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Riding the wave: Media fandom and informal science education

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ABSTRACT: Popular entertainment media about scientists can inspire interest in real-world science. Products that explore the "real science of" fictional worlds offer an opportunity for informal science education that taps into this inspiration. Such efforts need to be credible in the treatment of both the science and the fiction.

KEYWORDS: entertainment, fandom, media studies, science communication, science fiction

1. INTRODUCTION

Popular interest in entertainment media about scientists can, in turn, inspire interest in real-world science. Science communicators have tapped into this resource by developing books, television shows, and traveling exhibits that tie informal science education to works of fiction. These tools are often framed as the "real science of" a fictional universe. Scientists and science writers involved with "real science of" projects argue that science fiction, in particular, taps into a sense of wonder that can fuel the desire to learn more, or even to pursue a science career. Theoretical physicist Michio Kaku recalled his early consumption of science fiction: "I was mesmerized by the possibility of time travel, ray guns, force fields, parallel universes, and the like. Magic, fantasy, and science fiction were all a gigantic playground for my imagination" (Kaku, 2008, p. ix). Such experiences have led Kaku and others to be involved with projects that aim to use this delight in fantastical science as a vehicle for teaching real-world science. This paper will consider these efforts in general, and then focus on three recent productions—one book and two BBC television specials—that use the popular and long-lived program Doctor Who as a basis for science education.

Given the size of the audience for fictional movies and television shows, it is important to include entertainment media products and audiences in science communication research. Below I note some of the existing work about how science is portrayed in the mass media, and then I will discuss efforts to connect works of fiction to informal science education, followed by an analysis of the three examples.

2. SCIENCE PORTRAYALS IN THE MEDIA

Much of the research on how science appears in entertainment media has focused on how scientists are represented as characters. This work draws on theories and concepts such as cultivation theory (Gerbner, Gross, Morgan & Signorielli, 1985) and character identification (e.g. Steinke, Applegate, Lapinski, Ryan, and Long, 2012). Researchers have examined scientist portrayals in terms of gender (e.g. Flicker, 2003; Jackson, 2011; Kitzinger, Haran,
Chimba & Boyce, 2008; Steinke, 2005) as well as other demographic factors and stereotypes (e.g. Frayling, 2005; Jones, 1997).

More broadly, many scientists, science communication scholars, and science educators are concerned about the potential influence of "bad science" in entertainment media. One of the main reasons that the portrayal of science in entertainment media is an area of concern is the perception that the inaccuracies presented on-screen undermine formal and informal science education. In order to examine the impact of science fiction on science education, both scholarly and popular sources have addressed the extent to which fictional forms "get the science right" (e.g. Glassy, 1997; Lambourne, Shallis, & Shortland, 1990; Rogers, 2007). Is the information presented accurate when scientific principles are explained, when tests are conducted, when a scientific theory is used as the basis for saving (or destroying) the world? Do futuristic technologies represented onscreen operate according to the known laws of physics? Very often, the answer to these questions is no.

One response to this situation has been for scientists to get involved on the production side by serving as science consultants on films and television shows. Science consultants are an increasingly important part of science-oriented blockbuster films. Ethnographic research has explored the work of science consultants in Hollywood (e.g. Frank, 2003; Kirby, 2003). These studies provide another perspective on the relationship between fictional and real-world scientists; in addition to trying to help filmmakers simply get "the facts" right, many scientists who work as science consultants hope to influence public opinion or educate viewers.

However, fictional media do not have to feature accurate science in order to be used as educational tools. In a study based on interviews and focus groups with scientists, teachers, and students, Michael and Carter examined how “science fiction, soap operas and other ‘spurious’ sources of scientific knowledge might” play a role in how students understand particular areas of science (Michael & Carter, 2001, p. 8). Even programming with little or no science content can be used for educational purposes—Perales-Palacios and Vilchez-Gonzales (2005) had students analyze how physics principles were violated in Sylvester and Tweety cartoons. Rose (2003) argued against a narrow focus on the accuracy/inaccuracy of fictional science when using films as a teaching tool; an emphasis on what is and is not plausible may be more inspirational. Others have agreed that comparing accurate and inaccurate portrayals of science is valuable in and of itself:

When showing movie scenes, it is important to expose students to a variety of clips that represent both good and bad science, and particularly those scenes that attempt to create a scientific reality that is in contrast to currently accepted scientific beliefs. By examining a variety of movie scenes, we found that students will be in a better position to evaluate the scientific validity of science as predicted in film. (Barnett and Kafka, 2007, pp. 34-35)

Another strand of research about science in entertainment media considers not the accuracy of the scientific content, but its potential to inspire. This is the perspective embodied in the above quote from Michio Kaku. In popular sources, it is easy to find anecdotes about the inspirational role of science fiction, and a few studies exist about such inspiration at the personal level (e.g. Fleischmann & Templeton, 2009; O'Keeffe, 2013). The European Space Agency (ESA) decided that the inspirational nature of science fiction was worthy of serious study when they commissioned a report to identify science-fictional technologies with important, real-world potential (European Space Agency, 2001).

It has not been established, though, how inspiration from media images of science can actually be translated into specific learning outcomes. Much attention was given to the notion
that a boom in enrollment forensic science programs could be attributed to programs such as CSI (Perkins, 2004; Postrel, 2007) but now some commentators wonder if that boom will have lasting impact. Forensic scientist and lecturer at Australia's Victoria University, Ahmad Samarji, wrote that some students decided to consider careers in forensics based on "false expectations and misinformed opinions" from television, without the necessary educational background and "without considering whether they truly enjoy science" (2013, n.p.). The aim of "real science" texts is to give viewers a concrete but informal way to take the next step, to learn a bit about scientific principles or current research while maintaining a visible connection to the source of their inspiration.

Nevertheless, those with a traditional approach to science communication, that is, those with a "public understanding of science" orientation who emphasize that appropriate science communication is intended to foster informed citizenship, may see productions such as those under discussion here as part of a potentially dangerous trend that erodes the distinction between science and non-science. Barnett and Kafka (2007) developed an interdisciplinary college course utilizing media clips specifically to counter the entertainment model that "often creates misunderstandings regarding the nature of science and leads to a blurring between fact and fiction" (p. 31). Nowotny (2005) suggested that "selling science as sexy has gone too far, amusing as it may be to explain the magic in Harry Potter in scientific terms... Sexy communication is not going to be enough to inform good decision-making" (pp. 1117-1118). Nevertheless, attempts to engage in exactly this kind of discourse continue.

3. INFORMAL SCIENCE LEARNING AND MEDIA TIE-INS

Informal science education has been defined in a variety of ways, but some of the components that are relevant to the genre of media-based texts are that it is learning that is not restricted by age, that takes place outside of a school setting, that is voluntary and self-directed, and that is not driven by a formal curriculum imposed from the outside (Stocklmayer, Rennie, & Gilbert, 2010). One could argue that the genre of educational science materials based on popular entertainment predates the era of mass media broadcasting. Arabella Buckley’s 1879 children’s book The Fairy Land of Science is one example of Victorian-era efforts to expose children to scientific ideas through fairy tales. Such works strived to make science texts both "instructive and amusing" as part of a "melting pot of facts and fantasy that brought education and entertainment together" (Keene, 2012).

3.1 Media Tie-ins

Authors of media tie-in books aim to educate by utilizing the audience's affection for the media products under examination. The surge in "real science of..." products began with Lawrence Krauss's successful The Physics of Star Trek (1995). Krauss, a prominent physicist, acknowledged that Trek's popularity is the reason that it may serve as a useful tool for exposing people to physics, but hinted at a frustration with the enthusiasm with which fictional, rather than real, science is absorbed into the culture. At the same time, Krauss used the show's catch phrases to position himself as a Trek "insider" as well as a respected scientist:

When we consider that the Smithsonian Institution's exhibition on the starship Enterprise was the most popular display in their Air and Space Museum—more popular than the real spacecraft there—I think it is clear that Star Trek is a natural vehicle for many people's curiosity about the universe.
What better context to introduce some of the more remarkable ideas at the forefront of today's physics and the threshold of tomorrow's? I hope you find the ride as enjoyable as I have. Live long and prosper. (p. xvi)

The Physics of Star Trek was followed by a sequel (Beyond Star Trek, 1998) and a parade of similar work by other authors who tackled the fictional science about such things as superheroes (Kakalios, 2006), CSI (Ramsland, 2001), Jurassic Park (DeSalle & Lindley, 1997), Twister (Davidson, 1996), and The X-Files (Cavelos, 1998). Nor has such material been limited to books. As I will discuss in more detail below, there have been a number of touring science center exhibits related to mass media products as well.

Just as one would not argue that science journalism is “good” or “bad” for science, I suggest that it does not make sense to issue global pronouncements about the value of these “real science” texts. Rather, we should consider what the specific elements of the genre are, what approach might be most effective for informal science learning, and how individual texts measure up. Two of the key elements that could be used to assess such texts are the credibility that is established regarding both science and the fictional universe, and the techniques that are used to try to integrate the science content with the fictional content.

3.2 Credibility

Science popularization is a broad project that encompasses journalism, websites, museums, television shows, books, blogs, and films. It is often assumed that the process of popularization involves the communication of information from "scientists" to "the public," but this limiting binary reduces our ability to understand the actual ways that science operates in culture (Hilgartner, 1990). Current approaches to science communication take into account the differing backgrounds, experiences, and knowledge sets of different publics (e.g. Scheufele, 2013). This approach could be expanded to include different engagements with media texts. The target audience for works about the "real science" of fictional TV shows is one that is highly interested in the source material. These are people who are, at some level, fans, or they are parents of children who are fans.

Given the purpose of the "real science of" products, it makes sense to position them as fan-oriented texts. An in-depth discussion of the shifting meaning of the word "fan" is beyond the scope of this article, but by "fan-oriented" I mean to emphasize the way that the producers of such texts are acknowledging and speaking to an active audience that is ready to grapple with ideas from fiction outside of the context of simply consuming the original work. While notions of "fan subcultures" are still useful in considering how fans of a specific show interact with each other, Jenkins (2007) emphasized that in an interactive, digital, and convergent media environment, "fan culture" is becoming an important part of mainstream culture. Even casual viewers of a television program may visit a website about the show, comment on a blog, share or even make a meme based on the show. These are all "fannish" activities, even when performed by a person who will never attend a science fiction convention. Treating the "real science of" products as part of a fan culture is simply an acknowledgment that, for fans, the science is imbued with greater meaning by being filtered through the fictional work with which they are already so familiar. Nowotny (2005) may argue that this trivializes the science, but another approach would be to consider how this process makes the science more salient to the audience.
What model of science communication do "real science of" texts follow? At first blush, it may seem that they utilize a traditional (and widely criticized) "deficit model," for the basic assumption is that the viewer lacks the scientific knowledge presented by the supplementary text. However a pure deficit model would emphasize only the real science, and would fail to find any value in the source material at all, thus failing also to inspire the target audience. A more appropriate model might be the "contextual model" of science communication. Brossard and Lewenstein (2010) argued that using the contextual model acknowledges that people "process information according to social and psychological schemas that have been shaped by their previous experiences, cultural context, and personal circumstances" (p. 14) and that media representations play a role in this process as well.

In order to employ the contextual model, the communication strategy needs to include a demonstration that these cultural contexts are understood and valued. To be convincing as a popular science text, then, these products need to establish credibility regarding both the science and the fiction. Credibility regarding science is established through traditional means—noting that the author/star has held scholarly positions, published research or other popular science texts, engaged in research, and so on. Establishing legitimacy within context of a fan-oriented text can be trickier. Krauss provides a successful example of how to do this without diminishing his credibility as a scientist.

Throughout *The Physics of Star Trek*, Krauss indicated his knowledge of the lore *Star Trek* fandom. In addition to using the phrase "Live long and prosper," he referred to fans as "Trekkers" rather than the more widely known but insulting "Trekkies." Specific episodes are cited by title, demonstrating a broad knowledge about the show and an understanding that such details matter to his readership. Further emphasizing the book's credibility in both the world of physics and that of *Star Trek* fandom is the forward, which was written by prominent physicist Stephen Hawking. Hawking's efforts at science popularization have not only made him one of the most recognizable names in science, but also landed him a cameo role on an episode of *Star Trek: The Next Generation*, cementing his place in fan culture. His forward to Krauss's book ended with the inspirational lines, "[Today's] science fiction is tomorrow's science fact. The physics that underlies *Star Trek* is surely worth investigating. To confine our attention to terrestrial matters would be to limit the human spirit" (p. xiii).

While there can be great benefits to using popular texts in this way, in some cases the relationship between the media product and the science content is thin; this can raise questions about the media tie-in as an educational strategy.

### 3.3 Integration

When it comes to the role of fictional texts in informal science learning, one main point of contact is in the traveling exhibit. These are science center exhibits that use a media tie-in; topics include the science of *Star Wars, Indiana Jones, CSI, Sherlock Holmes*, and, as noted above, *Harry Potter*.

To take one example, from 2008-2012 a traveling exhibit offered science center visitors the chance to see "the science and wonder of Narnia" (http://www.narniaexhibition.com/AboutExhibition.aspx). C.S. Lewis's fantasy series has bewitched generations of readers, and the recent film adaptations offered new ways to engage with the stories. Both the original books and the movies, however, are firmly rooted in the world of fantasy; crafting a science center exhibit from the story of Narnia presented a
challenge. In a photographic (and positive) review of the exhibit's stop in Louisville, Kentucky, Nash (2011) explained how the designers tried to connect the individual displays with a broader discourse of science. A photograph of a fossil included the following caption: "Though Jadis (the White Witch) used magic to turn her enemies to stone, nature works its own magic by making fossils. Visitors may touch this real, fossilized cave bear tooth." One might argue that framing the process of fossilization as "magic" runs counter to the mission of a science center. Similarly, the exhibit included a replica ice throne as seen in the film; Nash wrote, "Science tie-in: Real ice palaces do exist" (2011, n.p.) In short, the science content was unconvincing and the relationship between the science and the fantasy was thin, or perhaps even negative.

The Narnia exhibit, therefore, suggests that Nowotny's concerns about trivial treatments of science were well-placed. Are exhibits and books which feature science through a media tie-in doomed to exist only as "amusing" but shallow attempts to market a "sexy" and meaningless version of science? Such a perspective foregrounds the commercial interests behind the books, shows, and exhibits that attempt to link science education to entertainment media. And these are, indeed, commercial ventures. For this reason, it may be unfair to compare a science center exhibit such as the "Narnia: The Exhibition" to books and televisions shows. Exhibitions such as the one based on Narnia are a type of blockbuster exhibit intended to draw large crowds to the science centers at which they are programed (Lui, 2011); some argue that their role in informal science education is not to educate, but to get patrons in the door, perhaps in the hope that they will view other exhibits as well (Smithsonian Institution, 2002). Because they need to appeal to the broadest audience, the blockbuster exhibits are not speaking to the "fan" community in the same way as the other examples. Nevertheless, the Narnia exhibit illustrates some of the challenges that any "real science of" product could encounter. To limit our analysis to the commercial aspect of these products would be to neglect their greater importance to public science communication (Mellor, 2003).

In order to succeed as both a fan text and a text of science communication, these works need to demonstrate an authentic and responsible position with respect to both the fictional and the non-fictional content. The Narnia exhibit was less successful as a fan text because it rings false—the original work was mined for any element for which a science connection—however tenuous—could be made, and the factual content was sprinkled unconvincingly on top. Krauss's Star Trek books were successful because they tapped into something that the fans already thought about the source material—that Star Trek had something important to say about the future of science and technology, and that it has even served as inspiration for real-world science (Jones, 2005).

For a successful integration of fictional material and educational content, key aspects of the source material need to be incorporated into the discussion, creating an authentic connection between the two. Such incorporation does not depend on the accuracy of the science content in the source material; rather, it reflects the perspective of the curious viewer who might wonder how an interesting aspect of a fictional story compares to real-world science. In his chapter on Star Trek's transporter technology, Krauss did not simply mention the existence of the transporter and call upon broad cultural familiarity with the phrase "Beam me up, Scotty!" Instead, he turned to the whole canon of Star Trek to provide tools for an examination of whether the transporters move the actual matter of an individual's body, or if the transporter encodes the person as pure information—a debate Krauss summarized as "atoms or bits?" (1995, pp. 65-83). Speaking to his knowledgeable reader, Krauss wrote:
You might wonder why I make this point, since the Next Generation Technical Manual describes the process in detail...[the] transporter...apparently sends out the matter along with the information. The only problem with this picture is that it is inconsistent with what the transporter sometimes does. On at least two well-known occasions, the transporter has started with one person and beamed up two. In the famous classic episode "The Enemy Within" a transporter malfunction splits Kirk into two different versions of himself, one good and one evil...If a transporter carries both the matter stream and the information signal, this splitting phenomenon is impossible. (pp. 67-68)

Having established both the contradictions within the fictional universe and his own familiarity with that universe, Krauss examined transporter technology from the vantage point of real science, touching on "quantum mechanics, particle physics, computer science, Einstein's mass-energy relation, and even the existence of the human soul" (p. 83) in the process. The fact that he ultimately concluded that transporters will remain the stuff of fiction does not diminish the sincerity of the chapter; what makes this discussion work is that he dealt with the source material as something worthy of thoughtful consideration.

4. "REAL SCIENCE" AND DOCTOR WHO

Before discussing the three examples, it is necessary to provide a brief introduction to some of the most well known elements of the Doctor Who. Produced by the BBC, the serial has an elaborate cannon, since its original run was from 1963-1989, and the new version has been on the air since 2005. The main character is referred to as "The Doctor" (never as "Doctor Who"), and to date 12 actors have held the role as leads on the series. The Doctor is a time-traveling alien from a race called the Time Lords; Time Lords have the ability to regenerate, taking on a new physical appearance (and providing the narrative justification for the casting changes). His time ship is called a TARDIS, which stands for "Time and Relative Dimension in Space." The written work that I am examining identifies it as a "Tardis" (without the capitals), so I will adopt that usage below. Although the Tardis can take on different shapes, it is generally stuck in the shape of a London police box. It is much larger on the inside than it appears from the outside, leading some to hypothesize that it is actually a doorway to a wormhole, new dimension, or an alternative universe. Other characters include the Doctor's traveling companions/assistants and a wide collection of aliens, including the cyborg Daleks.

In the following sections, I will discuss each of the three examples in chronological order of publication. I chose three works dealing with the same show in order to allow for greater comparison. Doctor Who was lends itself to this analysis because there are multiple "real science of" products available, it is a show with a strong fan base, and because the show's narrative offers the potential for significant science content.

I will consider the credibility of the product—how both scientific authority and fannish authenticity are established. In addition, I will evaluate how science concepts are integrated with the fictional source material. It must be noted at the outset that the comparison across media formats presents some inherent problems—obviously, the hour-long television specials have much less room to provide detailed scientific explanations than a 342-page paperback. My purpose is not to compare these texts with respect to the volume of science-based information; rather, I am interested in how the authors/producers of these works navigate the tension between fact and fiction in a genre devoted to explaining one through the lens of the other.
4.1 The Science of Doctor Who (Parsons, 2007)

Parsons (2007) wrote a book on the science of Doctor Who that has no affiliation with the BBC; the cover announces that it is "the highly acclaimed unofficial guide." Given its "unofficial" status, the book is missing the visual cues that would attract fans. There are no trademarked images or typefaces, there is no logo from the show, no image of the Tardis, and no photographs of any of the actors or other visual representations of the show. The cover image is an abstract blue design that evokes the "wormhole-like" animation in the show's opening credits; in lieu of a Tardis, a shadowy figure falls towards the center. Bulleted text on the cover reminds the reader of some of the topics that (apparently) cannot be pictured: the Daleks, the Tardis, the Time Lords, and the Doctor's robotic dog, K-9. Along the bottom of the cover, there is a pull quote from Colin Baker, one of the actors who has played The Doctor. The cover also promotes the fact that the forward was written by science fiction author and science writer Arthur C. Clarke. However, unlike Star Trek fan and guest star Stephen Hawking, Clarke is not interested in Doctor Who. The closest Clarke comes to "Whovian" fandom is admitting that he knew "many die-hard fans" and that "some have gone on to become top scientific experts in their chosen fields" (p. xi). Much of his forward is devoted to the debate about time travel—whether a time-travel story such as Doctor Who can be classified as "science fiction" or if it must be relegated to "fantasy." Clarke takes the latter position: "science fiction is something that could happen—but usually you wouldn't want it to. Fantasy is something that couldn't happen—though often you wish it would" (p. xii, italics in original). Yet ultimately Clarke agrees that a science writer exploring a "fantasy-based realm" for scientific concepts could be rewarding.

4.1.1 Credibility

Unlike Krauss, author Paul Parsons is not a physicist; he is a science writer. In part, he establishes credibility for his book by referencing Krauss's. In his own preface, Parsons explicitly discusses the earlier text, hoping that the reader will "find that [he has] done similar justice to the Doctor Who universe" as Krauss's treatment of Star Trek. He outlines his qualifications as both a science writer and a fan of Doctor Who by writing, "I've been a Doctor Who fan since the early years of Tom Baker, a science writer and journalist since 1996, and a keen science student and post-grad researcher for almost a decade before that" (p. xv). He also emphasizes that he contacted a variety of scientists as part of the research for the book, and that they have contributed information that appears throughout his text.

4.1.2 Integration

I have argued that readers of "real science" books expect careful attention to how the fictional narrative is woven into the presentation of science fact. This can be seen in a review of Parson's book, in which it is compared to an earlier science book based on Doctor Who, Michael White's A Teaspoon and an Open Mind. Clegg (2006) wrote, "White’s book had significant flaws. In particular, it failed to tie in closely enough to Dr. Who itself. It took a basic concept from the show – time travel, say – then went off on a long riff on time travel. This misses the point of the “Science of” genre. We don’t want to know all there is to know
about time travel, we want to know how the Tardis, the Doctor’s travel device, could work" (n.p.). Clegg indicates that Parsons’ book is more successful in this goal.

The book is divided into four main sections, each of which covers some key aspects of the show and weaves them in with discussions of current research. The first section is "The Doctor in the Tardis," which covers some fundamental aspects of the show’s lore, including the personality and biology of the alien Doctor, and the basics of the Tardis as a time-traveling machine. The second section, "Aliens of London, and beyond" features individual chapters on many of the most memorable aliens from the show. The third section, "Robot dogs, psychic paper and other celestial toys" covers the technological capabilities and inventions seen on-screen. The fourth section, "Mission to the unknown" deals with the cosmology of Doctor Who. Within each of these sections, individual chapters tackle specific show elements and examine the current scientific research that these elements can bring to mind, often including quotes from active researchers in the field.

Some of the connections are more tenuous than others. In discussing time travel, Parsons explains concepts such as wormholes and the time travel paradox; a reader approaching a text such as this would expect those topics to be included. These are issues that are explicitly part of the show and the discourse around it.

Parsons chooses to include research from social science and psychology as well, and this is less expected. This is seen most strikingly in Chapter 6, "Partners in Time," which addresses the phenomenon of the Doctor’s assistants. Throughout the show, the Time Lord has a series of traveling companions who serve a variety of narrative functions, including that of standing in for the viewer—and needing to have things explained. In the chapter devoted to the companions, Parsons includes analysis that is both within and external to the narrative of the show. He discusses research from the field of occupational psychology that explains why humans (and, we learn, Time Lords) benefit from companionship. Then, he considers the perspective of the screenwriters who may want to include young, attractive, female characters for marketing reasons. This latter assertion is bolstered with research about "the science of pornography." Given the volume of media and film research about gender portrayals outside of pornography, and given the fact that Doctor Who is not pornographic, this is an odd choice. Chapter 17, "Stupid Apes," also steps out of the show’s narrative to examine why some viewers find pleasure in watching scary content.

In general, though, the organization of the book is respectful of both the show and the science. Each short chapter takes on a concept from the show—either a running theme or an incident from a specific episode—and describes relevant, current research on the topic.

Of the three examples, Parson’s book is the one that most closely follows the simplistic deficit model of science communication. Topics are raised—some with strong ties to the show’s narrative, others less so—and Parsons explains some real-world research that relates to those topics. Perhaps because it does seem to embody the deficit model, this is also the one of the three examples that explicitly denies doing so. In the conclusion, Parsons writes:

It's probably somewhere around here too that I’m meant to say something profound about the noble pursuit of science…This book was written first and foremost to entertain, to boost enjoyment of the show, and to answer questions that it may have raised in the minds of intelligent fans. I hope I’ve fulfilled those aims. If I did manage to educate anyone along the way, I sincerely apologize. (p. 317)

I suggest that this awkward denial of the aim of the book—to teach the reader a little bit of science—reflects an understanding that readers may resist science popularization efforts that
appear to embrace the deficit model—yet it does not fully shift to the contextual model or any other alternative instead.

4.2 The Science of Doctor Who (2012)

The 2012 television special was produced by BBC America (O’Connor, 2012), and, unlike Parsons’ book, this licensed work was able to make extensive use of copyrighted materials. The one-hour special is peppered with clips from the show, and on occasion when interviewees mention specific moments from the show, the viewer is shown the scene in question.

4.2.1 Credibility

Whereas the single-authored books have to establish that the authors are credible as both scientists and as fans, this documentary program takes a different approach to the issue of legitimacy. The variety of interviewees includes scientists, actors, and production staff, insuring that experts regarding both science and Doctor Who are represented. By including many clips from the show and interviews with some of the (secondary) actors and the producer, O’Connor ensures that the program will have broad appeal to anyone interested in the show, not just aspiring scientists. At the same time, the notion that interest in Doctor Who can lead to interest in the sciences is made explicit by Maggie Aderin-Pocock, who says, "Watching Doctor Who made me the space scientist that I am today!" All of the scientists interviewed do establish some type of fannish identity through their familiarity with and interest in the show.

4.2.2 Integration

Science-oriented themes from Doctor Who are taken one by one and discussed by the diverse group of interviewees. Although they are identified by name and position on-screen, the manner in which the interview clips are used makes no distinction between the speakers. After each segment, some of the interviewees vote on how likely it is that a science-fictional theme or technological advance will become reality. Not every interviewee votes in every segment. The votes are all on a scale of one to five—with one indicating that that particular advance will be impossible for humanity to achieve and five indicating that it is a sure thing. Tardis icons at the bottom of the screen represent the votes visually.

The votes of scientists and non-scientists are treated in the same manner, and the specific disciplines of the scientists are not taken into account. The scientists interviewed for this documentary lean towards an optimistic interpretation of Doctor Who’s technologies; Michio Kaku, in particular, argues for an open mind regarding most of these possibilities, saying, "I believe that, given enough time, almost all of Doctor Who could become science fact." He gives time travel 4 "Tardises" out of 5. Aderin-Pocock is more conservative, coming in at a"2 or 3" out of 5, while theoretical physicist Jim Al-Khalili splits the difference, voting for "somewhere between a 3 and a 4."

No non-scientists vote on the issue of time travel, but segments on other topics such as the existence of extra-terrestrials, the potential for human-like cyborgs, and human cloning include votes from both scientists and non-scientists. Some current research is incorporated in cut scenes labeled "Let's Ask the Scientist." The section on cyborgs, for instance, includes an
interview with robotics and cybernetics engineer Kevin Warwick…but he is not given a vote in the final tally.

Nowotny's (1995) concern that products such as this erode the important barrier between science and non-science is most relevant in this production, which makes little effort to privilege the knowledge of scientists over that of actors and comedians. Interviewees from both "sides" stress the notion that elements from Doctor Who may become real-world possibilities.

If there is an advantage to this style of presentation, it is that it suggests that these concepts are broadly accessible and nothing to fear. We see that scientists, actors, and producers are all interested in and grappling with the wild concepts from Doctor Who. The non-scientists may acknowledge that some of the ideas are difficult--producer Steve Moffat confesses that he found trying to learn about space-time challenging: "I have tried to read up on it. At one point, about a year after I started running Doctor Who I said, 'I'll try and read up on this.' And, oh my goodness, it's difficult."

4.3 The Science of Doctor Who with Brian Cox (2013)

This Christmastime special (Cohen & Harrison-Hansley, 2013) features a bit of the history of public science communication along with the science content. The main element of the program is a lecture given by physicist and well-known science popularizer Brian Cox before a live audience at the Royal Institution (RI) in London. The RI was founded in 1799 and is known for supporting public engagement with science through a variety of initiatives, including the Christmas lecture series, which was founded in 1825. These public lectures are intended to present a scientific topic to a general audience, with special attention to young people.

Cox introduces his talk by discussing the RI Christmas lecture of 1860, "The Chemical History of the Candle," by Michael Faraday. This opening serves several purposes at once. First, by describing the Christmas lecture and its role in science popularization, while speaking at the Royal Institution during the Christmas season, Cox associates himself with the illustrious history of that lecture. His resume is not discussed within the show, but his presence on the stage at the RI emphasizes his position in physics. Second, he describes the content of Faraday's lecture, which provides the basis for other material that he covers in the show. Finally, Cox admits that if he had access to a working time machine, he would like to visit the Royal Institution in 1860 in order to see Faraday's lecture in person. This fantastical goal is used to provide a narrative structure, as Cox returns to it several times to illustrate various concepts.

4.3.1 Credibility

As in the 2012 television special, this BBC-produced program intersperses scientific information with fictional content about Doctor Who. In a creative twist, however, this program does not use existing clips from the show. Rather, the special features a series of cut scenes that show conversations between Cox and the 11th Doctor (played by Matt Smith). The two men banter in the Tardis and discuss matters of time travel and space exploration. That Cox is inside the Tardis suggests him as a possible new assistant for the Doctor; in this he trumps the fannish claims of other scientists. Cox does not have to tell the viewer that he was a
fan of the show as a child or demonstrate any particular knowledge about the show. A fictional "Brian Cox" character is created, one who can visit with the Doctor and travel with him. Suddenly, Brian Cox is not merely explaining the science of Doctor Who—it is suggested that he may be the closest thing that we have to a real Time Lord, or at least a companion.

4.3.2 Integration

As with the other examples, Cox refers to specific aspects of Doctor Who during the program, but there are a number of differences. First, the content is more narrowly focused on the physics necessary to discuss the possibility of time travel. This more narrow focus allows for a more in-depth presentation of the science. Second, because Cox is giving an actual lecture before a live audience, there is no pretense that this program not meant to be educational. In keeping with the idea that we, as viewers, are visiting a real science lecture, there is no obvious attempt to "dumb down" the science content. If anything, the production emphasizes traditional, academic trappings of a talk such as this.

Stephen Hawking has reported that, while working on his bestselling book A Brief History of Time, he was told that for every equation he included, his readership would be halved, and that for this reason the book contains only one equation—$E=mc^2$. A review of Cox's 2011 book, The Quantum Universe: Everything That Can Happen Does Happen related this story and bemoaned the fact that Cox did not follow this same advice (Devlin, 2011). While a book may lend itself to including many equations, common wisdom usually prevents equations from being used in entertainment television shows (except perhaps as graphic embellishments on a show such as Numbers). Here, too, Cox ignores traditional wisdom.

Not only does he include equations, and talk about them in detail, Cox actually writes them on an antique chalkboard with somewhat squeaky chalk. The chalkboard is fairly elaborate and of the design that allows the user to flip over the board and use the other side when more room is needed—and more room is needed. Thus, Cox's discussion of Maxwell's equations does not feature any CGI or other high-tech interventions—we just see Cox, at the chalkboard.

Although he does have one high-tech screen that is used during the talk, Cox also uses other low-tech methods to illustrate his points. Volunteers (including physicist Jim Al-Khalili, featured in the other video) are brought onstage for interactive displays; a piece of black tag board is rolled up to illustrate the fabric of space-time.

Throughout the show, fairly detailed explanations of scientific ideas are broken up with the cut scenes from the Tardis, and during his lecture Cox continues to return to the 1860 lecture of Michael Faraday as a touchstone. In closing, Cox moves into speculative science, and he is quite clear about what he is doing:

Could we design some configuration of matter and energy that would curve the light cones around, so I could get back into my own past? The answer is: We don't know. But nobody has been able to prove that it cannot exist, at least in principle—although most experts believe that it must in some way be forbidden. But there's still the faintest possibility, given the laws of physics as we understand them today, that someone, someday, maybe a young girl, a young boy, will be inspired to try. And even if they fail, by the very act of trying they might just go on to change the world.

Cox provides a clear distinction between known science and speculation; he is also explicit (and in the following cut-scene, perhaps even heavy-handed) about his goal of inspiring children to investigate the wonders of the universe.
5. CONCLUSION

On balance, these efforts demonstrate that looking at science through the lens science fiction can contribute to the popularization of science, and possibly even inspire viewers to learn more. These examples suggest that there are several elements that science communicators should consider in developing or evaluating projects such as these.

First, the demarcation between science and non-science should be clear. Impossible or wildly improbable science should be labeled as such, and an explanation provided. On-screen interviewees or people quoted in text should be clearly identified with their credentials. Second, the work must be authentic in its approach to both the world of science and the fictional universe. Third, authors and producers should consider the model of science communication to be adopted and the overall strategy should be consistent.

Scholars of science communication should continue to consider fictional entertainment media as one venue for science communication, alongside the more commonly studied non-fiction media forms. Just as a newspaper article cannot be evaluated with the measures of a textbook, and science blogs require a different mode of assessment than a newspaper article, “real science of” texts form a unique genre of science communication that must be considered on its own terms.

REFERENCES


