narrative aspects of comics that facilitate science communication, but also points to the fact that this is a

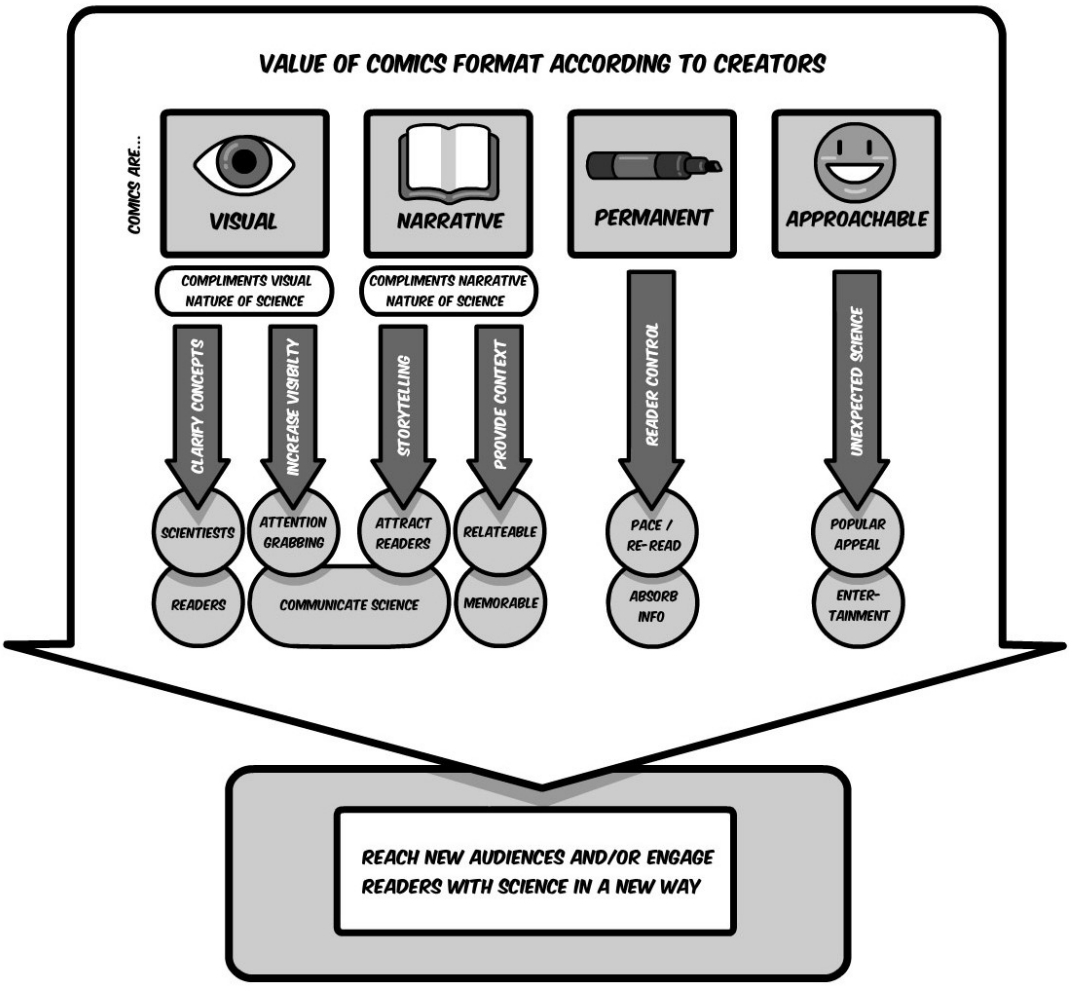

Figure 2. Value of Sci-Comics medium. The various facets of the comics format combine in ways that creators hope will increase or widen audiences for science and allow existing 'science interested' audiences to engage with science in new ways that will deepen their understanding or appreciation of science.

permanent medium (to which a reader can return for deeper understanding) as well as medium which is perceived by their creators to be approachable (i.e. readers are expecting an enjoyable, easy-to-read story).

An internal balancing act

> *"I always had this sort of double-life: I was doing my scientific research by day and drawing comics by night. And for many, many years, I never really thought about combining them. I don't know why."* *Matteo Farinella*

For several interviewees, becoming a sci-comic creator meant balancing apparently contradictory roles, that of scientist and artist and/or writer. Though this was by no means the case for all interviewees, it was only Aggs who seemed entirely secure in her role as an artist, for whom science offered creative fodder.

An uncertain identity — (BH, DC, ER, JE, JHa, JHo, K&ZC, MF, PA, ZW)

From Figure 1, it is evident that most participants tended to exist at the fringes of externally defined roles, overlapping with others and blurring the boundaries between them. Individuals were usually more than 'just' a scientist, or an artist, or a writer. For example, artists would often be involved in writing the script or dialogue (ER, K&ZC, MF, PA), and writers could be very involved in the artistic process (BH, JHa, MF). Despite the relative coherence of the groupings presented in Figure 1, this spectrum of identities made participants difficult to categorise — a reality not lost on the creators themselves. Indeed, one of the central experiences of many sci-comic creators was a sense of uncertainty surrounding their identity, often characterised by ambiguity, second-guessing, and self-doubt, as discussed below.

Science communicators — (BH, DC, ER, JHa, MN, PA, ZW)

Many of the comic creators identified as *science communicators* in some capacity (ZW, ER, DC, MN, JHa — with caveats. For example, Weinersmith specified that, while "certainly [science communication is] something I *do*, it's just not my goal…But I certainly end up in that position". Ross and Cunningham qualified themselves as primarily artists, but considered themselves 'de facto' science communicators *while* they were making sci-comics. Naro explained: "I go back and forth all the time [between cartoonist or science communicator], and it's been an identity I struggle with a bit" — a tension which prompted him to create a comic strip exploring the matter [see Naro, 2014].

Aggs was the notable exception: "I'm definitely not a science communicator [laughter]. No, I'm a comics person who happens to be making comics about science. It's just that I'm really interested in it, for probably peculiar reasons". For her, science was a topic of interest insofar as it presented an artistic challenge, approaching the subject from a purely 'comics' angle. Hudson was also an outlier in this regard, interacting with sci-comics as an editor and marketer rather than directly as a creator.

A bridge across identities — (ER, JE, K&ZC, L, MF, MN, PA)

Participants also highlighted a more existential conflict. Farinella described how he would "suffer" from dividing his life into two categories, something that "always felt unnatural". It was only when he combined his interest in science with comics that, "for the first time, I really felt this is what I needed to do". Similarly, after leaving the sciences to pursue a career in art, Evans began to "miss" science, and found that making a sci-comic was a way "to bring the two parts of my personality together". While for some, "combining them was just pretty natural" (L), it took others "many, many years" (MF) before "it clicked in my head that I could put the two together" (MN).

For artists without a formal science background (ER, K&ZC, MN, PA), sci-comics functioned as a potential way to fill "a sort of hole in our education" (ZC), providing them with the opportunity to retroactively explore an interest in science (ER, MN, PA): "I've always just been fascinated by science and sometimes I have a feeling that if I went back to college to do it over again, I'd probably want to do a

degree in biology" (KC). Thus, creating sci-comics gives these creators a sense of proximity to science — a way to engage with it through their art: "It's really enjoyable to be able to take part in it [the scientific world]... putting my own spin on it" (ER).

Neither one thing, nor the other — (DC, JE, JHo, MF, ZW)

The combination of art (visual/narrative) and science can cause difficulties for creators in terms of how they perceive their identity and that of their work. By drawing together the "two worlds" (MF) of science and art, creators often found themselves suspended in "this grey, blurred area" (MF) between them. As Hosler noted, "one of the problems" with sci-comics "is that they're not easily categorised". As a consequence, he recognised that "I probably am a man without a country — that I'm not artsy enough for art books and I'm maybe not sciencey enough for science books" (JHo).

But *why* the need for a 'double-life' in the first place? After all, as Cunningham noted, historically speaking "artists were often scientists as well". And yet, the Cannons said they were considered "a unicorn" (ZC) within the comics industry, where the combination of artistic skillset and an interest in science is suggested to be almost mythically rare. Farinella suggested that this perception may be "a by-product of the education we receive... because of the way we are trained, we tend to think in categories". (MF). Aggs and Weinersmith similarly lamented the fact that so few artists are comfortable with science — and vice versa — because "it was very difficult to learn both at the same time" (PA) in school.

Whatever the cause, it seems that many sci-comic creators are breaking free of this 'conditioning', to the extent that some, like Weinersmith, struggle with its premise: "I don't know that I want to recognise a distinction [between science and art]" (ZW). In its place, they are embracing the "blurriness" (ZW) between disciplines along with their own complex identities — even if that means being unsure of exactly how to define themselves or where their work belongs (JHo, MF, ZW). "Ultimately," says Hosler, "it's the decision of those reading it, what to call it... I am getting enough gratification doing what I'm doing to sort of stick with my guts and stay where I'm at".

Authorial intent

> *"They have to be both entertaining and informative. If they're not informative, they're not good science comics. If they're not entertaining, nobody will share them, and then they won't get a chance to be informative! It's a spectrum though."* *Lauren*

Through the interviews, we sought to understand the intentions of comics creators in relation to science communication, by exploring the relative importance they put on creating entertaining or educational/informative comics.

Educator, entertainer or both? — (AE, BH, DC, ER, JE, JHa, JHo, JO, K&ZC, L, MF, MN, PA, ZW)

Participants described making sci-comics as "a balancing act" (ER, JE, JHo, L) between their desire to entertain and to inform: "This is a line my work dances around all the time" (MN). In most cases the expectation was that the reader does learn something about science from the comics. This could be anything from communicating specific research (AE, BH, ER, JHa, PA) to explaining science more broadly — what the scientific method *is* (DC, JE) "and what it's like to be a scient-*ist*" (JO). Several creators viewed their comics as "gateway books" (KC) intended to excite and inspire new readers with the aim of creating a positive learning experience that will encourage further independent science learning (JHa, JHo, JO, Z&KC). One notable exception to this was Weinersmith:

> I don't know if this is unusual or not, but for me there was never an intent to use comics as a way to educate…it was just at the background of what I was doing.… I'm totally delighted when that happens…but it's not a goal in my comics or writing in general.

Even where learning was specified as a goal, it was just as — if not more — important to many creators that their comics were genuinely entertaining and connected with readers in a meaningful way (ER, JHa, JHo, JO, K&ZC, L, MF). As Hosler explained:

> When you pick up [my books], if you think you're going to get a straight didactic explanation…you're going to be mistaken…I'd be a liar to say that I didn't have broader aspirations as a storyteller [than] just…the conveyance of scientific information…I want to share my sense of wonder. I want to show them [the reader] that, even in the most dreary places, they are surrounded by wonder and amazing things. And you can't do that if you hand them an encyclopaedia.

However, creators were wary of "skewing" (JO, MN) too far in either direction. Ross explains that "the problem I can envision is science sucking out all the creativity" (also DC, JHo, MF, PA) "and creativity sucking out all the science" (ER; also DC, MF, K&ZC). "Either one is no good" (ER). In the creators' eyes, a successful sci-comic was one that managed to negotiate all these extremes. While artistic decisions are sometimes made which favour clarity over scientific *detail* or *complexity* (ER, JHo, JO, DC, K&ZC, L) — something Farinella refers to as having to "silence my science side" — participants were clear that they do not compromise on scientific *accuracy* (JHa, JHo, JE, MF, MN, PA, ZW). Evans explained that "if I saw the science is wrong [in a comic] I would pull a hissy fit…The science shouldn't be tempered with, but the *way* you express it can…but it still has to be accurate". According to Farinella,

> "Sometimes you kind of have to sacrifice a bit of science for the story. Which doesn't mean — I want to be clear — it doesn't mean making things up or doing bad science communication, it just means finding the right balance. You don't oversimplify things, you don't give any wrong information, but at the same time don't kill the narrative." (MF)

Overall, participants agreed that framing sci-comics as either entertaining or educational actually posed a false dichotomy between two goals that are not mutually exclusive. Instead, the argument seems to be that they are mutually *dependent* — that sci-comics are most informative when they also succeed in being entertaining. Achieving this fine balance between 'science' and 'comics' could be characterized as the primary, overarching goal of sci-comics creators.

Discussion

According to interviewees, sci-comics offer a range of advantages when it comes to communicating science, but these advantages also shed light on the interviewees' identities in that they suggest a desire to engage (new) audiences with science. Implicit in these advantages is a positive attitude to science; this is not a group seeking to critique science, but to share their appreciation of and enthusiasm for science. This is important, in terms of identity, because it suggests a group with a strong proximity to science (rather than one with a more distant or uneasy relationship), even if they did not pursue science subjects through higher education.

A case of blurred boundaries

Using the three facets of identity outlined by Stets and Burke [2009], we have developed a model proposing a relationship between the facets of identity discussed by our interviewees (Figure 3), which could be tested further amongst those working in or with Sci-Arts more broadly. The blurring of boundaries is evident across all three aspects of identity (role, social and personal), with creators occupying multiple roles (e.g. scientist and artist, artist and writer), identifying tensions in their social purpose (e.g. between education and entertainment) and emphasising a personal identity that combines a close proximity to both arts and sciences. For most interviewees, sci-comics were seen as a way to bring together diverse interests that were sometimes seen externally as incompatible –a tension also raised by Gewin [2013] and arising, perhaps, from Snow's 'two cultures' arguments.

Within this model, meanings become evident through the negotiation of contradictory roles. For example, several interviewees sought to negotiate the apparent contradiction between being a scientist and artist, through exploration of the visual (e.g. that visualisations are a necessary part of science) and a need to make one's research more widely accessible (conforming to the 'public engagement' agenda). In Farinella's and Evans' case, this also led to a shift in career. Another tension that arose, similar to those highlighted by Sørensen Vaage [2016], Hilton [2014], and Wilkinson and Weitkamp [2016], is the need to produce work that has both scientific validity and artistic merit — and in some cases a recognition that sci-comics may struggle to meet this criterion. Further, our interviewees were very aware of the need for a balance between educational and entertainment value in their work as highlighted by Wysocki and Thompson [2014], leading them to strive for a blended social identity as educators and entertainers through the internal moderation of their scientific and artistic 'sides'. We hypothesize that this blended role (entertainer/educator) is one also traversed by others working in science communication, particularly those involved in areas where 'edutainment' is being trialled, and it would be interesting to explore

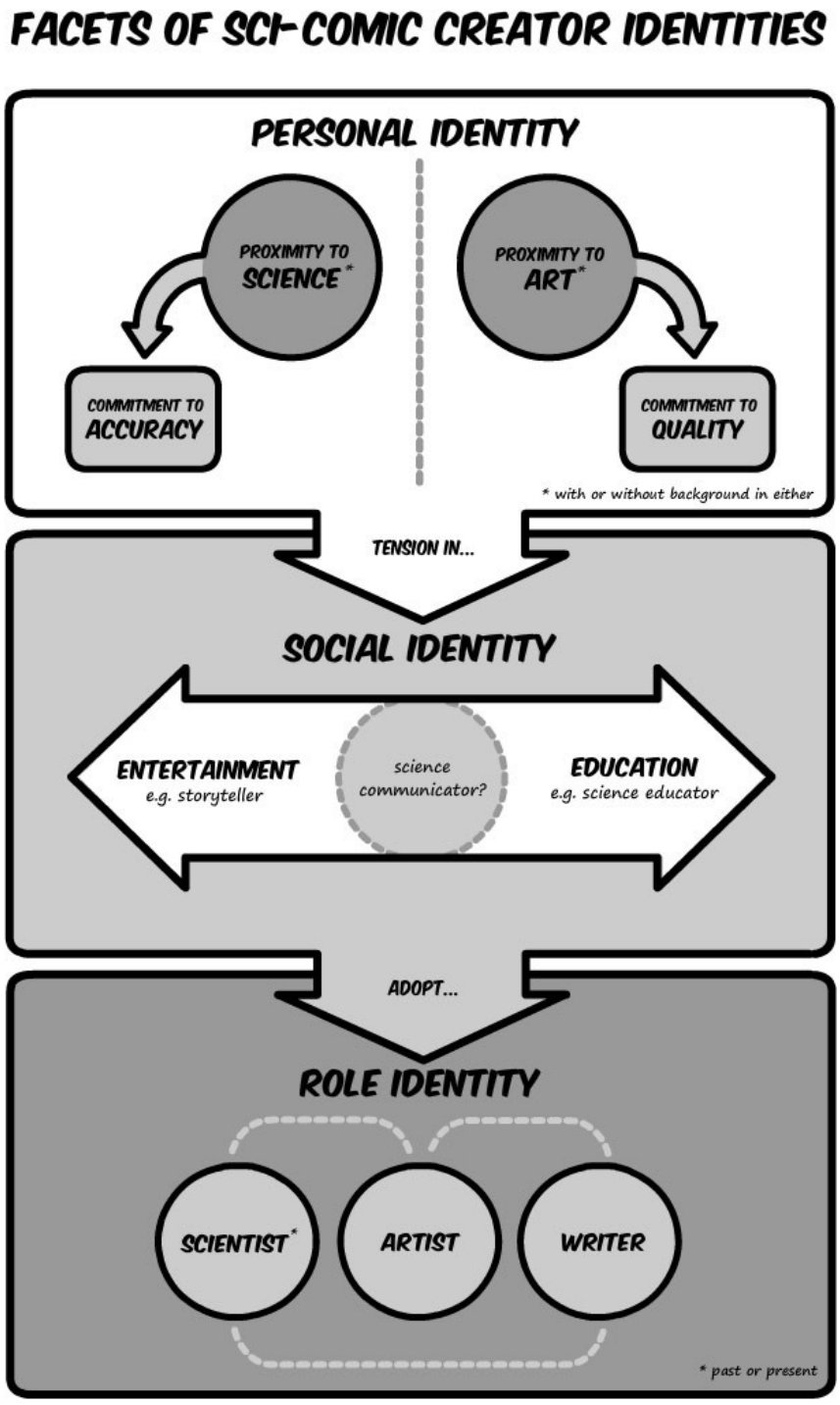

Figure 3. Facets of a Sci-Comic creator's identity. Sci-comic creators highlighted shared facets of personal identity (e.g. proximity to science and/or art, a focus on artistic quality but without putting scientific accuracy at risk). This personal identity underpins externally perceived roles — which, depending on the person, comprises one or more of 'artist', 'writer', or 'scientist' roles. It is notable that there are no real scientist advisors in this group (unlike in other sci arts projects), instead, sci-comics creators adopt multiple roles. Interviewees also articulated a tension in their social roles between that of educator/informer and entertainer, with science communicator also seen as a de facto (if not explicitly sought) social role that potentially combines both.

whether they experience similar tensions and identity issues in negotiating these roles.

Sørensen Vaage [2016, p. 10] has observed that "fields, or disciplines, are increasingly seen, by some, as artificial constructions, an attempt to create firm boundaries in an environment of frequent overlapping". Many sci-comics creators seem to fit within this emerging paradigm, where eschewing a rigid commitment to disciplinary boundaries has led to a harmonization of different interests (science and art) and functioned as a facilitator of exploration that allowed 'non-scientific' creators a certain proximity to science. This is also relevant to the way in which sci-comics themselves teeter on the fulcrum between entertaining and informing — a complex alloy where creators must get the mixture right between the storytelling and the science content, so that they are stronger together than they would be on their own.

Like science communication itself, intentionality — deliberately creating sci-comics — to educate, as Tatalovic [2009] uses it — did not come through strongly in the interviews. Certainly, our interviewees recognised that they did engage in science communication and most did hope that the readers would learn something through reading their comics (and in fact some argued that this was one of the key benefits of sci-comics, as a permanent and self-directed object), but intentional or self-conscious communication were not necessarily part of their identity. Instead, science communication arose somewhat inadvertently through their personal interest in science and the comic form. Even those that did align more closely with the science communication role felt there was at times a conflict between this and the role of artist, reflecting a challenge of priorities in the form of balancing story and science — a challenge also expressed by theatre practitioners working with science [Dowell and Weitkamp, 2011], and explored by Rödder [2016] in the context of visual arts and Pinto, Marçal and Vaz [2015] in the context of comedy.

A commitment to accuracy

One notable area where sci-comic creators differ from those working in other types of entertainment media is in their commitment to accuracy. Kirby's [2008a] experience with film and television writers indicates that, for them, "scientific accuracy will always take a backseat to storytelling. The point of movies is not to devise 'accurate/educational' communications about science, but to produce images of science that are entertaining" [p. 51]. In contrast, sci-comic creators strive to do *both*; although the science is still often used in service of story, accuracy remains paramount. It may be said, therefore, that sci-comics strive to maintain a higher standard of fidelity towards the scientific information they include than in some other genres or media — perhaps more akin to so-called 'hard science-fiction', which crafts stories rooted firmly in scientific realism [Dahlstrom, 2014].

In light of these interviews, the definition of sci-comics offered by Tatalovic [2009] could thus be modified to describe them as comics that feature science as a predominant or recurring theme, *irrespective* of intention or agenda, but with an overall commitment to scientific *accuracy*. This definition favours subtlety over precision, and encompasses the diverse range of comics included in this study,

along with the perspectives and intentions of their creators. Ultimately, it seems sci-comics creators are wary of becoming committed to a single definition, preferring to remain open to the many possible forms in which the genre might manifest itself.

Science in/as culture

Sci-comics can be plotted along the historical trajectory of their medium's increasing academic 'legitimacy' [Fisher and Frey, 2011; Tatalovic, 2009; Weitkamp and Burnet, 2007] — not only as a tool for communication, but also for their artistic merits. The creators in this research represent a move away from viewing art as an instrument in service of a 'more noble' scientific cause [Wilkinson and Weitkamp, 2016; Wysocki and Thompson, 2014]. By striving to create comics that have both artistic and scientific value [Jee and Anggoro, 2012; Sørensen Vaage, 2016; Hilton, 2014], they fulfil the dual criteria of a true sci-art project and embody an attitude of "art for art's sake" [Wilkinson and Weitkamp, 2016, p. 102]. They also "contribute to wider, cultural conversations" surrounding science [Sørensen Vaage, 2016, p. 7] by adding stories about science to the roster of subjects explored by art, revealing to readers and creators alike that science can have an aesthetic value as well as a utilitarian one. In this way, sci-comics can challenge public perceptions of who an artist is, who a scientist is, and what to expect from both.

Conclusion

These interviews establish that, when it comes to making sci-comics, the situation is not as clear-cut as Snow's Two Cultures [1993] makes it out to be. Indeed, it could be argued that creators of sci-comics represent a rejection of the dichotomy between science and art [Sørensen Vaage, 2016] in favour of a 'hybrid' identity that actively seeks to join the arts and sciences [Gewin, 2013] and in doing so blends entertainment and information (or in some cases education). Many of the creators represented by this study are evidence of the fact that to be a scientist or an artist — or to have an interest in either discipline — are not mutually exclusive identities. It is therefore more accurate to depict sci-comic creators as holders of complex identities that exist along a spectrum between 'science' and 'art', and that combines confidence and interest in science with artistic skills that cross both visual and narrative communication. If indeed it can be said that *are* Two Cultures, then they are complimentary ones, unified through a shared form of communication: the visual language of comics.

Through the analysis of interviews with science comic creators, this research has highlighted several areas of importance for science communication:

- Interviewees felt that the visual, narrative, permanent, and approachable qualities of comics made the medium particularly adept at explaining science and bringing it to new audiences.
- Making comics was a way for creators to reconcile the scientific and artistic components of their lives, often kept separate, or to pursue a latent interest in science. As such, sci-comics can be seen not merely as a way to traverse any perceived divide between science and art, but to overcome it.

– Ultimately, sci-comic creators strive towards being simultaneously as informative and as entertaining as possible; as concise and as accurate as possible. For them, sci-comics work best when they strike this balance and have something more to say than simply a checklist of facts. Accordingly, science comics should not be thought of as having educational merits alone; aesthetic ones are often just as important to creators.

We are so often inclined to compartmentalise things into neat little packages — confined to narrow expectations of what does and does not constitute an 'educational' comic; of who is and is not considered a scientist or artist. In the end, this may have more to do with our fixation on the institutional and cultural vessels we construct to contain these ideas than it does with any substantive differences between their contents. Consider the possibilities, for science communication and beyond, if we removed these boxes.

Appendix A. *Interviewees & science comics*

Interviewee / Initials	**Roles & Collaborations**	**Relevant Titles**	**Type of comic**	**Outcome**
Jay Hosler (JHo)	Scientist, educator, and comic artist/writer Solo & collaborator (Cannons)	- *Last of The Sandwalkers* - *Clan Apis* - *Evolution* - *Sandwalk Adventures* - *Optical Allusions* - *Drawing Flies* - etc.	Blog comics, full-length graphic novels through mainstream publisher, academic textbook	Skype interview on 16/06/2016 1hr 35min
James Evans (JE)	Former scientist-turned comic artist Solo	- *On The Revolution*	Self-published/ distributed comic booklet	Skype interview on 22/06/2016 1hr 3min
Jamie Hall (JHa)	Scientist Collaborator (Ross)	- *Parasites* - *Malaria* - *Sleeping Sickness* - *Hope Beyond Hype* - etc.	Comic booklets published through various funders (e.g. Wellcome Trust, EU)	Skype interview on 24/06/2016 1hr 30mins
Edward Ross (ER)	Comic artist Collaborator (Hall)	- *Parasites* - *Malaria* - *Sleeping Sickness* - *Hope Beyond Hype* - etc.	Comic booklets published through various funders (e.g. Wellcome Trust, EU)	Skype interview on 10/08/2016 (originally 03/06/2016) † 1hr 14mins
Jim Ottaviani (JO)	Science-educated comic writer, librarian Collaborator (Cannons)	- *Feynman* - *Primates* - *T-Minus* - *The Imitation Game* - *Cowboys, Bone Sharps & Thunder Lizards* - etc.	Full-length graphic novels through mainstream publisher	Skype interview on 30/06/2016 1hr 6mins
"Lauren" * (L)	Scientist and comic artist/writer Solo & collaborator (not included)	- "Wildlife Webcomics"	Online webcomics	Email interview on 06/07/2016 (follow-up response 14/07/2016)

Continued on the next page.

Kevin & Zander Cannon ** (KC, ZC, or K&ZC)	Comic artist duo Solo & collaborator (Ottaviani, Hosler)	- *Evolution* - *T-Minus Cowboys Bone Sharps & Thunder Lizards* - etc.	Full-length graphic novels through mainstream publisher	Skype interview on 07/07/2016 55min
Maki Naro (MN)	Comic artist/writer Solo	- *Boxplot*	Online webcomics	Email interview on 11/07/2016 (follow-up response 13/07/2016)
Darryl Cunning-ham (DC)	Former psychiatric nurse-turned comic artist Solo	- *Science Tales* - *Psychiatric Tales* - *Graphic Science* (forthcoming)	Full-length graphic novels through small publisher	Skype interview on 20/07/2016 58min
Ben Hudson (BH)	Editor, marketing Collaborator (Aggs)	- *Cartoon Abstracts*	One-page comics through academic journal publisher (Taylor & Francis)	Skype interview on 21/07/2016 50min
Patrice Aggs (PA)	Comic artist Collaborator (Hudson, and others not included)	- *Cartoon Abstracts* (e.g. "Surviving a Global Zombie Attack") - *Horrible Science*	One-page comics through academic journal publisher (Taylor & Francis)	Skype-telephone interview on 21/07/2016 47min
Matteo Farinella (MF)	Scientist, comic artist Collaborator (not included)	- *Neurocomic*	Full-length graphic novel through mainstream publisher, Wellcome Trust.	Skype interview on 09/08/2016 1hr 12min
Andrew Endy (AE)	Scientist Collaborator (not included)	- *Adventures in Synthetic Biology*	Short comic published in *Nature*	Email interview on 17/08/2016 (follow-up response 04/9/2016)
Zach Weiner-smith (ZW)	Comic artist/writer (science-education) Solo	- *Saturday Morning Breakfast Cereal (SMBC)*	Online webcomics	Skype interview on 05/09/2016 1hr 5mins

† Original Skype interview with Edward Ross on 03/06/2016 lost due to technical failure during recording, after which alternate interview was arranged.

* Participant has requested to remain anonymous, referred to in this study using the pseudonym "Lauren" and her work as *Wildlife Webcomics*.

** Joint Skype interview arranged with Kevin Cannon and Zander Cannon (no relation).

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