SCIENCE, ENTERTAINMENT, AND EDUCATION
AN ANNOTATED BIBLIOGRAPHY

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SECTION I. PORTAYALS OF SCIENCE AND THE WORK OF CONSULTANTS

TV AND FILM PORTRAYALS OF SCIENTISTS AND SCIENCE

Dudo, A., Brossard, D., Shanahan, J., Scheufele, D. A., Morgan, M., & Signorielli, N. (in press). Science on television in the 21st century: Recent trends in portrayals and their contributions to public attitudes toward science. *Communication Research*.

This study quantitatively analyzes the depictions of scientists in prime-time TV programming appearing between 2000 and 2008, building on the findings of past studies by George Gerbner and colleagues. The study identifies several key trends:

> (1) Scientists rarely appear in prime-time programming. Among the occupations of prime-time characters, only 1% are portrayed as scientists.
> (2) When scientists are portrayed, they are most often white.
> (3) Scientists are considerably more likely to be categorized as "good" (81%) than as bad (3%). And, of all the occupations coded, scientists are the least likely group to be categorized as bad. If in the few cases when "bad scientists" do appear, they are more likely to be white males than characters in other demographic groups.
> (4) Science is portrayed as one of the more dangerous and violent professions. In terms of violence and victimization, 3.2% of scientists kill others, compared to 2.2% of medical personnel and 2.5% of lawyers. Thus, scientists continue to commit violence more than some other professions. Also, they are victimized more: 6.5% are killed, compared to 1.3% of medical personnel and 0% of lawyers.

The authors contextualize these findings, noting that the results extend what Gerbner et al. found in the mid-1980s. The analysis shows mainly that scientists are rarely represented in prime-time entertainment TV, but that when they are shown they are usually depicted as "good" or "mixed" rather than as "evil scientists." The authors note how this empirical finding is at odds with the common claim that entertainment TV consistently depicts scientists in a negative light, either as odd and/or evil.

Collins, H. M. (1987). Certainty and the Public Understanding of Science: Science on Television. *Social Studies of Science, 17*(4), 689-713.

Collins critically examines how TV portrays science and muses about how these portrayals are likely to influence public understanding of science. His qualitative analysis is concerned with how TV portrays scientific uncertainty—a concept of great importance that has rarely been analyzed.
As case studies, Collins examines 2 BBC TV shows "The Geneva Event" (about physics) and "QED on the Shroud of Turin." He finds these programs exhibited 4 main features:

> (1) Science is shown as overly certain (i.e., that it produces unambiguous knowledge).
>
> (2) The issue of uncertainty is broached more often if the subject is controversial or "fringe."

(3) When the subject is controversial, TV producers are more likely to add their comments. When this happens, the TV producers' comments are often decisive.
(4) Uncertainty is shown as temporary; something that subsequent scientific research will negate.

Collins also suggests that these TV depictions of science are likely to have negative effects on public understanding of science. Specifically, he contends that we cannot expect the public's scientific decision-making to improve if TV depictions of science underplay the uncertainty inherent in the scientific process.

Goldman, S. L. (1989). Images of Technology in Popular Films: Discussion and Filmography. *Science, Technology, & Human Values, 14*(3), 275-301.

Goldman conducts an interpretative analysis of popular films produced from 1925-1989 (what he refers to as a "filmography") and identifies some common images that negatively characterize the nature of science and scientists. Goldman posits that common images include the following:

(1) Powerlessness - scientists and engineers are depicted as servants of corporate, political, or military institutions, committed to executing the misguided and frequently insidious agendas of those institutions.
(2) Inherent dangers - the knowledge generated by scientists, engineers etc. is initially positive, but is eventually exploited and corrupted for negative purposes.
(3) Ambivalence - depictions of science and technology are largely ambivalent, reflecting widespread public anxiety over their ultimate social impact.

Hornig, S. (1990). Television's Nova and the construction of scientific truth. *Critical Studies in Mass Communication, 7*(1), 11-23.

Hornig performs a critical examination of how the long-running PBS show NOVA depicts science in terms of scientists, the scientific process, and the distinction between science and everyday life. After critically reviewing 2 NOVA episodes, Hornig derives these conclusions:

(1) NOVA obscures the scientific process. NOVA does not demystify science even though it professes to. It glorifies science and shows the technology of science, not the process.
(2) The NOVA audience is elite and watches the show to confirm and reinforce their previously help believes about the power of science.
(3) Scientists are shown as special, superhuman, and clearly different than everyday folks (e.g., they are depicted as busy, in suits or white lab coats, in front of chalkboards, etc.).
(4) Science is shown as profitable (i.e., a promising economic endeavor).
(5) NOVA commonly frames science as a "race against time" or a "conflict."
(6) Ultimately, NOVA reinforces the power of the scientific community.

Hornig's analysis suggests that additional research should examine how depictions of science differ across various TV genres and programs.

LaFollette, M. C. (1982). Science on television : Influences and strategies. *Daedalus, 111*(4), 183-197.

LaFollette, believing that TV has been underused to bring information about science to the mass audience, provides a brief history of televised science and presents 5 principles for improving its presentation in entertainment television and documentaries.

LaFollette's (brief) history of televised science:

(1) Science on TV during 50s and 60s was poor.
(2) The 1970s introduced Mr. Wizard and NOVA, both of which, LaFollette contents, were improvements and respected by scientists.
(3) Most commercial TV presents dubious images of science.

Of potential interest to entertainment content creators, LaFollette suggests 5 principles that, when followed, would improve the depiction of science in entertainment television and documentaries:

(1) Straightforward reporting of new results and of old principles.
(2) Placing facts in scientific context; that is, within the processes of science.
(3) Placing scientific knowledge in non-scientific contexts (i.e., contexts that may be more relevant to non-scientific audiences, such as social, cultural, political, historical contexts).
(4) Describing and placing scientific results within the social system of science.
(5) Evaluating how well science attains social and cultural goals.

Ley, B. L., Jankowski, N., & Brewer, P. R. (in press). Investigating CSI: Portrayals of DNA testing on a forensic crime show and their potential effects. *Public Understanding of Science*.

Inspired by the "CSI Effect," Ley and colleagues build on previous quantitative content analyses and examine how the TV show CSI depicts DNA testing. The authors describe the following results:

(1) The dominant message on CSI is that DNA testing is common, swift, reliable, and instrumental in solving cases. The CSIs look for DNA evidence from an unknown source in almost two-thirds of all cases, analyze DNA evidence in slightly more than half of all cases, and use DNA matches to solve slightly more than a fourth of all cases.
(2) Consistent with Kirby's "perceptual realism," the show conveys a sense of scientific plausibility despite not being obsessed with scientific accuracy.
(3) CSI glamorizes genetics and DNA testing.

This study complements other studies concluding that TV depicts science as overly authoritative and certain.

Long, M., Boiarsky, G., & Thayer, G. (2001). Gender and racial counter-stereotypes in science education television: a content analysis. *Public Understanding of Science, 10*(3), 259-273.

Noting the under-representation of women and minorities in science and math careers, and the

potential for mediated depictions to influence stereotypes of scientists, Long and colleagues examine the genders and ethnicities of characters in children's TV science education programs.

Using content analysis techniques, the authors examined 4 shows—Bill Nye The Science Guy, Beakman's World, Magic School Bus, and Newton's Apple—evaluating the programs across a number of criteria. Analyses of the scientist characters on the shows include the following results:

(1) Males are no more likely to be shown as scientists than females.
(2) Caucasians are more likely to be shown as scientists than minorities.
(3) Males scientists are not shown as older than female scientists.
(4) Caucasian male scientists did not have higher status than female and minority scientists.

Analyzing the non-scientist characters on the shows who typically demonstrate an interest in science, they report the following findings:

(1) Males appear more often than females.
(2) Males and females are on the screen for the same amount of time.
(3) Caucasian characters appear more often than minorities.
(4) Males appear more often as adults than females.

The results, overall, lead the authors to observe that these programs are presenting positive counter-stereotypes in their images of science and of people interested scientists, but that science is still portrayed overall as a subject and career dominated by whites.

Long, M., & Steinke, J. (1996). The thrill of everyday science: images of science and scientists on children's educational science programmes in the United States. *Public Understanding of Science, 5*(2), 101-119.

Using several media effects perspectives as guidance, Long and Steinke examine thematic patterns in televised children's science shows and consider the effects of these depictions.

Using quantitative content analysis and a clearly-articulated conceptual rationale, the authors examine 4 shows—Beakman's World, Bill Nye the Science Guy, Mr. Wizard's World, and Newton's Apple—and find the following main results:

(1) Science is rarely depicted as mysterious or magical
(2) Although uncommon, science is sometimes presented as dangerous
(3) Science is often depicted as truth.
(4) Sometimes is sometimes depicted as a solution to problems
(5) Science is often depicted as being fun
(6) Science is depicted as being part of everyday life and as intended for everyone
(7) Scientists are depicted as omniscient
(8) Scientists are often shown as being elite or part of a privileged group
(9) Scientists are sometimes portrayed being eccentric, but not evil or violent

Citing social learning theory and other perspectives, the authors discuss how these themes—mostly

positive—might influence children's perceptions of science and scientists. Overall, this is an interesting study with strong conceptual and methodological approaches.

Long, M., Steinke, J., Applegate, B., Lapinski, M., Johnson, M., & Ghosh, S. (in press). Portrayals of male and female scientists in television programs popular among middle school-age children. *Science Communication*.

In this study, Long, Steinke and colleagues continue their line of research investigating how science and scientists are represented in television programs meant for children. In this study, they focus on depictions of gender in 14 TV programs popular among 12- to -14-year-olds. (Note: some of these programs are educational (Bill Nye), while other are not (CSI, The Simpsons).

Like their other studies, they use a clear conceptual and methodological approach to explore these televised depictions, and reflect on their potential effects. Using quantitative content analysis their key results include:

(1) There were significantly more male scientist characters than female scientist characters
(2) The NSF-funded shows in the sample provided a more equitable gender distribution of scientist characters than non-NSF-funded programs
(3) Male scientist characters did not have higher status scientific positions than the female scientist characters; both sexes are shown as being married equitably; and male scientists are more often shown as being parents
(4) Results about gender stereotyping were mixed: male scientist characters were significantly more likely to be portrayed as independent, while female and male scientist characters were equally likely to exhibit the feminine gender-stereotyped behaviors of caring, dependent, and romantic. Additionally, gender stereotypical behavior did not differ by program genre.
(5) Male scientist characters were labeled as nerdy or geeky significantly more often than were female scientist characters (most often in cartoons); however, the groups did not differ in the extent to which they were shown alone in scenes.
(6) Male and female scientist characters did not differ significantly for intelligent, respect, and caring attributes; however, male scientist characters were portrayed as more violent than were female scientist characters.

The authors advocate that presenting more positive depictions of scientists on television, especially of female scientists, may be a particularly effective strategy for motivating girls to consider science and engineering careers.

Perkowitz, S. (2007). *Hollywood science: Movies, science, and the end of the world*. New York: Columbia University Press.

In this 2007 book, Stanley Perkowitz examines science in Hollywood films. Noting the dearth of research examining the "science" of science-based movies, Perkowitz explores two research questions:

(1) How accurate / realistic is the science in the movies?
(2) How does this content influence public reactions and attitudes about science?

Perkowitz first examines films according to six themes: alien life, being hit by an asteroid, natural disasters, nuclear, disease and genetic engineering, and robots and computers. (See the book for details on how these themes are presented.)

Perkowitz also reflects on how these films portray scientists. Like other research, his findings show that these depictions are a mixed bag. Some findings include:

(1) Scientists are shown as heroes, nerds, and villains.
(2) Most movies feature scientists with the right disciplinary background.
(3) Common characteristics include: white lab coats, bad hair, glasses, hard workers, antisocial, serious, lacking emotion, lacking morals, and walking the line between genius and madness.
(4) Some of the portrayals are relatively accurate (e.g., scientists are serious and work hard) some are not (e.g., scientists don't want to take over the world).
(5) Evil scientists are often shown as lacking morals, having God complexes, and being in science for the money.
(6) Biographical films (e.g., Kinsey, A Beautiful Mind) portray scientists most accurately.
(7) *Contact's* Ellie Arroway is perhaps the most realistic / believable depiction of a scientist.

Of interest to film producers, Perkowitz also discusses what makes a good science-based film. These characteristics include:

(1) Reasonable scientific veracity.
(2) A meaningful portrayal of scientists.
(3) An effective look at how science influences people and society.
(4) A persuasive and thought-provoking extension of today's science into tomorrow's world.
(5) Perkowitz also notes that the level of scientific accuracy is only part of the evaluation; that there are more important characteristics defining a good science in films. (This observation is particularly noteworthy considering that "accuracy" is often the most common critique scientists make about entertainment media depictions of science).

Overall, Perkowitz believes that science fiction films can and do influence public understanding. He makes a compelling argument for how these films can inspire young people to pursue scientific careers, and argues that science fiction films can aid formal science education, noting programs like Physics in Film, CICSO, We All Use Math Everyday.

Steinke, J. (2005). Cultural representations of gender and science. *Science Communication, 27*(1), 27-63.

Citing the lack of females in science and engineering careers, and the power that media—particularly film— have to reinforce cultural assumptions about the lives and role of women in society, Steinke examines how female scientists and engineers are portrayed in a representative sample of popular films released between 1991 and 2001.

Using textual analysis techniques, Steinke examined 23 films in which female scientists and engineers were primary characters. The characters were assessed on five themes:

(1) appearance
(2) characterization
(3) expertise, ability, and authority
(4) work versus romance
(5) work and family life balance

Steinke finds that while many depictions of female scientists and engineers emphasized their appearance and focused on romance, most depictions also presented female scientists and engineers in positions of high professional status. Images of female scientists and engineers' interactions with male colleagues, however, reinforced traditional social and cultural assumptions about the role of women in science and engineering through overt and subtle forms of stereotyping (e.g., female scientists and engineers are questioned or challenged by male colleagues or peers, criticized for lacking credentials and professional experience, experienced a loss of resources when male supervisors failed to see value in their research, pushed away as male colleagues took credit for their accomplishments, etc.)

Steinke's suggests numerous paths for future research, including:

(1) Additional analyses of mediated depictions of female scientists and engineers.
(2) Examine the features of these media portrayals of female scientists and engineers that most appeal to girls and to determine which portrayals, if any, are most effective in changing girls' attitudes toward science and engineering careers.

Other studies and resources …

Jones, R. (2001). "Why can't you scientists leave things alone?" Science questioned in British films of the post-war period (1945-1970). *Public Understanding of Science, 10*(4), 365-382.

Jones, R. A. (1997). The Boffin: a stereotype of scientists in post-war British films (1945-1970). *Public Understanding of Science, 6*(1), 31-48.

Kirshner, J. (2001). Subverting the cold war in the 1960s: Dr. Strangelove, The Manchurian Candidate, and The Planet of the Apes. *Film and History, 31*(2), 40-44.

Murphy, S., Wilkin, H., Cody, M., & Huang, G. (2008). Health Messages on Prime-time Television. In D. Kunkel (Ed.), *Media Messages and Public Health: A Decisions Approach to Content Analysis* (pp. 173): Taylor & Francis.

How not to respond to The X-Files. (1998*). Nature, 394*, 815.

Nelkin, D., & Lindee, M. S. (1996). *The DNA Mystique: The Gene as a Cultural Icon*. New York: W.H. Freeman.

Podlas, K. (2006). 'The CSI Effect': Exposing the Media Myth. *Fordham Intellectual Property, Media, and Entertainment Law Journal, 16*, 429-465.

Rosenstone, R. A. (2003). Comments on science in the visual media. *Public Understanding of Science, 12*(3), 335-339.

Silverstone, R. (1987). Narrative strategies in television science. In J. Curran, A. Smith & P. Wingate (Eds.), *Impacts and influences: Essays on media power in the 20th century* (pp. 291-300). London: Methuen.

Sobchak, V. (2004). *Screening space: The American science fiction film*. New Brunswick, NJ: Rutgers

University Press.
Steinke, J. (1997). A portrait of a woman as a scientist: breaking down barriers created by gender-role stereotypes. *Public Understanding of Science, 6*(4), 409-428.
Steinke, J. (1999). Women Scientist Role Models on Screen. *Science Communication, 21*(2), 111-136.
Steinke, J., & Long, M. (1996). A Lab of Her Own? *Science Communication, 18*(2), 91-115.
Turney, J. (1998). *Frankenstein's footsteps: Science, genetics, and popular culture*. New Haven, CT: Yale University Press.
Vieth, E. (2001). *Screening science: Contexts, texts, and science in fifties science fiction film*. Lanham, MD: Scarecrow Press.
Weingart, P., & Pansegrau, P. (2003). Introduction: Perception and Representation of Science in Literature and Fiction Film. *Public Understanding of Science, 12*(3), 227-228.
Yklgan, F. (2009). *The image of science in Mythbusters.* B Lkent University.

SCIENTISTS AS CONSULTANTS ON FILM AND TV PRODUCTIONS

Elam, M. (2005). When scientists meet film-makers: Inventing a Swedish approach to public engagement with biotechnology. *Acta Sociologica*, *48*(3), 237-251.

Elam analyzes the role the Swedish non-profit organization Scientists Meet Filmmakers (SFM) in the production of a two-hour, two-part TV documentary Life At Stake, which was financed by the Swedish research community and broadcast in 2003 on Swedish public service television (SVT). The documentary ran on successive Mondays as part of the SVT series World of Science, and had a combined audience of approximately 1 million Swedes. The project grew out of a larger government communication initiative that was launched following the 2001 Swedish debate over embryonic stem cell research and medical cloning. The first part of the initiative focused on the launch of an educational Web site that would be used in schools and in adult education. Following the creation of the Web site, the Swedish research agency contacted a well-known science journalism professor about the idea for a TV documentary series. By happenstance, the professor had recently helped create the non-profit Scientists Meet Filmmakers (SFM).

SFM played a central coordinating function in developing the program. The organization identified and recruited Folke Ryden, a well-known Swedish documentary filmmaker and media personality to produce and star in the program, gained cooperation and agreement from SVT to broadcast the program, and worked with the affiliated Swedish science agencies to raise government funding for the film. The organization also helped put together and connect the filmmakers with a list of 40 relevant scientific experts and advisors.

The documentary's two parts focused on medical biotechnology and food biotechnology respectively and was intended to "educate the public on the impacts of biotech on their lives and whether or not it was living up to promised expectations." According to Elam, the film's narrative structure features Ryden on a first-person voyage as a Swedish "foreign correspondent" traveling to other countries to investigate the nature and promise of biotechnology. The issues and related science are told through the perspective of strong, emotionally gripping accounts of personal stories and by way of the testimonies of scientific experts, usually in the context of their labs. Biotechnology is depicted as the product of scientific inquiry free from politics or special interests. Only when biotechnology is released into the market does research become vulnerable to social forces. Under this condition, it is

important to defend biotech from irrational forces that seek to undermine its development and progress. Importantly, the public as portrayed via the documentary are defined as spectators to this social struggle, with little participation or voice in societal decision-making on biotech, and instead deferent and trusting of scientists.

Elam concludes by describing the role of SFM and the film itself as less a documentary that sponsors greater public discussion and involvement on the issue of biotechnology, and more as a carefully organized, political intervention similar in strategy to techniques used by environmental groups such as Greenpeace. This is not a critique of scientists actively investing in public engagement efforts, but rather a criticism of the creation of this specific film as a vehicle to sell the public on the merits of research rather than as an initiative that increases and enables public participation and input.

Kirby, D. A. (2003a). Scientists on the set: science consultants and the communication of science in visual fiction. *Public Understanding of Science*, *12*(3), 261-278.

Drawing on interviews he conducted as well as those previously published with scientist consultants, Kirby analyzes the nature of science consulting on fictional films, including compensation, a consultants' role in the filmmaking process, and the scientific elements that consultants influence in a film. Kirby recounts that across the 1990s, the demand for scientist consultants steadily increased as films grew strongly dependent on special effects to generate revenue. As Kirby notes, by using scientists as consultants, filmmakers can claim legitimacy for their presentations and narratives, while gaining added publicity and credibility among critics and fan bases. Kirby notes that scientists are increasingly featured as part of the press work in advance of a film and that film consultation has become a thriving business with several scientists having turned full-time consultants and two companies launched to connect filmmakers and scientists (Takeoff Technologies, CA and The DOX, Germany.)

Kirby describes several motivations for scientists to work as scientists:

(1) The first is *advocacy*, with many scientists believing that science is portrayed negatively or inaccurately in film and that their work can improve the image and realism of science in film portrayals.
(2) Other motivations include *activism*, as Kirby recounts several scientists who worked on environmentally-themed films of the 1970s such as *A China Syndrome* or the primatologist who worked with the human actors portraying apes in *Greystoke: Legend of Tarzan, Lord of the Apes*.
(3) A third motivation is *compensation*, with Kirby reporting that some consultants charge $100-200 an hour, while others ask for and receive grants or other forms of support for their research.
(4) Many scientists, however, do not work for compensation and instead donate their time out a sense of *public service and/or advocacy*.
(5) Apart from individual scientists, scientific institutions such as NASA, Argonne National Laboratories and the Field Museum have consulted on films, considering this work part of their *institutional mission*. NASA set up its Hollywood liaison office in 1964 and have

consulted on films such as *Deep Impact, Space Cowboys*, and *Mission to Mars*. NASA withdrew as a consultant to Red Planet, objecting to a scene where one astronaut shoots another. NASA does not ask for compensation believing the consultation promotes the agency's image and mission.

Among consultants interviewed, most acknowledged that their advice was sometimes ignored, often because of budget limits or because of storytelling needs. For example, producers of *Outbreak* did not want to cover their female lead in Ebola lesions and producers of *Contact* altered the sound of an alien radio signal to be more engaging to audiences. Yet the majority of scientists said that they were astonished at the amount of advice that filmmakers did heed as well as their intense interest in their input.

Kirby also notes the types of activities and advice that scientists provide. These include:

(1) Assisting actors with appearing or behaving like scientists and with the use of scientific jargon.
(2) Assisting with the "look" of science by providing input on the depiction of scientific labs or work spaces, as well as types and uses of equipment and instruments, sometimes even providing equipment for the set.
(3) Ensuring that depictions correspond to natural laws and scientific understanding. Examples include the presentation of dinosaur behavior in Jurassic Park, the presentation of an erupting Volcano in Dante's Peak, and the surface of Mars in Mission to Mars. In other cases, expert opinion on a topic is not yet established, and the scientist has the opportunity to promote their interpretation of a still uncertain area of science. An example includes the feeding habits of a T Rex in Jurassic Park.

Kirby concludes by noting that most scientists' work on films is motivated by a Deficit Model view that inaccuracies in films erode scientific literacy, and that corrections can bolster public knowledge. Yet he notes several problems with this assumption:

(1) In most cases, audiences are not able to distinguish accurate versus inaccurate presentations of science in film. Consultants can improve the accuracy of presentations, but that does not mean audiences will recognize these improvements or recall them. The increasing use of scientists in publicity work surrounding a film also blurs the ability of audiences to distinguish accuracy since then the impression from publicity is that an entire film is authentic when only several scenes may adhere to scientific consultants' advice.
(2) Even when scientific advice is closely followed, accuracy remains subjective. Kirby notes one film that presented a lab that used donated equipment from a scientist that was 10 years out of date and another that used equipment that only a few laboratories could actually afford.

According to Kirby, instead of the accurate presentation of facts or the "look" of doing science, the true impact for consultants is their potential influence on how scientists are portrayed as characters, directing presentations from geek or mad scientist characters to either realistic or hero portrayals.

Kirby, D.A. (2008) "Hollywood Knowledge: Communication Between Scientific and Entertainment Cultures," in *Communicating Science in Social Contexts*, D. Cheng, et al. (eds.), (New York: Springer): 165-181.

In this chapter, Kirby uses as a point of departure the commonly voiced perception that scientists and entertainment producers operate within two separate cultures. Communication therefore under this context is not from an expert community to a wider lay public, but between two distinct expert communities. The increasing incentives for these two expert cultures to communicate and collaborate (see Kirby, 2003b), has led to the emergence of a new class of scientist consultant, which Kirby refers to as "boundary spanners," individuals with some scientific training who have developed extensive experience in the entertainment industry, and who can bridge the scientist and filmmaker communities. As Kirby describes, filmmakers pose specific questions to the boundary spanner who then locates appropriate researchers, obtains and synthesizes scientific information, and translates it into the language of cinema. For boundary spanners, success is achieved when the transformed product on the screen bears enough resemblance to scientific authenticity to satisfy both the scientific and the entertainment communities.

As Kirby describes, successful boundary spanners provide filmmakers access to a wide range of scientific advice without the need for filmmakers to ever interface directly with the scientific community. Their familiarity with entertainment culture allows them to take this acquired knowledge and put it into a form that filmmakers can actually use. Their inside knowledge of filmmaking also enables them to work with filmmakers during production to turn this modified scientific information into the final product on screen.

Yet to perform this function, boundary spanners have to first establish credibility among both scientists and entertainment producers. They also have to develop and successfully manage a large network across both cultures.

As examples and case studies for achieving these necessary conditions, Kirby examines The Dox, a German consulting company founded in 1997 by medical research scientists and which has worked on over 25 fictional films and TV movies and the independent consultant Donna Cline, a biomedical illustrator and forensic artist, who has worked on more than 12 major Hollywood films including Outbreak, The Shaggy Dog, The Relic, and Deep Blue Sea.

Kirby identifies the following key strategies that the two boundary spanners needed to establish authority, trust, and access across the two cultures and to serve as effective bridges:

(1) The Dox relied on their record of scientific publication to be perceived as experts by filmmakers while Cline relied on her access to and recommendations from several prominent scientists to appeal to filmmakers and also scientists.
(2) Both also had to demonstrate their understanding of entertainment culture. For the Dox this came only when they began to "accept the rules of media and change stories in that direction. We no longer fight for the right of being correct. We fight for the right of telling a good story." For Cline it was easier since she had worked as a storyboard artist and therefore was

perceived as an "insider" by entertainment producers which can manifest itself in very subtle ways such as understanding how to properly walk around a set.

(3) Another way both established authority and effectiveness was by knowing who to speak to within the film or scientific hierarchy and, more importantly, understanding norms and conventions for how to phrase their conversations across cultures.

(4) Both Dox and Cline had to also be successful at synthesis. As Kirby describes, simplified, fragmented scientific information is not useful to filmmakers. More than organization and simplification, the synthesis performed by Dox and Cline involved "deciding which information merits inclusion, which information is irrelevant, and what to do with contradictory information." Managing contradictory information often involved the consultants transforming emerging, uncertain areas of scientific research into unified "normal" science that had the appearance of consensus and authority. As Kirby quotes Cline describing, when she interviews 10 medical experts about a topic such as Ebola virus for film Outbreak, she might receive 10 varying views, and she then has to conflate or unify these views: "I either decide what meets our story needs or I take the average. I want to make sure it is in the ballpark." At other times, the consultants realized that filmmakers needed choices to craft a narrative around. When the Dox provided producers with ideas about treatment for Lou Gehrig's disease, they presented not just the dominant treatment strategy (surgery), but also rare alternatives (retrovirus or drugs).

(5) In combination with synthesis, the consultants also had to address the storytelling and dramatic needs of producers. This included the ability to visualize a problem or topic and the need for conflict, climax, action etc. For example when working on Outbreak, Cline realized that her synthesis of scientific information was only useful if it help create a visually engaging story which included lab sets, gore, spooky costumes and propelled along the plot.

In conclusion, Kirby notes that most scientific consulting on films is a one-off process for the individual and that very few professional boundary spanners exist. Understanding the process of intercultural communication that enables boundary spanners to exert authority across science and entertainment is important to institutionalizing scientific advice and input in entertainment.

Kirby, D.A. (2008) "Cinematic Science: The Public Communication of Science and Technology in Popular Film," B. Trench & M. Bucchi (eds.), *Handbook of Public Communication of Science and Technology*. (New York: Routledge): 67-94.

In this chapter, Kirby provides a synthesis of available literature across dimensions of how film is related to science communication. Past work, according to Kirby, can be grouped in three main questions:

(1) How are scientific representations constructed in the process of production? 2) How much science and what kind of science appears in film?

(2) What are the cultural meanings and interpretations of science in film?

(3) What effect if any does the fictional presentation of science have on science literacy and science attitudes?

When considering portrayals, science in fictional film involves much more than the inclusion or presentation of scientific information, but involves broadly presentations relevant to the methods of science, social interactions among scientists, laboratory equipment, science education, industrial and state links, science policy, science communication, and cultural meanings of science. In whole, Kirby refers to these multiple dimensions as constituting the "systems of science."
Across the four areas relative to science communication the chapter is a valuable overview of several of the studies described in this bibliography. Of particular use is a table by Kirby that summarizes research findings on the dominant stereotypical images of scientists that have appeared across decades. During the 1920s and 1930s, the dominant image was of the mad scientist as portrayed in Frankenstein, in the 1940s, films focused on biopics of real scientists such as Louis Pasteur and Madame Curie. During the 1950s the dominant image was that of the amoral scientist as portrayed in Destination to the Moon. The 1960s featured the dominant stereotype of the "absent minded" scientist as portrayed in The Nutty Professor or in 2001: A Space Odyssey. The 1970s was a return to the "amoral scientist" in films such as Silent Running. The 1980s featured the "helpless scientist" in films such as War Games and Robocop. According to Kirby, the 1990s to the present is dominated by the stereotype of "hero scientist" as presented in Jurassic Park or Deep Impact.

Apart from scientist stereotypes, Kirby also discuss the field of science that dominated portrayals in films across decades. Often the fields portrayed would connect with social debates at the time or emerging new areas of science. The stereotypical image of the scientist would depend in part on the field and social context presented in a film. For example, the 1970s featured heavily in film the field of ecology, the 1980s the field of computer science and robotos, and the 1990s the fields of genetics and genetic engineering.

Sarewitz, D. (2010). Entertaining science. *Nature*, *466*(7302), 27-27.

In a commentary focused on the Science and Entertainment Exchange, Sarewitz questions claims that there is a strong anti-science contingent among the public that needs to be responded to by more positive portrayals of science in entertainment, or that predominant negative stereotypes of scientists persist in society and culture. He defines the initiative as an example of overly simplistic and faulty assumptions, what science communication scholars refer to as the deficit model: increasing the accuracy of scientific information and promoting positive images of science will lead to widespread public support for policies supported by scientists.

As Sarewitz writes, "scientists and engineers are different from cops, lawyers and morticians — not because they are any less human, but because they are part of an enterprise that is continually transforming society, nature and even humanity in ways that everyone can experience but no one can truly understand." According to Sarewitz, science and technology "are expressions not only of human creativity and determination, but also of hubris and the will to power." Sarewitz warns that "smoothing" over this reality through positive image construction in entertainment, reduces the inherent value to many entertainment media productions.

Using the hypothetical example of a film produced about the Gulf oil disaster, Sarewitz writes that the movie could engage audiences usefully on the important social context in which science and technology is developed, managed, and applied: "A movie about the oil spill would not be made great by its engaging portrayals of scientists and science. It would be great if it raised hard questions about the rightful place of science and technology in the world, examined….Through the story of the spill, the movie could explore the intimate ties between the political need for economic growth and the scientific and technological enterprise that feeds this growth. It could probe the pathetic inadequacy of tools for assessing risks at the frontiers of human technological endeavour. It might even confront the moral problem of how and when human wisdom should put limits on the reach of science and technology."

Other studies and resources:

Simon, A. (1999). *The real science behind The X-files: microbes, meteorites, and mutants.* New York: Touchstone. [Written by a consultant on the TV series.]

Gerbner, G. and Linson, B. (1999) Images of Scientists in Prime Time Television: A Report for the U.S. Department of Commerce.

Mooney, C. & Kirshenbaum, S. (2009). *Unscientific America: How Scientific Illiteracy Threatens Our Future.* New York: Perseus.

SECTION II: ENTERTAINMENT MEDIA, PERCEPTIONS, AND LEARNING

Besley, J. C., & Shanahan, J. (2005). Media attention and exposure in relation to support for agricultural biotechnology. *Science Communication, 26*(4), 347-367.

Analyzing nationally representative, cross-sectional survey data, the authors examine the effects of using different types and genres of media—including TV news, entertainment TV, and science TV programming—on perceptions of agricultural biotechnology.

> (1) After controlling systematically for social background factors including education and political ideology, heavier TV science viewers were *more likely to support* agbiotech. ("TV science" was an index composed of three measures asking how often respondents watched TV news about science, the environment, and biotechnology.)
> (2) After similar controls, heavier entertainment TV viewers *were more likely to support* agbiotech. ("Entertainment TV" was a measure consisting of how often people watched TV dramas and situation comedies.)
> (3) After similar controls, heavier TV news were *less likely to support* agbiotech. ("TV news" was a measure consisting of how often people watched local, state, and national TV news coverage of the government or public affairs.)

In response to these findings, the authors suggest that TV use generally encourages people to process heuristically, relying on mental short-cuts and peripheral information rather than engage in close examination of a topic. In this case, audiences' strong general belief in the promise of science likely serves as a natural short cut in forming opinions about agbiotech. The authors note that this finding is

inconsistent with popular claims and previous work suggesting that entertainment TV's effect on science attitudes is negative.

Brewer, P. R., & Ley, B. L. (2010). Media Use and Public Perceptions of DNA Evidence. *Science Communication, 32*(1), 93-117.

Brewer and Ley examine how overall television viewing, crime television viewing, newspaper readership, and local television news viewing are related to self-perceived understanding of DNA, perceptions of DNA evidence as reliable, the weight attached to DNA evidence (or the absence thereof) in jury decision making, and support for a national DNA databank. The authors also run an experiment to test whether priming thoughts about media (i.e., asking respondents questions about media before asking them questions about DNA) shapes these perceptions.

Analyzing nationally representative cross-sectional survey data, the authors find the following key influences, controlling for a range of social-background influences and other potential confounds.

> (1) Watching more TV was associated with less understanding of DNA. ("Understanding of DNA" was assessed by asking respondents if they have a clear understanding of what it means, a general sense of what it means, or little understanding of what it means.)
> (2) Overall television viewing predicted belief in the reliability of DNA evidence, weight attached to the absence of DNA evidence in a jury decision-making scenario, and support for a national DNA databank.
> (3) Regarding the CSI Effect, crime television viewing did not predict the weight attached to the presence or absence of DNA evidence in jury decision-making scenarios. However, watching crime television did predict self-perceived understanding of DNA and belief in the reliability of DNA evidence.
> (4) Results of the embedded experiment revealed evidence for media priming effects; receiving the media questions before the DNA questions—rather than the other way around—led respondents to attach more weight to the presence and the absence of DNA evidence in jury decision-making scenarios. (The embedded experiment was conducted by randomly assigning all respondents to receive one of two forms for the survey: a form that asked the media questions before the DNA questions (*N*=456) or a form that asked the media questions after the DNA questions (*N*=452).)

It should be noted that the overall variance explained in each model was low, suggesting that perceptions of DNA evidence reflect other factors as well.

Barriga, C. A., Shapiro, M. A., & Fernandez, M. L. (2010). Science Information in Fictional Movies: Effects of Context and Gender. *Science Communication, 32*(1), 3-24.

Noting the dearth of work examining the impact of entertainment media on audiences, the authors conduct an experiment that explores the effects of the portrayals of science in movies and how they interact with the background of audiences.

Specifically, the study examines how three factors including the (1) perceived centrality of the science information to the overall plot of the movies, (2) the degree to which the story transports the viewer

into the story world, and (3) audience background factors including prior knowledge about science and the gender of the viewer—may influence viewers' processing of the depicted scientific information.

In the experiment, participants watched several movie clips containing inaccurate scientific facts. Perceived centrality of the science information was also manipulated, such that some people thought science played a central role in the film, and others thought the science was just background. Likewise, transportation into the story world was manipulated. Specifically, participants were randomly assigned to either watch the clips and enjoy them as they would at home (transportation condition) or to watch them and report the number of words that an eighth grader might not understand (no transportation condition). Participants were then asked to answer general true-false questions about science (e.g., atoms are smaller than electrons, the size of the universe is expanding). They were also asked specific questions about the science presented in the movie clip they viewed (e.g., Robots exist that require no resources beyond those used to create them). This was to test whether they had adopted the inaccurate facts presented as truthful.

The researchers found that whether or not incorrect science facts are accepted as true after seeing identical segments from movies depends on the gender of the participant and a manipulation of the perceived centrality of science to the plot. Specifically, men tended to detect more inaccurate science facts when they thought science was central to the plot, while women detected more inaccurate science facts when they thought science was peripheral to the plot. (In the peripheral condition a plot summary emphasized the relational conflicts between characters and not the scientific nature of the film's content.)

While discussing the study's implications, the authors note that the role that a viewer perceives science plays in a movie may be critical to the influence that science facts have on real-world beliefs, but this perception also depends on the gender background of the viewer.

Bates, B. R. (2005). Public culture and public understanding of genetics: A focus group study. *Public Understanding of Science, 14*(1), 47-65.

Bates explores the public culture and its relationship to public understanding of genetics in the U.S. Of relevance to this bibliography is his examination of how film and TV contribute to citizens' understanding of advances in genetics.

Using a focus group methodology, Bates finds that people process mediated messages about genetics in ways that are far more complex than is commonly assumed. Specifically, he finds that people tend to integrate these mediated messages more critically (e.g., considering a greater variety of messages), in ways that enable them to arrive at complex understandings of genetics.

Bates uses his findings to argue against the tendency of researchers to assume a "transmission model" when it comes to media effects on perceptions of science. This study provides further evidence that entertainment media influences do not occur in a vacuum—these effects are complex and are shaped by audiences who are more sophisticated than commonly assumed.

Dudo, A., Brossard, D., Shanahan, J., Scheufele, D. A., Morgan, M., & Signorielli, N. (in press). Science on television in the 21st century: Recent trends in portrayals and their contributions to public attitudes toward science. *Communication Research*.

Following an analysis of the depiction of scientists in primetime TV (see discussion earlier section), the authors analyze nationally representative survey data to examine how TV use contributes to attitudes about science. They find the following results controlling for relevant factors such as sociodemographic background:

(1) Contrary to common belief, overall time spent viewing TV does not predict negative attitudes toward science. (The measure of overall TV viewing asked respondents how many hours in an average day they watch television.)
(2) TV use, however, does appear to displace the use of other media that would lead to higher levels of science knowledge and that would contribute both directly and indirectly to more positive attitudes toward science.
(3) TV use has differential effects for different audience groups. Heavy TV use leads people *without college science experience* to *have more positive views about science*. Conversely, heavy TV use leads people with *college science experience to have more negative views about science*. This finding holds after controlling for other demographic variables as well as knowledge.

These results complement other recent science communication research illustrating (1) that entertainment TV contributes to public attitudes about science, (2) but that these effects occur in complex ways that often cut against conventional assumptions.

Nisbet, M. C., & Goidel, R. K. (2007). Understanding citizen perceptions of science controversy: bridging the ethnographic-survey research divide. *Public Understanding of Science, 16*(4), 421-440.

Analyzing cross-sectional, nationally representative survey data, this study examines the influence of difference forms and genres of media on public perceptions of embryonic stem cell research and therapeutic cloning. In isolating the influence of media use, their analysis controls for relevant sociodemographic influences such as education and ideology. They also control for knowledge and generalized views about the impact of science on society.

Specifically, they find that TV has a unique influence above and beyond this existing background factors:

(1) Watching televised science documentaries is positively related to support for embryonic stem cell research.
(2) Watching Christian TV is negatively related to support for embryonic stem cell support.
(3) Watching science fiction TV is positively related to support therapeutic cloning.

Overall, the authors note that their findings show that regular consumption and attention to different types of television content likely provides an important social context by which citizens judge

controversial areas of science. As was the case in similar studies, the finding that science fiction television viewing is positively related to support for therapeutic cloning is somewhat contradictory to conventional assumptions. The authors propose that science fiction as a genre might introduce ethical and extreme scenarios to audiences, desensitizing heavier viewers to the type of heuristic "yuk factor" reaction that occurs among other audience segments. This is one of few studies that examines entertainment media effects in a comprehensive theoretical model.

Nisbet, M. C., Scheufele, D. A., Shanahan, J., Moy, P., Brossard, D., & Lewenstein, B. V. (2002). Knowledge, reservations, or promise? A media effects model for public perceptions of science and technology. *Communication Research, 29*(5), 584-608.

Noting that little research has examined media depictions of science across types of media and its effects on perceptions of science, Nisbet and colleagues propose a media effects model centered on the interrelationships between different types of media use (including newspaper reading, science documentary TV viewing, and general entertainment TV viewing), two types of science knowledge (factual and procedural), and belief in either the promise of science or reservations about its impact on society.

Based on a statistical analysis of nationally representative survey data that controlled for gender, education, and, results showed that general entertainment TV use promoted greater reservations about the impact of science in society, while science documentary TV viewing promoted stronger beliefs in the promise of science.

In addition, part of TV's influence on perceptions of science is indirect by way of knowledge. Science TV use promotes factual knowledge, which in turn is related to a greater belief in the promise of science. General entertainment television viewing is negatively related to knowledge of the process of science, with lower levels of procedural knowledge linked to stronger reservations.

The study also identifies a significant gender gap in media use, knowledge of science, and perceptions of science. Women are less likely to use media that foster informal learning about science and hold comparatively lower levels of knowledge than men. As a result of their lower levels of knowledge, along with other possible social and cultural influences not examined in this study, women are more likely to have reservations about science and less likely to believe in the promise of science.

The study also indicated an education gap in media use, knowledge of science, and perceptions of science. Individuals with higher levels of general education are more likely to read newspapers and use science media and are less likely to engage in general television viewing. They also hold comparatively higher levels of factual and procedural knowledge of science. As a partial result of these traits, society's best educated are less likely to hold reservations about science and are more likely to believe in the promise of science.

Sjöberg, L., & Engelberg, E. (2010). Risk perception and movies: A study of availability as a factor in risk perception. *Risk Analysis, 30*(1), 95-106.

Citing the dearth of empirical research examining how/if credible entertainment films influence risk perceptions, the authors conducted a carefully designed experiment to test this relationship.

The main results include the following:

> (1) The films investigated—*China Syndrome* and *Towering Inferno*—were not associated with average shifts in risk perceptions.
> (2) The films, however, were associated with strong mood effects, creating tense and depressed moods among viewers.
> (3) Movie viewing was associated with shifts in individual-level risk perceptions immediately after watching the films, but these shifts were no longer evident 10 days after the experiment.

Overall, this study makes a noteworthy contribution to entertainment media effects research, finding, through a strong experimental design, that viewing credible entertainment movies seem to have idiosyncratic and short-lived audience effects. The authors question the ability of entertainment films to have lasting effects on risk perceptions.

Other studies and resources …

Gerbner, G. (1987). Science on television - How it affects public conceptions. *Issues in Science and Technology, 3*(3), 109-115.

Gerbner, G., Gross, L., Morgan, M., & Signorelli, N. (1985). Television entertainment and viewers' conceptions of science. *Report to National Science Foundation, Annenberg School of Communications, University of Pennsylvania*.

Holliman, R. (2004). Media coverage of cloning: a study of media content, production and reception. *Public Understanding of Science*, *13*(2), 107-130.

Leiserowitz, A. A. (2004). Before and After The Day After Tomorrow. *Environment, 46*(9), 22-37.

Lowe, T., Brown, K., Dessai, S., Doria, M. D., Haynes, K., & Vincent, K. (2006). Does tomorrow ever come? Disaster narrative and public perceptions of climate change. *Public Understanding of Science, 15*(4), 435-457.

SECTION III. CLASSROOM USE OF FILM, TV, AND GAMES

USE OF SCIENCE TV AND FILM CONTENT IN THE CLASSROOM

Barnett, M., & Kafka, A. (2007). Using science fiction movie scenes to support critical analysis of science. *Journal of College Science Teaching, 36*(4), 5.

With a goal of making students critical consumers of mediated portrayals of science, the authors describe a course they developed for undergraduates studying to become elementary teachers. During the course, titled "The Living Earth II," the authors used various scenes from popular science fiction films to foster discussions among their students about the veracity of the science portrayed in the films (what they frequently refer to as "separating fact from fiction").

Before describing their course, they recount what existing literature suggests are potential pedagogical advantages to the instructional use of science fiction films. These advantages, they recount, are that films (1) help create lasting mental images that relate to scientific theory, (2) provide visual and enjoyable connections between scientific concepts and application, (3) enhance student interest in science because it connects science to relevant social issues, (4) and help students identify illustrations and violations of scientific principles.

The authors then describe two instructional episodes in which scenes from the movies "Red Planet" and "The Core" were used to engage students in critiquing the science depicted in the films. Based on student feedback, they posit three main instructional implications.

(1) The authors argue that film clips pique students' interest and maintain student engagement in lectures.
(2) They also argue that using film scenes can help instructors identify students' preconceptions about scientific topics, enhance class discussion, and introduce or reinforce a particular scientific concept.
(3) Last, they note that when showing movie scenes, instructors should expose students to a variety of clips that represent both good and bad science, and should frame the scene with questions either before or after the clip to ensure that students focus their attention on the relevant concepts represented in the clip.

Barnett, M., Wagner, H., Gatling, A., Anderson, J., Houle, M., & Kafka, A. (2006). The impact of science fiction film on student understanding of science. *Journal of Science Education and Technology, 15*(2), 179-191.

Noting the (potential) influence of popular media on student understanding of science, the authors examine the potential impact of The Core, a popular science fiction film, on middle school students' understanding of Earth science.

The authors found that a single viewing of the film influenced student ideas and conceptual understanding of scientific concepts. Specifically, they identified three themes that illustrate the impact of the movie on students:

(1) Student misunderstandings of Earth science concepts were built upon general scientific

plausibility established early in the film.
(2) A seemingly scientifically credible protagonist can influence acceptance of the movie's science (regardless of how accurate its portrayed).
(3) Movie images can be more memorable than hands-on in class experiences.

The authors discuss implications for science educators and film producers:

(1) For educators, they suggest that science fiction films be incorporated into curricula because they can capture the attention of students and foster discussions about the scientific concepts they portray.
(2) They also suggest that teachers be trained to evaluate science as presented in movies.
(3) Of potential interest to film creators, the authors note that student reception seems particular sensitive to films that establish an initial sense of scientific accuracy/credibility and that present scientific ideas in accessible ways.

Dhingra, K. (2003). Thinking about television science: How students understand the nature of science from different program genres. *Journal of Research in Science Teaching, 40*(2), 234-256.

Recognizing that televised science is likely to contribute to students' preconceptions about science, Dhingra explores how high school students at single-sex, private schools in an urban setting understand the nature of science from different television program genres.

Dhingra examines how high school students (*N*=63) think about science that is portrayed by four different program genres on television: documentary, magazine-format programming, network news, and dramatic or fictional programming. Using interviews, open-ended questionnaires, small group discussions, and free writing responses to gather data from students, Dhingra found that different TV program genres were related to different student perceptions of the nature of science. For example, key findings show:

(1) Network TV news and Dramatic programming (X-Files) were associated with students perceiving science as uncertain and more open to question.
(2) Whereas documentary TV (Wild Discovery) and magazine-format programming (Bill Nye) were associated with students perceiving science as comprised of established facts.

In light of her findings, Dhingra makes some noteworthy recommendations. He implies that creators of TV programming that is explicitly educational (e.g., magazine and documentary formats) should make more transparent the activities that produce scientific knowledge. Dhingra contends that this approach helps children understand that science is a socially situated human activity. Additionally, Dhingra suggests that TV producers show debate among experts from different fields and show different kinds of people (including males and females) as science practitioners. Dhingra also explores possible benefits of including TV science in the classroom, noting its potential to help them question, discuss, and critique what they view.

Dhingra, K. (2006). Science on television: Storytelling, learning and citizenship. *Studies in science education, 42*(1), 89-123.

In this synthesis of available research and literature, Dhingra examines how television can be used by educators to speak to the different forms and expressions of science-related citizenship, rather than be used in a way that considers the citizen simply an eager consumer of scientific information and applications.

This requires moving away from thinking of television and science communication more generally in terms of the "transfer" or "transmission" paradigm from experts to the public and students but rather through a "crosstalk" or interactive paradigm where there is an exchange of knowledge and perspectives among specialist experts and non-specialist members of the public. Incorporating television into formal education settings, argues Dhingra, can enable these important forms of cross-talk communication and enhance goals related to scientific citizenship.

Dhingra also notes that TV programs can be a powerful learning tool if incorporated into the classroom, since as cognitive flexibility theory concludes, to learn requires revisiting the same material at different times, in rearranged contexts, for different purposes, and from different conceptual perspectives. TV has the capacity to portray scenes from these multiple perspectives.

When compared with classroom instruction, TV programs can be used to enhance activities related to investigation, exploration, discussion, debate, experimentation, practice, and articulation.

Dhingra's review of relevant past research points to several considerations when choosing fictionalized film and TV portrayals to be used in the classroom, these include:

(1) The gender and race of the scientists and supporting characters portrayed. Previous research suggests that these portrayals can lead to gender or race-biased stereotypes about careers in science and that students, depending on their own gender or race background, may learn differentially from programs featuring more or less diverse characters.
(2) Past studies of children's educational programs also suggests that editing, sound effects, cuts, wipes, fades, dissolves, zooms, and special effects can either enhance or impair learning. Similar variables relative to fictional portrayals might also influence the memorability, vividness, and usefulness for classroom use of science-related presentations within chosen films or TV programs. More research is needed to more fully understand how these features combine to influence learning.
(3) How non-scientist characters are portrayed relative to scientists and science is also important. Are non-scientists portrayed as active participants in decisions, co-equals to scientists? Are scientist characters open to questions, suggestions, and leads from non-scientists in solving problems. Dhingra cites Simon (1999), a consultant who served on *The X-Files* series, in offering lead character Dana Scully as a ideal-type of scientist character: "Contrary to most students expectations about the nature of a scientists, one of the lead characters on the programme is portrayed as a person who does not have all the answers, but continues to question and problem-solve with other experts, and by other forms of research." (p. 105).
(4) The usability of a particular film or TV program will vary across students based on the

student's past experience. Dhingra refers to a past study where she observed that a 16 year old female student, already experienced with complex data sources and the use of specialized equipment, found the experiments depicted in Bill Nye to not seem representative of "real" science. Another student, a fifteen year old male and a regular viewer of The X-Files, was more comfortable than other students in discussing and applying elements of the plot to the class.

Dhingra concludes her review, by offering several questions for future research and attention that are directly relevant to efforts at successfully integrating fictionalized film and television into formal science education contexts.

(1) How can teachers be educated to see their role as educators in media literacy relative to science as a cross-cutting function, across a variety of academic disciplines, not just science?
(2) How can teachers be educated to appreciate and use television (or film) is a significant sociocultural phenonmena to which they can draw upon to enhance science learning?
(3) What strategies and techniques can educators use to transform film and TV viewing outside of the classroom away from just an entertainment or information gathering activity into one that is truly reflective, especially as regards the social and political context for science?
(4) What are the relevant interactions between classroom education, TV viewing, Web use, visits to informal learning contexts, discussion, and reading as apply to science learning?
(5) How can educators and scientists be socialized to think of communication and education not as a transmission process of scientific facts and rather as integral to a cross-talk, interactive process designed to facilitate public participation and two-way learning?
(6) How can research guide the production and design of entertainment TV and film in more productive ways?
(7) How can fictional TV and film productions be used to facilitate greater public participation and input?
(8) How can TV and film be used to explore and connect locally-relevant, community-based discussions and interactions?

Dubeck, L.W., S.E. Moshier, and J.E. Boss. 1995. Using science fiction films to teach science at the college level. *Journal of College Science Teaching*. 25(Sep./Oct.): 46-50.

The authors assert that the "American public has turned to pseudo-science as a way of understanding nature," citing as evidence the popularity of Star Wars, Jurassic Park, E.T., and Terminator, all films of "dubious scientific accuracy." The turn to pseudoscience is assumed to be a reaction to the perceived "evils" of technology, which the public may perceive as indistinguishable from science.
The authors posit that using science fiction films in physics and other science courses with appropriate supporting materials can correct anti-scientific attitudes among students, by moving them from experiences they find interesting in film to unfamiliar experiences they anticipate as dull and difficult such as learning physics, astronomy, and biology. According to the authors, creating a positive attitude toward science is the single most important outcome of using films in the classroom. The authors review the findings and experience from a one-semester course created in 1978 by Dubeck at Temple University titled "Science and Science Fiction in Film" which included undergraduates as well as science teachers. Experience and evaluations led to the following conclusions about the use of science fiction films in toto or segments:

(1) Based on anecdotal experience at the college level, Dubeck et al. report that attitudes of students towards science improved. The lone quantitative evaluation was applied to students in a high school setting, as part of use of film by 14 teachers across 9 high schools. In this evaluation, 75% of the test classes "showed a statistically significant improvement in student attitude toward science."
(2) Scientific principles illustrated or violated in film are better understood by students than if they are learned solely from more traditional approaches. In the quantitative evaluation of high school classes, 50% of the classes demonstrated a statistically significant improvement in knowledge.
(3) Screening and discussing the films significantly enhanced the understanding of science as a "rational process and discovery process." The authors believe this is important in helping students distinguish between science and pseudoscience.
(4) Films--through drama and by relating science to socially important issues--makes science more relevant to students.
(5) Films often deal with issues or topics from an interdisciplinary perspective, which is important, since students are not often taught science from an interdisciplinary perspective.

The authors also discuss the different techniques or "modes" for incorporating films into the course which might involve screening entire films in class or across classes; having students view film outside of class which enables them to pace their viewing across science-relative examples, but requires the library availability of the film; and screening only relevant segments from films.

Dubeck et al. describe their experience of screening segments from films in general education physics courses. About 35 film segments were used across the two-semester course, taking up about 10% of total class time. They report that the students were strongly positive in their reaction and generally more interested in the film clip discussion than traditional lecture segments. Examples of film clips include the giant rotating space station in *2001: A Space Odyssey* and the rotating space ship in the sequel *2010* where the artificial gravity produced by the station is accurately portrayed and the inaccurate presentation of "instantaneous" terra-forming portrayed in *Total Recall*.

The article also discusses methods for training faculty and teachers in using film in science education. Dubeck has conducted two-day and one-day short courses for faculty in physics and chemistry, with this time period considered effective and sufficient.

Fisch, S. (2000). A capacity model of children's comprehension of educational content on television. *Media Psychology, 2*(1), 63-91.

Though this study focuses on the production and effects of educational television on younger student learning, the principles reviewed and focus on the dual influence of both film narrative and education content on learning are of value to media producers. When viewers process film or TV content, they are constrained by the limited capacity of working memory. Unlike reading, watching film and TV draws on both visual and auditory information simultaneously usually in a context that is not self-paced i.e. the viewer is not able to go back and review content they did not understand. [With and

DVD and DVR technology, the ability to self-pace has increased, but the ability may not be commonly used or taken advantage of, except only among the highly motivated viewer.]

With limited capacity to recognize, access prior knowledge, draw inferences, and remember content, viewers are pulled between simultaneously paying close attention to narrative and any embedded educational content. For a number of different reasons, viewers default to paying closer attention and effort comprehending narrative over education content. As a result, when educational content is tangential or distant from the central narrative of a program, comprehension of the educational content is likely to be impaired.

A small distance between narrative and educational content corresponds to education content that is embedded in causal-chain events or the hierarchical structure of the central story. An example was an episode of "Square One TV," where the narrative in these segments featured mathematical detectives who helped a boy find hidden treasure by figuring out a series of puzzles which relied on applying a mathematical series of numbers called the Fibonacci sequences. A large distance corresponds to education content that is embedded in dead-end events, i.e. that do not forward the story. An example is a program about learning to play a musical instrument that included educational content about musical vibration. The two topics are not integral to each other since playing an instrument does not require understanding musical vibration.

When there is a greater distance between narrative and education content, this can be countered by increasing the motivation of the student viewers such as assigning the program or "co-viewing" the content in class with the student, where the instructor calls greater attention to educational content over narrative, though the tendency to process narrative over educational content is never abandoned entirely.

The implication is that in creating or choosing fictional films, TV programs, or video games to use in a classroom setting, science teachers and faculty should pay close attention to the distance between the central narrative of the film/program and the embedded educational content or example. The less distance there is between the two, the more likely that learning outcomes will be met.

Mares, M. L., Cantor, J., & Steinbach, J. B. (1999). Using television to foster children's interest in science. *Science Communication, 20*(3), 283-297.

Exploring ways to enhance science education in the U.S., Mares and colleagues conduct two studies examining how televised science programs can build student interest in science.

Study 1. Using an experimental design with 5th-grade students (*N*=79), the authors found the following results:

(1) Children learned information from the televised science segment.
(2) Children learned more when the info was in the form of a pop out from a feature story than when it was shown by itself.
(3) Children enjoyed the science segment, especially when it was combined with a feature story and not labeled as science.

Study 2. Using an experimental design with 4th- and 5th-graders (N=179), the authors found the following results:

> (1) Repeated exposure to a science magazine program—whether viewing was done in school or at home—was associated with students seeing science as an activity that is interesting, worthwhile, and fun.

In summary, the authors state that their studies show that TV programming with scientific content can positively contribute to students' science-related perceptions, whether its enjoyment of the show, knowledge gain, or positive attitudes toward science.

Rose, C. (2003). How to teach biology using the movie science of cloning people, resurrecting the dead, and combining flies and humans. *Public Understanding of Science, 12*(3), 289-296.

Based on his experience as a science teacher and in developing a course titled "Biology in the Movies," Rose explores the extent to which the scientific accuracy and plausibility of a movie's story line can influence the public's understanding of the related science. Using case studies of popular films like *Jurassic Park* and *The Sixth Day*, Rose considers the qualities of movies that potentially make them useful for furthering public understanding of science.

Rose's primary argument is that plausible ideas have far greater potential than accurate details to motivate the public toward a better understanding of science. He notes that films presenting plausible ideas are thought-provoking simply because they make people wonder whether the fictional science is possible, which enables numerous opportunities for teaching and learning about science.

Additionally, Rose discusses other related criteria that make films good teaching tools. These criteria include films that include (1) informed speculation about the possibilities of science, (2) information showing how the characters or the director are thinking about the science, and (3) sufficient information for the audience to formulate some level of understanding of a particular scientific concept, technique, or discovery. In closing, Rose notes that plausibility, unlike accuracy, is not at odds with good storytelling.

Of interest to science teachers, Rose lists the four questions he uses to guide student discussions about science fiction films:

(1) What is the additional science necessary to achieve the film's goals?
(2) What are the theoretical flaws or technical limitations that might make them impossible?
(3) Are there any real science analogies to the fictional science?
(4) And how do the goals and implications of the real science compare with the fictional treatment?

Rose, C. (2007). Biology in the Movies: Using the Double-Edged Sword of Popular Culture to Enhance Public Understanding of Science. *Evolutionary Biology, 34*(1), 49-54.

As a science teacher, Rose argues that movies provide opportunities to educate not by finding faults,

but by making connections. In this article, Rose explores how science teachers and popular science writers can use movies with genetics and developmental biology themes to clarify and deepen the public understanding of science, specifically ideas such as how genes control animal development and evolution, how cloning works, whether DNA is sufficient to create life, and how much genes matter in determining human behavior. Rose points out how he thinks use of films such as *The Fly* can be used as entry points for facilitating students discussions of these highly-relevant scientific issues, and urges teachers not to dismiss these opportunities based on the lack of accuracy commonplace in popular movies.

Steinke, J., Lapinski, M., Crocker, N., Zietsman-Thomas, A., Williams, Y., Evergreen, S., et al. (2007). Assessing media influences on middle school-aged children's perceptions of women in science using the Draw-A-Scientist Test (DAST). *Science Communication, 29*(1), 35.

Steinke et al. continue their line or research investigating how mass media contribute to children's perceptions of stereotypes relative to careers in science and engineering.

In this study they assess the efficacy of media literacy training designed to teach critical thinking about images of women, including women in science and engineering professions, in changing middle school students' perceptions of women scientists. Specifically they test two different media-literacy training conditions relative to a control.

The first condition focused on discussions of stereotypes and counter stereotypes of women in television programs and films. The second condition included viewing video clips of stereotypical and counterstereotypical images of women in television programs and films as well as discussions of stereotypes and counterstereotypes of women in the video clips.

The participants—304 seventh-grade students—were randomly assigned to one of the three conditions, asked to complete the DAST and to write down the source of information for their drawings. These are the main findings:

(1) Across conditions, girls we more likely to draw female scientists and boys were more likely to draw male scientists.
(2) Contrary to expectations, the media literacy interventions, both the discussion-only condition and discussion-plus-video condition, did not influence children's gender stereotyping of scientists.
(3) Boys across conditions also showed greater overall stereotyping of scientists than did girls on most of the other DAST stereotype variables.
(4) Both boys and girls cited television programs and films as the primary source of information for their drawings of scientists.

The authors offer some suggestions for why the media literacy interventions were ineffectual and consider how these interventions could be altered to produce greater positive effects. They recommend further research on media contributions to girls' science self-concept.

Stocklmayer, S.M., Rennie, L.J., & Gilbert, J.K. (2010). The roles of the formal and informal sectors in the provision of effective science education. *Studies in Science Education, 46* (1), 1-44.

In a state-of-the-art synthesis of relevant studies and cross-national reports, the authors propose a framework for incorporating "second space" informal science education-type activities and modes of learning into "first space" formal science education curricula. The result is a "third space" for science education that is likely to increase student engagement, clearly demonstrate the relevance of content, promote inquiry-based learning, provide for transdisciplinary contexts, and promote understanding of the social and historical context of science.

While not addressing the use of fictional film and television in the classroom, their framework and recommendations provide useful support and guidance on the functions that film use might have in formal science education. In short, structuring activities around carefully selected films can achieve some of the "third space" goals that Stocklmayer et al emphasize and their article provides a bigger picture context for where the use of fictional film in the classroom fits relative to broader reforms within science education.

Drawing on a conceptualization by Roberts (2007), the authors note that science education reform needs to shift from a "Vision I" narrow emphasis on the canon of orthodox science, its products, and processes and instead focus more on a "Vision II" emphasis which includes preparing students to:

> -Appreciate and understand the impact of science and technology on everyday life.
> -Take informed decisions about things that involve science, such as health, diet, use of energy sources.
> -Read and understand the essential points of media reports about matters that involve science.
> -Reflect critically on the information included in, and often more important omitted from reports.
> -Take part confidently in discussion with others about issues involving science.

Drawing on their own previous work (Rennie & Stocklmayer 2003), they add the following additional goals for science education as leading to:

> --people who feel that science and technology like within their interest and their personal lives.
> --people who feel that the nation's science is both their property and their responsibility.
> --people who are able to access new knowledge in science and technology and understand how it will affect their lives.
> --people who feel comfortable about processing relevant scientific information so that their personal areas of interest are well served
> --people who feel that their own knowledge and concerns are values by the scientific community.

Stocklmayer et al in their review argue that activities and programs developed in the informal learning sector at science centers, museums, and related community programs, if integrated into the formal education setting, are uniquely suited for achieving these Vision II goals.

In synthesizing available research on informal learning, they summarize in a valuable Table (page 25) the factors identified from the informal sector that enhance learning and individual engagement. These include:

(1) Affective factors such as providing for free choice, creating activities that are internally driven and challenging, encouraging wonder, delight, and awe, and making activities entertaining, interesting, and enjoyable.
(2) Factors related to learning science that include holistic, trans-disciplinary content; emphasis on transferring knowledge across contexts and drawing on student existing knowledge; emphasis on narrative; and presentations that are jargon-free and in the active voice.
(3) Factors related to learning *about* science that include drawing active connections to community, personal relevance, built around social interaction with others on the science topic; and presenting science as messy, human, and exploratory in nature, addressing real and current problems.
(4) Factors related to *doing* science that including facilitating inquiry based science using real contexts and real data and involving real projects and real outcomes.

They emphasize in their conclusion that if these factors from the informal sector are to be incorporated into formal education—creating a third space for learning—it has to be a holistic approach driven by systematic revisions to the education system rather than a piecemeal effort where individual educators or scientists experiment with strategies.

This article would seem to argue for the need to consider the introduction of fictional film within a larger science education reform framework.

Also of note, the article suggests the usefulness of after-school community programs that are partnerships between schools and informal learning institutions such as science centers. Fictional film might usefully be used within these settings as well.

Related studies and resources …

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Huckle, J. (1995). Using television critically in environmental education. *Environmental Education Research, 1*(3), 291-304.

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Phipps, M. (2010). Research Trends and Findings From a Decade (1997-2007) of Research on Informal Science Education and Free-Choice Science Learning. *Visitor Studies, 13*(1), 3-22.

Reiser, R. A., Williamson, N., & Suzuki, K. (1988). Using "Sesame Street" to Facilitate Children's Recognition of Letters and Numbers. *Educational Communication and Technology, 36*(1), 15-21.

Seels, B., Fullerton, K., Berry, L., & Horn, L. (1996). Research on learning from television. *Handbook of research for educational communications and technology* (pp. 299-377).

Stocklmayer, S., Rennie, L., & Gilbert, J. (2010). The roles of the formal and informal sectors in the provision of effective science education. *Studies in science education, 46*(1), 1-44.

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GAMES, VIRTUAL REALITY, AND SCIENCE EDUCATION

Annetta, L. A., Minogue, J., Holmes, S. Y., & Cheng, M. T. (2009). Investigating the impact of video games on high school students' engagement and learning about genetics. *Computers & Education, 53*(1), 74-85.

This study evaluated the incorporation of a Multiplayer Educational Gaming Application (MEGA) covering key genetics concepts into a high school biology courses. MEGA's are a new type of game where the instructor is the principal game author. Since the teacher designs and builds the MEGA,

they are more likely to effectively use the game as part of their teaching and courses. In addition, the customization of a MEGA by a teacher allows the game to better align with specific curricula content standards, with other traditional classroom activities, and with the teacher's experience with his/her students. Use of MEGA's however, requires specialized teacher training and support for early adopters of such games into the classroom.

Authors note that it is important that educators identify strategies for combining the time children spend playing video games and the time they don't spend on academic work. Because playing does not feel like "working," students are apt to spend more time with a game than they would reading related material or doing problems at the end of a textbook chapter. Apart from conjoining time spent learning and playing, there are two main mechanisms by which the authors believe MEGA-style games may enhance science learning:

(1) Drawing on Flow Theory, the authors posit that the more engaged and focused a student the greater the learning that will take place. Past studies show that student time spent on task is the most predictive factor in learning. Past research indicates that engagement is increased in high school students when the challenge of a task and their own skills were in balance and when encountering more problem-based activities. According to the authors, multi-player educational video games have the ability to increase engagement by introducing problem-based activities to students in a mildly competitive context. They also may be especially useful for students for whom traditional educational activities are not successful, adapting to their learning styles especially to decreasing attention span for students, who are less likely to move off-task with their attention when playing an educational game.

(2) Video games also employ heavy use of graphics and audio which can aid in learning through multiple-representations of scientific models and visualizations which enable students to better understand abstract concepts. Video games also consistently stimulate the student user, promoting constant, deliberate mental activity and putting the student in the participant role. This constant stimuli reduces some of the working memory demands on the players and thereby enhances the capacity for learning.

The MEGA used in the study was designed to enhance high school biology students' understanding of pedigress, Mendelian inheritance, blood types, and DNA fingerprinting through a problem-based crime science investigation mystery. Four biology courses in a South Eastern high school involving 61 students, equal in gender split, played the MEGA in pairs for 90 minutes using a PC-based desktop computer. The comparison group consisted of 63 students who did not play the game. Both the experimental and control group participated in a traditional classroom instruction on genetics. So the deisgn examined if playing the MEGA had enhanced impact on learning above and beyond that from traditional classroom instruction.

The experimental and control groups were compared relative to learning based on a post-exposure exam on the genetics unit and student engagement using a standard framework developed as part of the Protocol for Classroom Observations from the Annenberg Institute for School Reform. As an additional control, student grades on their last three report cards in the biology course were compared.

Results found no statistically difference in terms of performance on the unit exam across groups though students playing the MEGA exhibited higher levels of engagement. The authors posit that a single 90 minute period of game play might not be sufficient to enhance learning. Though the students exhibited engagement, the bulk of their time might have been spent on exploring the mechanics of the game and orienting to its environment rather than focused on the educational content. In addition, since the game experience was new, and students were asked to apply genetics knowledge to authentic problems, students may have focused on conflicts on what they perceived they learned in the traditional classroom setting, inhibiting game learning.

Bainbridge, W. S. (2007). The scientific research potential of virtual worlds. *Science, 317*(5837), 472-476.

In this article, Bainbridge discusses the virtual worlds and the potential they pose as rich sites for social scientific and economic research.

Bainbridge discusses the methodological benefits popular games such as Second Life (SL) and World of Warcraft (WoW) pose for researchers. Specifically he reflects on how these games are rich areas for doing social scientific and economic research via virtual laboratory experiments, observational ethnography, and analysis of social networks and economic markets.

Additionally, Bainbridge raises the potential of these virtual worlds to enhance their users' scientific habits of mind (e.g., socialization to group norms, learning intellectual skills, and expressing individuality). This article provides useful background on virtual worlds and their promise in education and research.

Barab, S., & Dede, C. (2007). Games and immersive participatory simulations for science education: an emerging type of curricula. *Journal of Science Education and Technology, 16*(1), 1-3.

Barab and Dede introduce this special issue of the Journal of Science Education and Technology focused on understanding how games and immersive participatory simulations, with their focus on doing science (not receiving science), are becoming an emerging type of curricula for supporting science education.

This article provides excellent perspective for educators interested in the state of research examining MUVEs in science education. Barab and Dede share their impressions of this issue, noting the great potential communication technologies have to help students' inquiry and provide rich learning experiences.

They also summarize overarching insights from the research articles in this special issue, among them:

> (1) Game-like virtual learning experiences can provide a strong sense of engagement and opportunities to learn for all students.
>
> (2) Game-like virtual learning experiences have the potential to establish participatory narratives that can aid learners in developing a contextual understanding of what are all too

often presented as decontextualized scientific facts, concepts, or principles.

Overall, Barab and Dede note that the collection of research articles in this special journal edition show that game-based technologies and methodologies provides a powerful potential for supporting deep and engaging science learning.

This article is a must read overview for educators who are interested in classroom VR.

Dede, C. & Barab, S. (2009). Emerging Technology for Learning Science: A Time of Rapid Response. Journal of Science Education and Technology, 18: 301-304.

As the introduction to a special issue of the journal focused on emerging technology for use in science education, Dede and Barab describe three main forms of technology-based instructional tools and a fourth use of technology that is an overlooked source of informal learning.

(1) The use of Web 2.0 tools that enhance learning by promoting creativity, collaboration, and sharing. These Web 2.0 media can be categorized into:
    a. *Sharing tools* such as communal bookmarking, photo/video sharing, social networking, writer's workshops, social networking, and fan fiction.
    b. *Thinking tools* such as blogs, podcasts, online discussion forums
    c. *Co-creating tools* such as Wikis, collaborative file creation, mashups/collective media creation, collaborative social change communities
(2) Augmented realities, a learning context where students are immersed in a combination of virtual and real settings. In augmented reality educational techniques, students use handheld devices such as smart phones which allow them to physically move though a real-world location while collecting location-dependent simulated field data, interview virtual characters, and collaborative investigate simulated scenarios
(3) Multi-user Immersive Environments, virtual worlds and games where students access buildings and labs, interact with digital artifacts and tools, and represent themselves through avatars, and communicate with other avatar students or virtual agents.
(4) Commercial multi-player game discussion forums are representative of a context not intended to facilitate science learning but may actually serve informal learning purposes. Dede and Barab note a study examining player interaction via the World of Warcraft that identified observed players voluntarily engaged in many of the scientific negotiation practices teachers struggle to elicit students to adopt in formal school contexts. How to leverage complex game spaces to foster meaningful dialog in a way that a community evolves their knowledge through complex scientific discourse remains a topic worthy of further investigation and experimentation.

Dede and Barab assert that these new emerging technologies represent a shift from the passive acquisition of someone else's ideas to active learning experiences that empower people to inquire, critique, create, collaborate, problem solve, and create understanding. This new learning freedom

could also however increase the probability that students acquire information that is inconsistent with scientific understanding.

Gerber, S., & Scott, L. (2010). Gamers and gaming context: Relationships to critical thinking. *British Journal of Educational Technology*.

Gerber and Scott provide an empirical test of the relationship between gaming and the development of critical thinking skills. They examine differences between gamers and non-gamers as well as game context on the development of these higher-level cognitive skills.

Using an online survey sent to undergraduates and gaming forums, the authors find the following main results:

(1) Gamers tend to be college-age males. (Of course, that's mostly who they surveyed.)
(2) Contrary to their theoretical estimates, gamers and non-gamers exhibit similar critical thinking dispositions.
(3) Gamers who play less (<2 hours) have higher critical thinking skills than those who play more (>2 hours).
(4) Less involvement with the gaming community (i.e., following gaming news, having more friends involved with gaming) is associated with higher critical thinking skills.
(5) Strategy is the only gaming genre associated with higher critical thinking skills.

Collectively, the results suggest that gaming, writ large, is not associated with the development of critical thinking skills, but that more nuanced use of gaming contexts are worthwhile. For example, playing strategy games and limiting gaming involvement are both associated with higher critical thinking dispositions.

Lim, C. P., Nonis, D., & Hedberg, J. (2006). Gaming in 3D multiuser virtual environment: Engaging students in science lesson. *British Journal of Educational Technology*, *37*(2), 211–231.

Based on the exploratory study of how *Quest Atlantis (QA)*, a multiuser virtual environment (MUVE) is used in a series of science lessons to support learning engagement among 10- to 11- year-old students. Lim and colleagues examine issues of learning engagement and describe the context of QA's implementation by highlighting the core challenges and tensions.

Using multiple methods of data collection (e.g., pretest posttest questionnaires, interviews, observations and students' work), the authors examined how QA contributed to 8 students' learning engagement about science. [Please see the abstract and article for the specific findings.]

Of particular interest to educators, the authors highlight three ways in which MUVEs can be used to engage students in science:

(1) Teachers must analyze students' competencies so that timely computer competencies can be taught and appropriate scaffolding can be built into the lesson. This enables students to maximize their engagement in the 3D MUVE context for the learning of science concepts.
(2) Teachers spending time to demonstrate and orient their students to the MUVE context so

that they can succeed.
(3) Teachers working to ensure students engage in learning tasks while in the MUVE context.

The authors recommend promoting dialogue among education researchers and practitioners about the design of MUVEs and the reconfiguration of learning activities in schools to enhance long-term engagement of students in science.

Messinger, P., Stroulia, E., Lyons, K., Bone, M., Niu, R., Smirnov, K., et al. (2009). Virtual worlds—past, present, and future: New directions in social computing. *Decision Support Systems, 47*(3), 204-228.

This paper provides an excellent overview of virtual worlds and serves as a logical entry-point for audiences interested in virtual worlds (e.g., Second Life). That said, the content of the paper is broad and not focused on how virtual worlds can contribute to science learning. The authors do, however, briefly explain "education-based virtual worlds" (see pps. 207-208).

Nilsson, E., & Jakobsson, A. (2010). Simulated sustainable societies: students' reflections on creating future cities in computer games. *Journal of Science Education and Technology*, 1-18.

Interested in the educational potential of computer games, the authors examine the urban simulation computer game *SimCity 4* as a potential facilitator for science learning contexts. The case studied is Future City 1 a national competition for Swedish students (ages 12–15) who take on the role of urban planners, with the mission to create sustainable cities in SimCity 4. Specially, the authors are interested in how interactions in gaming environments can support students' reflections on simulated ''real'' world problems, and how students contextualize and use their scientific knowledge in this learning environment.

Using focus groups interviews and video recordings of the study participants, the authors find:

(1) Most students were able to use and apply the scientific concepts embedded in their game experience in a relevant way. Students related the concept of 'sustainability' to issues concerning quality of life for citizens, which involved ecological, social, and economical factors concerning their cities.
(2) Students' reflections also made certain misunderstandings obvious (e.g., some students did not express an awareness of the link between the combustion of fossil fuels, carbon oxides, and global warming).
(3) Different levels of student abilities exist when it comes to using science concepts in a contextualized and complex problem-solving situation.
(4) Computer games, such as SimCity 4, used in meaningful science classroom contexts, may contribute to an educational situation where reflections on the embedded scientific content are facilitated and made explicit by teachers and/or peers.

The authors conclude that computer games can contribute to meaningful educational situations in science classrooms, such as facilitating students' use of scientific concepts and theories.

Neulight, N., Kafai, Y., Kao, L., Foley, B., & Galas, C. (2007). Children's participation in a virtual epidemic in the science classroom: Making connections to natural infectious diseases. *Journal of Science Education & Technology, 16*(1), 47-58.

Interested in how various forms of participatory simulations can teach students about infectious diseases the authors investigate the integration of *Whyville*, a multi-user virtual environment (within classroom curriculum about infectious disease.

In this study, 46 sixth-grade students became members of Whyville and were able to access the website at home and during science class where they learned about infectious diseases. The students created avatars in Whyville, which experienced the outbreak and spread of a virtual epidemic called Whypox during a 4-week period. The authors then investigated the integration of Whypox within the science classroom curriculum and its relationship to students' understanding of natural infectious diseases.

Using surveys and analysis of videotaped classroom activities and discussions, the authors reach the following results:

(1) The students and the teacher mentioned, if not discussed, major terms and concepts of infectious disease.
(2) The student and the teacher often compared symptoms, preventions, or aspects of Whypox to those experienced in their everyday lives or from their previous studies on natural infectious diseases.
(3) The students and the teacher used Whypox to understand natural infectious disease through immersion.
(4) The students perceived several features of the virtual infectious disease as features inherent in natural infectious diseases (e.g., being contagious, having symptoms, etc.)
(5) Twice as many students reasoned about natural infectious disease with a biological reasoning at the end of the study.

Overall, this study contributes to the growing literature on participatory simulations on infectious diseases. Their results suggest that integrating MUVE games into the curriculum, stimulated teacher–student discussions about the causes and spread of virtual and natural diseases.

(For more information on WhyVille and the Whypox epidemic, see Foley & LaTorre, 2004.)

Srinivasan, S., & Crooks, S. (2005). Multimedia in a science learning environment. *Journal of Educational Multimedia and Hypermedia*, *14*(2), 151–167.

In this literature review, the authors first explore multimedia; its definition, its history and development, and its potential to enrich science learning. They then review what is know about how teachers use/regard multimedia in learning environments, and reflect on theoretical and conceptual orientations that can facilitate research examining the relationships between multimedia and learning.

The authors finish their review with some general recommendations, which include the following:

(1) The use of multimedia is advantageous, but only if it is interactive and allows its users to control it. In other words, the user has to be an active participant rather than a passive observer.
(2) Multimedia also allows for easy integration into the curriculum and instruction standards, especially when most of Mayer's principles are followed.
(3) They list some common barriers to maximizing the use of multimedia in the classroom, including confusing software, overcoming anti-technology bias, etc.

There review contains some useful background information about the use of multimedia in science learning.

Wofford, J. (2009). K-16 Computationally Rich Science Education: A Ten-Year Review of the Journal of Science Education and Technology (1998-2008). ***Journal of Science Education and Technology, 18*****(1), 29-36.**

This article reviews a decade of research across areas of technology use in science education appearing in the Journal of Science Education and Technology (JSET). Of specific interest, Wofford describes the number of studies appearing specific to Multi-User Online Virtual Environments (MUVEs) which are defined as a "digital, 3D environment that allows multiple simultaneous participants to access virtual contexts, to interact with digital artifacts, to represent themselves through avatars, to communicate with other participants and with computer-based agents, and to enact collaborative learning activities of various types." According to Wofford, shared characteristics of MUVEs include "students immersive role play, a nonlinear narrative that frames a research problem; non player characters that provide information required for problem solving, and collaborative learning and play.

In 2007, JSET published a special issue focused on MUVE games which included:
Astronomy Village, a NASA sponsored multi-media curriculum where students learn image processing and program star-related simulations; *Mad City Mystery*, a murder mystery game where students find a death as a result of toxic chemicals found Lake Mendota Wisconsin, the game involves additionally the use of PDAs and cell phones to interact with the realworld environments; *Outbreak at the Institute*, a game where students use hand-helds to contain a biological virus that is spreading on a university campus; *Whyville*, a MUVE where middle-school students using avatars are asked to contain a viral infectious disease, the game involves chat, a discussion board, and email; *QuestAtlantis*, a game for fourth-graders involving a virtual park that is experiencing water quality problems, students learn environmental science and earth science along with social and ethical topics; and *RiverCity*, an active-worlds environment set in the late 1800s where students use 3D technology and an internet browser to investigate the sources of an illness.

Related studies and resources …

Aldrich, C. (2005). *Learning by doing: A comprehensive guide to simulations, computer games, and pedagogy in e-learning and other educational experiences*. San Francisco: Wiley.
Annetta, L., Folta, E., & Klesath, M. (2010). Learning, psycho-cognition, and flow. *V-Learning*, 109-123.
Baker, S., Wentz, R., & Woods, M. (2009). Using virtual worlds in education: Second LifeÆ as an

educational tool. *Teaching of Psychology, 36*(1), 59-64.
Barab, S., Scott, B., Siyahhan, S., Goldstone, R., Ingram-Goble, A., Zuiker, S., et al. (2009). Transformational Play as a Curricular Scaffold: Using Videogames to Support Science Education. *Journal of Science Education and Technology, 18*(4), 305-320.
Bourgonjon, J., Valcke, M., Soetaert, R., & Schellens, T. (2010). Students' perceptions about the use of video games in the classroom. *Computers & Education, 54*(4), 1145-1156.
Crandall, R. W., & Sidak, J. G. (2006). *Video games: Serious business for America's economy*. Washingtod, DC: Entertainment Software Association.
Gee, J. P. (2003). *What video games have to teach us about learning and literacy*. New York: Palgrave Macmillan.
Hansen, M. (2008). Versatile, immersive, creative and dynamic virtual 3-D healthcare learning environments: a review of the literature. *Journal of medical Internet research, 10*(3).
Jayakanthan, R. (2002). Application of computer games in the field of education. The Electronic Library, 20(2), 98–102.
Linn, M. C. (2004). Using ICT to teach and learn science. In R. Holliman & E. Scanlon (Eds.), *Mediating science learning through information and communication technology*. London: Routledge Falmer.
Prensky, M. (2000). *Digital game-based learning*. New York: McGraw-Hill.
Rowe, J., Shores, L., Mott, B., & Lester, J. (2010). *Individual differences in gameplay and learning: a narrative-centered learning perspective.* Paper presented at the Proceedings of the Fifth International Conference on the Foundations of Digital Games.
Salmon, G. (2009). The future for (second) life and learning. *British Journal of Educational Technology, 40*(3), 526-538.
Squire, K. (2006). From Content to Context: Videogames as Designed Experience. *Educational Researcher, 35*(8), 19-29.
Shaffer, D. W. (2006). *How computer games help children learn*. New York: Palgrave MacMillan.
Tomlinson, B., Black, R., Yau, M., & Baumer, E. (2008). A participatory simulation for informal education in restoration ecology. *E-Learning and Digital Media, 5*(3), 238-255.

USE OF TV, FILM, AND MULTI-MEDIA IN INFORMAL LEARNING ENVIRONMENTS

Bell, P., Lewenstein, B., Shouse, A. W., & Feder, M. A. (2009). *Learning Science in Informal Environments: People, Places, and Pursuits*. Washington D.C.: National Academies Press.

This is a chapter from the report, "Learning Science in Informal Environments: People, Places, and Pursuits," compiled for the National Academies in 2009. This chapter provides a literature review on the role of media in informal science learning.

The chapter structure is as follows:

(1) Summaries of how different media are associated with science, including print media, educational broadcast media, popular film and TV, giant screen film and other immersive media, digital environments.
(2) The authors then explore the role of media in particular venues and configurations for science learning, including everyday and family learning, designed settings (e.g., museums, zoos), and programs for science learning (e.g., after school programs).

(3) Based on these summaries, the authors then discuss 5 cross-cutting themes or issues, which include:

- Who uses media to learn science in informal environments.
- Questions of identity.
- The importance of format.
- Science as a process (e.g., learning scientific practice; that is, learning how to execute and plan scientific investigations).
- The need for longitudinal and cross-media studies.

In their final remarks, the authors note that science-related media are likely to continue to play a major role in the ways that people learn about science informally. Based on extant literature and informed estimates, they also note the potential for science-related media to help learners develop initial interests in science and to influence people's perceptions of science and scientists.

This chapter provides a useful overview and would be of interest to both entertainment content producers and educators interested in informal science learning. (Also see Rockman et al., 2007).

Chen, M. (1994). Television and informal science education. In V. Crane, H. Nicholson, M. Chen & S. Bitgood (Eds.), *Informal science learning* (pp. 15-59). Dedham, MS: Research Communications.

In this chapter, Chen provides a useful overview of TV in information science education. Chen explores the reasons for the lack of research in this issue. These reasons include:

(1) Methodological and theoretical challenges to studying TV (e.g., experiments and surveys aren't sufficient; qualitative and quantitative are needed).
(2) A lack of funding, and little formative and summative evaluation research.
(3) The "producer-driven" nature of such programs.
(4) Little transfer across social science disciplines on this subject.

Chen also discusses preliminary research in this area, noting results indicating that TV can share science knowledge by introducing new concepts and information, broaden viewers pre-conceived feelings about science, and stimulate interest in science (info-seeking and more learning experiences). Chen then recommends future research on TV as an informal science-learning tool that:

(1) Combines research from different disciplines.
(2) Examines long-term effects.
(3) Considers effects on all ages (more research on adults).
(4) Considers TV (media) influence alongside other informal learning factors (e.g., interpersonal discussion).

Although dated, Chen's discussion of research on TV's role in informal science education is still instructive. Indeed, Chen's directions for future research are still relevant.

Falk, J. H. (2002). The contribution of free-choice learning to public understanding of science. [Editorial Material]. *Interciencia, 27*(2), 62-65.

In this article, Falk calls attention to the importance of the free-choice learning sector. “Free-choice learning” refers to lifelong learning that is intrinsically motivated and largely under the choice and control of the learner, and includes learning via media, family, friends, community organizations etc. He explores the notion of free-choice learning in detail and argues that it has been consistently under-appreciated by government and policy makers.

Citing his previous research, Falk says there is strong evidence that a significant percentage of all lifelong science learning occurs within the free-choice sector. Falk then notes that free-choice science learning is likely to increase given the rapid growth of the Information Age and advocates that decision-makers in the area of educational policy and practitioners recognize the critical role this type of learning plays in public understanding of science.

Overall, this article provides useful background on the issue of informal science learning.

Fisher, M. S. (1997). The effect of humor on learning in a planetarium. *Science Education, 81*(6), 703-713.

Fisher tests the extent to which humor in a planetarium show influences retention of instructional material in audience members with hopes that their work can be brought to bear on the use of humor to enrich classroom learning.

Adult planetarium visitors (*N*=495) took part in the experiment, which used two versions of a 15-minute show (one version without humor, the other with humor inserted) and follow-up questionnaires that measured participants’ short-term retention of the information included in the show.

Fisher finds that in terms of recall, subjects who saw the humorous show scored slightly lower than the visitors who saw the non-humorous show. Fisher concludes saying that the use of humor in an educational setting can actually have a negative effect on learning.

Flagg, B. N. (1991). Visitors in front of the small screen. *Association of Science-Technology Centers Newsletter, 19*(6), 9-10.

Flagg discusses the use of two-dimensional video screens in museum exhibits. First, Flagg discusses the effectiveness of video screens at attracting visitors, noting various ways in which they successfully garner visitor attention (e.g., they're used more often when placed in high-traffic areas).

Flagg then discusses the ability of video screens to hold visitor interest, noting, among other things, that the educational design of an exhibit matters more to visitor retention than the technologies it contains. Flagg also notes that visitor interest is retained more effectively when the tech interfaces are simple to understand and navigate.

Last, Flagg discusses what is known about the effects of video screen museum exhibits. She cites

research showing that (1) visitors read more when interacting with tech than conventional exhibits, and that (2) video screens contribute positively to visitors' knowledge gain.

Flagg acknowledges the need for more research, but concludes that the limited evidence suggests that computer/video technology in museums can be successful learning tools (e.g., they can attract visitors, hold their attention, and contribute to positive cognitive and affective outcomes).

Foley, B. J., & La Torre, D. (2004). Who has why-pox: A case study of informal science education on the net. In Y. B. Kafai, W. A. Sandoval & E. N. (Eds.), ***Proceedings of the sixth international conference on the learning sciences*** **(pp. 598). Mahwah, NJ: Lawrence Erlbaum Associates.**

Foley and LaTorre explore the impact of "Why-Pox" on the community in the MUVE, Whyville. "Why-Pox" was a virtual virus released by the managers of Whyville with hopes of making science a more ubiquitous topic on the site. To examine the effect of "Why-Pox", the authors examined chat transcripts from the site, the Why-Pox specific bulletin boards, and the articles from the Whyville Times. The authors found that Why-Pox was highly successful at raising the profile of science topics on the site (e.g., chat about science topics increased x200 because of the Why-Pox) and motivating users to explore the virtual CDC, where users could learn about the disease.

The Why-Pox event increased interest in science and learning about science on the site and, the authors conclude, hints at the potential for MUVEs to help people to learn about science and health issues.

Rockman Et Al. (1996). ***Evaluation of Bill Nye the Science Guy: Television series and outreach*****. San Francisco.**

Rockman ET AL, an independent research group, produced this examination of the TV show Bill Nye The Science Guy for PBS. The evaluation was charged with exploring the impact of the series on children at home, in school, and in other settings where children can watch television. Science learning outcomes, attitude change, and the impact of the series on girls and minority children were of particular concern.

School and home viewers were recruited from three US locations to participate. Using a comprehensive methodology, assessment material was collected from 1,350 children in schools (800 in the viewing group and 550 in comparison classrooms) and ~400 children completed interviews with project researchers at the beginning and end of the study.

Overall, the aggregate findings show that the BILL NYE program enhances children's science understanding, especially in connection with higher order thinking skills and critical thinking. Additionally, the interviews reveal that viewers of BILL NYE from home or school, or both, increased their active exploration, observation, and hypothesis generation.

Some other notable findings include:

> (1) There is little change in children's attitudes towards science as a consequence of viewing the BILL NYE series. (They probably already have positive attitudes toward science.)

(2) Girls may not always begin with the same knowledge base as boys, but they often come nearer to closing the gap after viewing the series. When gains in science knowledge and scientific thinking are seen, girls improve as much or more than boys.
(3) Where improvements in knowledge and thinking were seen, minority students gained as much or more than majority students. However, these children, too, started with less knowledge than majority children and began to come closer to parity.
(4) Watching BILL NYE promoted family interaction; almost all parents (92%) reported watching it with their child at least once and 92% said their child talked to them about the show.

In light of these results, it seems BILL NYE is an exemplar of the type of TV show that educators and entertainment producers can create with goals of improving informal science learning.

Rockman, S., Bass, K., & Borse, J. (2007). ***Media-Based Learning Science in Informal Environments Commissioned Paper*****: Prepared for Learning Science in Informal Environments Committee of the National Research Council National Academy of Science.**

Similar to Bell et al. (2009), this report attempts to provide an overview of media-based science learning in informal settings. The authors try to synthesize the few research studies and many professional evaluations that have sought to identify the outcomes of media-based science learning programs. The report is organized around the following questions:

(1) What is the nature and quality of the evidence on media as a tool for learning science?
(2) What are the defining characteristics of learning from media? Are they different across the types of media? Are they different across audiences?
(3) To what extent have traditional theories of learning informed the design and evaluation of media in informal science environments?
(4) How can theories of learning be brought to bear on media design and evaluation?
(5) What are the methodological challenges in conducting studies on the impact of media on learning? What methodologies have been most effective?

In their final remarks, the authors state, "It is surprising how little we know from the research on science media intended for the adult general audience." They then suggest some future research needs, which include:

(1) Improved assessment of depth of understanding and behavior (especially increased use of social scientific theory).
(2) Cumulative, long-term studies (i.e., longitudinal studies) of multiple influence on science learning.
(3) Assessments of groups and dyads, not just individuals.
(4) More sophisticate analytical procedures testing relationships between attitudes and behaviors.
(5) Clearer, more sophisticated conceptualizations and operationalizations of crucial concepts (e.g., "attitudes toward science").
(6) More comprehensive sampling.

The authors also provide a list of additional (more specific) suggestions. See page 29-32 of the report.

Like the Bell et al. (2009) chapter, this report provides a useful overview of media contributions to informal science learning. This report is a helpful entry point for anyone interested in this topic. That said, the utility of this report is restricted because it lists so few of the studies it claims to summarize. This prevents readers from going deeper into the literature and makes it hard to evaluate the quality of the report's synthesis and recommendations.

APPENDIX: ENTERTAINMENT EDUCATION AND HEALTH

Bouman, M. (2002). Turtles and peacocks: Collaboration in entertainment-education television. *Communication Theory, 12*(2), 225-244.

Bouman explores the (dis)connections between the health communication professionals and television professionals who collaborate on the creation and implementation of Entertainment-Education (E-E) TV programs. This article contains a useful literature review about E-E, including an explanation of the type of E-E partnership agreements, and their four stages (orientation, crystallization, production, implementation).

Grounded in Bourdieu's general theory of practice, Bouman analyzes the collaborative processes of E-E teams using interviews of the health communication and television professionals involved with the creation of 12 Dutch TV productions that used the E-E strategy.

Not surprisingly, he finds that these relationships are incredibly complex, noting that the TV professionals tend to dominate the process. Bouman argues for a more equitable partnership between TV and health communication professionals in this context, noting the need for both fields to better understand their objectives and frames of reference. More specifically, Bouman argues that new incentives are needed to develop these joint frames of reference. For example, Bouman suggests that professional standards to create E-E programs be established and that these standards stress audience-centered approaches. He also suggests that all E-E partnerships begin with workshops and briefing retreats that acclimate participants to the project. Additionally, Bouman suggests that health organizations become more TV literate and pro-active when it comes to establishing beneficial E-E partnerships.

Byrd-Bredbenner, C., Finckenor, M., & Grasso, D. (2003). Health related content in prime-time television programming. *Journal of Health Communication, 8*(4), 329-341.

Citing a gap in the literature, the authors seek to identify, content analyze, and describe the health-related content (HRC) presented in the popular prime-time network (i.e., ABC, CBS, NBC, Fox, and WB) programs targeting the ages 2 to 11 year-old category. The results include the following:

(1) Viewers see one HRC-containing scene approximately every four minutes.
(2) The greatest amount of program time that included HRC focused on food/nutrition.
(3) Overall, the least common types of HRC focused on drug abuse, smoking, mental health, and promiscuous sex.

(4) Longest length HCR scenes were smoking and medical treatment. Shortest length HCR scenes were of drug abuse.
(5) The HRC was seldom directly related to the main point of the scene.
(6) The characters involved in HRC-containing scenes most frequently were white, male, and slender.
(7) The overall valence of HCR scenes were mixed: about half positive and half negative.

While the analysis was thorough, it must be noted that the sample consists of only one week of coverage, and that no intercoder intercoder reliability assessment was conducted. Without this assessment it's impossible to evaluate the quality of the findings.

Cottone, E., & Byrd-Bredbenner, C. (2007). Knowledge and psychosocial effects of the film Super Size Me on young adults. *Journal of the American Dietetic Association, 107*(7), 1197-1203.

The authors examine the effect of the film *Super Size Me* on young adults' fast-food knowledge and psychosocial measures (i.e., attitudes, self-efficacy, healthy weight locus of control, and stage of change) and evaluate the effectiveness of this film as a form of emotional arousal and consciousness-raising.

Using an experimental design (*N*=135), the authors find the following results:

(1) The study groups did not differ significantly on any measure at pretest.
(2) The experimental group's mean follow-up knowledge score was significantly higher than that of the control group.
(3) The experimental group's mean follow-up score for Feelings About the (Un)Healthfulness of Fast Food was significantly higher than the that of the control group (i.e., they believed fast food was less healthful immediately after seeing Super Size Me).
(4) The experimental group's mean score on the Personal Concern about Maintaining a Healthy Weight scale was significantly higher than the control group at the posttest, indicating that they were more concerned about maintaining a healthful weight after seeing Super Size Me. But this significant difference was not retained at the follow-up test.
(5) At posttest, the experimental group had significantly higher consciousness of maintaining a healthy weight after seeing Super Size Me than the control group. At the follow-up test, mean scores between these groups remained significantly different from each other.

Overall, the experiment shows that viewing the film Super Size Me led to an increase in knowledge of nutrition, fast food, and obesity-related health conditions that persisted at least an average of 9 days after viewing this film. Viewing the film also had positive, short-term effects, such as personal concern about maintaining a healthy weight, and self-efficacy related to minimizing the consumption of fast food. Of interest to educators, these results suggest that Super Size Me can be a positive tool toward empowering people to lower their intake of fast food.

Chew, F., Palmer, S., & Kim, S. (1995). Sources of information and knowledge about health and nutrition: Can viewing one television programme make a difference? *Public Understanding of Science, 4*(1), 17-39.

This study was designed to examine the long-term influence of a one-hour TV program, Eat Smart, on informing and educating the public about a critical public health issue, healthy eating habits.

Using a strong methodology (e.g., a three-stage national longitudinal study), Chew and colleagues reached the following results:

(1) Across all groups, nutrition knowledge increased after viewing Eat Smart and across the stages.
(2) Media users had higher knowledge than non-media users.
(3) Watching the program Eat Smart led respondents to an increased use of TV and newspapers as sources of health information.

In sum, Chew et al. note that viewing the TV program Eat Smart (1) was associated with increased knowledge levels of nutrition that, mostly, remained five months after viewing the program, and (2) stimulated use of different info sources for health info.

This study provides an empirical example of how a TV program can contribute positively to audience comprehension of a health issue. It must be noted, however, that the study's lack of a control group attenuates the findings.

Chory-Assad, R. M., & Tamborini, R. (2001). Television doctors: An analysis of physicians in fictional and non-fictional television programs. *Journal of Broadcasting & Electronic Media, 45*(3), 499-521.

Using a quantitative content analysis, the authors examined televised depictions of physicians. Notable findings include the following:

(1) Physician depictions were mostly positive in terms of their personal characteristics, though not as positive as earlier research found in 1992.
(2) Physicians are depicted differently across programming genres (e.g., they're often sexier and more stylish on soap operas).
(3) Fictional TV programs depict doctors more negatively than non-fictional programs.
(4) There were minimal differences in doctor portrayals based on sex and race.

The authors also provide a nice synthesis of extant research examining television portrayals of physicians.

Chory-Assad, R. M., & Tamborini, R. (2003). Television exposure and the public's perceptions of physicians. *Journal of Broadcasting & Electronic Media, 47*(2), 197-215.

Chory-Assad and Tamborini extend their earlier work by testing how television viewing contributes to public perceptions about physicians. The analysis is guided by an assumption that the increasingly

negative portrayals of TV doctors may lead to decreased public confidence and trust in physicians.

Using a survey, respondents were asked to report their exposure to numerous genres of TV programming (including prime-time doctor shows) and, among other things, to rate their perceptions of physicians. Results include:

> (1) Viewers of prime-time doctors TV shows were more likely to have more negative perceptions of doctors' ethical character, regard for others, and composure.
> (2) Viewership of other TV genres had mixed results: frequent prime-time news magazine viewers were more likely to perceive scientists as competent; viewership of network news and daytime talk shows were more likely to perceive scientists as being attractive.
> (3) Aggregate TV viewing was not linked with perceptions of doctors.
> (4) The strongest predictor of perceptions of doctors was direct personal experience (i.e., the medical outcomes experienced by respondents after being seen/treated by physicians.

Overall, the authors found evidence of what they suspected: prime-time doctor TV shows, which they previously found to have become more negative than years before, are associated with more negative perceptions of doctors. While this study was strong both theoretically and methodologically, it must be noted that the sample was comprised of undergraduates and that the data was cross-sectional.

Hether, H., Huang, G., Beck, V., Murphy, S., & Valente, T. (2008). Entertainment-education in a media-saturated environment: Examining the impact of single and multiple exposures to breast cancer storylines on two popular medical dramas. *Journal of Health Communication, 13*(8), 808-823.

Concerned with how Entertainment-Education (E-E) initiatives to provide health information in primetime TV might be mitigated by the increasingly media-saturated media environment, Hether and colleagues examine the usefulness of a repeated-message approach to E-E. Specifically, they test the effectiveness of repeating similar health messages about a breast cancer risk on multiple primetime TV shows (ER and Grey's Anatomy).

Using a panel survey with three time points (*N*=599 females), the authors found the following results:

> (1) The individual ER and Grey's Anatomy storylines were similarly effective in the number of outcome variables they impacted, but the storylines influenced different outcome variables (e.g., knowledge, attitudes, behavioral intentions and behaviors). (See Table 5 for a breakdown of these effects.)
> (2) The study's most notable finding is that exposure to both storylines (i.e., seeing the ER program and the Grey's Anatomy program) was associated with change on more outcome measures than viewing either storyline alone.

Petraglia, J. (2007). Narrative intervention in behavior and public health. *Journal of Health Communication, 12*(5), 493-505.

Petraglia explores how to improve narrative interventions (primarily those referred to as "Entertainment-Education") aimed at public health issues. Specifically, Petraglia tries to diversify the conceptual and theoretical frameworks that underlie E-E approaches by considering philosophical and cognitive approaches for narrative.

Reflecting on this literature, Petraglia makes four primary suggestions about how to enrich narrative intervention on public health issues. They include:

(1) Understanding the limited applicability of the behavior change approach in non-Western contexts.
(2) Placing an increased emphasis on reception, rather than just the production of messages.
(3) Understanding the differences between messaging versus providing an alternative worldview.
(4) Understanding the inherent complexities when it comes to evaluating narrative interventions.

Overall, this article provides a useful exploration of considerations that have the potential to enrich the efficacy of narrative interventions on public health issues.

Slater, M. D., & Rouner, D. (2002). Entertainment-education and elaboration likelihood: Understanding the processing of narrative persuasion. *Communication Theory, 12*(2), 173-191.

This article is a useful resource for individuals who are interested in a deeper understanding of Entertainment-Education (E-E). Slater and Rouner discuss E-E within a broader model of narrative persuasion. Specifically, hoping to expand on E-E's typical link to social cognitive theory, they explore how the elaboration likelihood model of persuasion (the ELM) might be used to provide a richer understanding of how people process persuasive narrative information.

Again, this article is useful for audiences—both educators and content producers—who are interested in expanding their conceptual and theoretical understanding of the links between persuasive messages and audience beliefs, attitudes, and behaviors. It should be read after an individual is familiar with E-E.

Other studies and resources …

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