Chapter 24
Popular Culture in Teaching, Scholarship, and Outreach: *The Simpsons* and *Futurama*

Sarah J. Greenwald

Abstract Subject to thoughtful analysis of the benefits and challenges, popular culture can be an ideal source of fun ways to connect students and the general public to mathematics. My colleague Andrew Nestler and I created, class-tested, and widely shared activities related to the Twentieth Century Fox television show *The Simpsons*. The Scholarship of Teaching and Learning (SoTL) provides us with an analytic framework to develop, improve, and share our activities. We designed the activities to introduce or review important mathematical concepts and engage students. Later I expanded my interest into *Futurama*, another Twentieth Century Fox television show. I will describe informal outreach activities connected to both programs, including our educational website Simpsonsmath.com and my interactive lecture that audiences have accessed worldwide from a *Futurama* DVD. I will summarize the reception of my work by departmental colleagues, the institution, and the mathematical community. I will reflect on how this work has affected students and general audiences. I will also consider the direct and indirect impacts on my career and the unique challenges and rewards of working with popular culture in teaching, scholarship, and outreach.

Key Words Popular culture, Outreach, SoTL, *The Simpsons, Futurama*
MSC codes 00A09, 00A66, 97A40, 97A80, 97D40

24.1 Introduction

Educators have a variety of methods available to them to deliver mathematical content and facilitate student engagement and learning. Mathematical cartoons can be a fun way to introduce or review concepts and reduce student anxiety (Schacht and Stewart 1990). The audio and video components of animated cartoons can also help make material more memorable.

The Simpsons (Groening and Brooks 1989–present) and *Futurama* (Cohen and Groening 1999–2009) are animated sitcoms that include hundreds of mathematical references. One reason is that a number of the writers have mathematical backgrounds, including college and graduate degrees (Greenwald 2007). For example, Ken Keeler, who has a PhD in applied mathematics and originally worked at Bell Labs, wrote for both television shows.

For over 15 years, my co-author Andrew Nestler and I have been not only engaging students but also sharing with teachers mathematical humor from the television show *The Simpsons*. The Scholarship of Teaching and Learning (SoTL) gives us a framework in which we create valuable activities, analyze their benefits and challenges, refine them, and share them (McKinney 2006). A SoTL project may take many forms, and in our case we mainly use reflection and analysis based on observational research and student evaluations. We have found that the best popular culture related activities for the classroom are those that tie into course content, have an interactive component, and work at least as well as other pedagogical techniques would for the same material (Greenwald and Nestler 2004a, b). In this chapter I will discuss how this work developed as I highlight the unique challenges and rewards of

working with popular culture in teaching, scholarship, and outreach. Through our educational website Simpsonsmath.com (Greenwald and Nestler 2001) I became involved with *Futurama*, another television show, and filmed a 25-minute feature for the *Futurama* DVD movie *Bender's Big Score* (Cohen et al. 2007). I will summarize the reception by the department of mathematical sciences at Appalachian State University (ASU), the institution, and the broader mathematical community. I will also reflect on how our work has affected students, general audiences, and my career.

24.2 *The Simpsons* and *Futurama* in the Classroom and Beyond

For years, Nestler and I analyzed the mathematical moments in *The Simpsons* as we developed and refined activities for our classes. We wanted to share these publicly with teachers and students at other schools, so we began to participate in informal outreach activities, including presentations at conferences and schools, as well as wider outreach through our educational website Simpsonsmath.com that we founded in 2001. We created classroom activity sheets for the website filled with questions designed to engage students with the mathematical moments in the show. These are aimed mainly at high school and college students and general audiences. Later my interest expanded into *Futurama* as well.

24.2.1 *The Simpsons* and Simpsonsmath.com

The Simpsons is an award-winning animated sitcom. It centers around the life of a nuclear family, Homer and Marge Simpson and their children Bart, Lisa and Maggie, as well as their neighbors and relatives. As of 2016 it is the longest running sitcom in television history and contains many references to scholars and academic subjects, including mathematics and its own mathematician character, Professor Frink. *The Simpsons* first aired in December of 1989 when I was an undergraduate student at Union College. My mother died the year before and I was the guardian of my younger brother, so time was precious; however, there was always a spare hour for friends. Our group gathered for dinner, television and the premiere of *The Simpsons*. The laughter was good for the soul and provided some much needed relaxation. There was even a quip about odds and multiplication, but we dismissed it as a fluke. The next episode aired in January 1990. It was "Bart the Genius" (Vitti and Silverman 1990) and we were surprised that it showcased an entire mathematics word problem, and even a separate calculus joke about derivatives. That same year Ernest Boyer's *Scholarship Reconsidered: Priorities of the Professoriate* (Boyer 1990) was published, and this was a pivotal moment in SoTL. Little did I know that these two events would later converge, to my great benefit. Group gatherings for dinner and *The Simpsons* continued in graduate school at the University of Pennsylvania. It is there that I met Andrew Nestler, a fellow graduate student, and we bonded over mathematics as well as *The Simpsons*.

The mathematical references in the show are diverse and range from basic arithmetic to advanced research topics in mathematics. For instance, *The Simpsons* showcases interesting numbers and equations, makes references to geometry and mathematical physics, and jokes about innumeracy and women in mathematics. Many of the mathematical moments appear briefly but prominently, e.g., in a close-up of a blackboard; however, in a few episodes mathematics has been key to the main plot. Second grader Lisa Simpson, the oldest daughter of the titular family, is featured in these episodes. For instance, in "Girls Just Want to Have Sums" (Selman and Kruse 2006) Lisa pretends to be a boy to do mathematics. Matt Selman

wrote the episode in response to Lawrence Summers' controversial comments about the innate abilities of women in mathematics (Summers 2005). In "MoneyBart" (Long and Kruse 2010) Lisa uses sabermetrics, the statistical analysis of baseball. In yet another episode, "Mathlete's Feat" (Price and Polcino 2015), Lisa is a member of Springfield Elementary's Mathlympics Team. For a television show, the breadth and depth of the mathematical moments are quite remarkable.

Boyer (1990) noted that "Pedagogical procedures must be carefully planned, continuously examined, and relate directly to the subject taught," and we have taken these as guiding principles in our work. In developing Simpsonsmath.com, Nestler cataloged the mathematical references as I interviewed the writers and investigated their mathematical backgrounds. There are hundreds of items detailed in Nestler's online guide to mathematics and mathematicians on *The Simpsons*. We created separate webpages for the episodes where mathematics is fundamental to the main plot, and for each of the mathematician writers. We developed worksheets related to arithmetic, calculus, geometry, number theory, pre-calculus, probability and topology. We tested the worksheets in classes and refined them before we included them online. We chose a website format so we could share our work freely and update it regularly, rather than a book that would be outdated as soon as more references appeared on the show. Although we are on opposite sides of the country, we continue to improve the website and watch television together, by hitting play at the same time on our respective digital video recorders as we chat by phone.

24.2.2 Sample Activity on the Digits of π

Many references to π appear on *The Simpsons*, prompting us to develop activities related to the irrationality of π as well as unsolved questions about whether π is normal. A worksheet is available on Simpsonsmath.com for the following activity.

In the episode "Marge in Chains" (Oakley et al. 1993), Apu Nahasapeemapetilon, who runs a popular convenience store near the Simpsons, takes the stand during a court case. When the validity of his memory is challenged, he claims he can recite π to 40,000 decimal places, and notes that the 40,000th digit is one. My students laugh when Homer Simpson, the donut-loving patriarch of the Simpson family, responds: "Mmm, pie."

We ask students for the definition of π, how many digits they know by heart, the probability that a person would guess correctly if he had randomly guessed the 40,000th digit, and whether it is humanly possible to memorize that many digits. We have shared this activity with middle grade, high school, and college students on Pi Day, and it leads to interesting discussions about the world record for memorizing digits of π and why anyone would want to memorize or compute so many digits. We introduce these questions if the students do not.

Students are often amazed to learn that Hideaki Tomoyori, the world record holder during the making of and original airdate of this episode, knew exactly 40,000 digits. We share quotations that highlight Tomoyori's motivation and methodology, as well as a psychological study that investigated his cognitive abilities (Takahashi et al. 2006). Researchers compared Tomoyori to a control group and concluded that he was not superior. They attributed his achievement to extensive practice. We also discuss the motivation to calculate trillions of digits of π, noting that series algorithms are used to stress test computers,

and number theory questions about the distributions of the digits are much more interesting than any specific digit.

Apu was correct in the episode—the 40,000th digit of π is indeed one, and students ask how this story ended up in an episode of *The Simpsons*. The show's writers wanted to honor Tomoyori's accomplishment. Mathematician Jon Borwein first shared the story with us of how the writers obtained the digit. The writers enlisted the help of mathematician and computer scientist David Bailey. We have a copy of the fax the writers sent to Bailey containing an image of Bart Simpson, the fourth grade son on the show. They asked Bailey for the 40,000th digit of π. At the time, Bailey was working at NASA, and he faxed all 40,000 digits. The writers told Nestler and me that they placed a huge pile of fax pages into another episode "22 Short Films About Springfield" in honor of all those pages Bailey sent. The pile elucidates the magnitude of that many digits of π and students laugh when I show them a picture of it. Students are also interested to learn that research on π continues. Bailey, Peter Borwein, and Simon Plouffe (1997) published a series representation of π that we share with students who have taken calculus:

$$\pi = \sum_{i=0}^{\infty} \frac{1}{16^i}\left(\frac{4}{8i+1} - \frac{2}{8i+4} - \frac{1}{8i+5} - \frac{1}{8i+6}\right).$$

The Bailey-Borwein-Plouffe (BBP) formula can be used to compute binary digits of π in hexadecimal notation without the preceding digits, theoretically eliminating the need for many fax pages, at least in this setting.

24.2.3 *Futurama,* DVD Feature, and Greenwaldian Theorem Activity

In 2003, Art Benjamin, then co-editor of *Math Horizons*, a journal aimed at undergraduates, asked if I would write an article about *Futurama*. *Futurama* is a satirical science fiction cartoon that is often associated with *The Simpsons* because many of the same people developed and wrote for it. However, the focus of the show is quite different. In the pilot, Philip J. Fry accidentally falls into a cryogenic chamber and awakens 1,000 years later, in the year 3,000. Fry connects with his great-great-...-great nephew Professor Farnsworth, a scientist, inventor and owner of the Planet Express Delivery Company. Fry joins the delivery crew whose members include a one-eyed alien named Turanga Leela and a robot, Bender Bending Rodriguez, who is simply known as Bender in the show. *Futurama* revolves around their adventures.

Futurama makes many significant mathematical references, including the Goldbach conjecture, supersymmetric string theory, and taxicab numbers to name a few. Mathematical references abound in each show. I enlisted the help of chemical engineer Tom Georgoulias and computer scientist Marc Wichterich to write a *Math Horizons* article (Georgoulias et al. 2004). From this I developed my own educational website (Greenwald 2004). I subsequently met David X. Cohen, the head writer and an executive producer of *Futurama*, who holds a master's degree in computer science. He invited me to film a 25-minute feature presentation for the *Futurama* DVD movie *Bender's Big Score*. Live action is interspersed with animated content in this interactive mathematics lecture that is aimed at a general audience. I explore the mathematical moments in *Futurama* with help from the writers, executive producers, and

animated characters. Cohen advertised it prominently on the back cover of the *Bender's Big Score* DVD as a special bonus feature.

As a surprise, Cohen included a "Greenwaldian theorem" on a blackboard in *Bender's Big Score* itself. In classes that explore non-Euclidean geometry or as a hands-on outreach activity, I can show Fig. 24.1, and we discuss why it is true. In the *Bender's Big Score* movie, Professor Farnsworth and Bubblegum Tate, a member of the Globetrotter's basketball and physics team, examine the blackboard. While I was certainly not the first to discover the spherical equation, I was thrilled to have my name up in the lights of the show. I created an activity sheet and posted it on my *Futurama* website. On a ball, as I demonstrate in the DVD feature and in the classroom, we mark three vertices of a spherical triangle from the north pole to the equator and over a bit. Next we use string to measure the lengths of a from the north pole to the equator and b along the equator. Now we create a Euclidean right triangle with a and b pulled tightly on the flat table. Students work in pairs because more than two hands are helpful to form the hypotenuse of that triangle, c_{flat}. Back on the sphere, we compare c_{flat} to the spherical c_{sphere}. As we place c_{flat} from the equator to the north pole, it is too long. Since c_{flat} satisfies the Pythagorean theorem,

$$a^2 + b^2 = c_{flat}^2 > c_{sphere}^2.$$

While this is just an illustrative example, we next examine small and large right triangles in a dynamic geometry software program. We notice that the smaller the triangle, the flatter, and hence the Pythagorean theorem is closer to holding true. The opposite holds for large triangles.

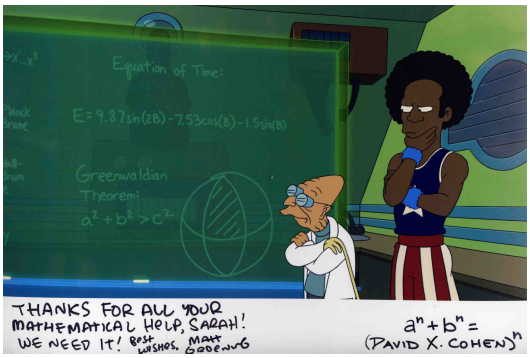

Fig. 24.1 Greenwaldian Theorem (Image used with permission, courtesy of Twentieth Century Fox Home Entertainment, all rights reserved, *Futurama*™ and © Twentieth Century Fox and its related companies)

24.3 Reception, Impact, and the Challenges and Rewards of Working with Popular Culture

SoTL, by definition (McKinney 2006), requires public sharing and review. McKinney advocates for SoTL in traditional formats, like peer-reviewed presentations and publications, as well as innovative formats to reach the public (McKinney 2012). One of the challenges of informal outreach is how to best judge its impact and success. My interactive mathematics lecture has been distributed on over one million *Futurama* DVDs worldwide, but I have no way of knowing how many people have actually watched it or how they have used it. In addition to the DVD sales, the Greenwaldian theorem has also aired on television and on streaming video sites, but it is impossible to gather data on how many people paid attention. A better measure is the number of visitors to Simpsonsmath.com, which lists over 800,000 page views. This count could be considered low because it does not include the first year of the site, Nestler's guide or my *Futurama* pages. On the other hand, since the count is by unique

Internet Protocol (IP) address, the same viewer using different addresses will be counted multiple times.

Regardless of the difficulties in counting users, we do know the reach has been broad because we have received unsolicited feedback from all over the world, typically in the form of e-mail messages or from people who have approached us at conferences. We have other indications of success, such as those detailed below, even as we faced diverse challenges unique to the pedagogical use of popular culture.

24.3.1 Encouragement and Criticism from the Broader Mathematical Community

The broader mathematical community has consistently recognized and encouraged our outreach activities. They have also assisted us by sharing their critiques. In 2002 Brian Winkel, editor of the journal *Problems, Resources, and Issues in Mathematics Undergraduate Studies* (*PRIMUS*), asked Nestler and me to organize a special popular culture issue based on an upcoming conference session. At the same time, Winkel sent us long emails detailing what he referred to at the time as his severe bias against popular culture. We had many very interesting discussions about the value of studying and connecting to what the younger generation is in touch with, and how popular culture reflects cultural beliefs about mathematics and its value to society (Appelbaum 1995; Morrell 2002). These discussions were essential as they helped me formulate how I would justify my pedagogical use of popular culture to departmental colleagues and other teachers. Winkel (personal communication, February 29, 2016) recently noted: "It is pretty clear now that you and your colleagues were in the vanguard of appreciating mathematics and science in the popular culture and we all owe you our gratitude." Art Benjamin was also instrumental. I am not sure that I would have taken the time to work on the mathematics in *Futurama* had it not been for his encouragement to contribute an article on that topic to *Math Horizons*.

We have spoken to teachers at conferences for the Mathematical Association of America, the National Council of Teachers of Mathematics and the Ontario Association for Mathematics Education, to name a few, and the reception has been mostly positive. Huge audiences have attended our conference talks. The main area of critique has been that the activities are too high-level for elementary and middle grade students. Teachers have requested that we develop worksheets for their students. We did develop some activities with Carli Entin for *Scholastic Math* (Entin 2003) and I have used the Greenwaldian activity with middle grade students. However, even if elementary school children are watching *The Simpsons* or *Futurama*, I personally believe that the content is too mature for them. Both shows contain low-brow suggestive humor, especially *Futurama*, and *The Simpsons* movie was rated PG-13.

Teachers have suggested that we should distribute mathematical clips from the shows on our website or on DVD, but *The Simpsons* and *Futurama* are copyrighted by Twentieth Century Fox and this would violate educational fair use guidelines, as it is illegal to break DVD encoding to create clips. However, even without permission from the copyright holder or the purchase of performance rights, it is generally accepted that educators can still show a small portion played directly from a DVD owned by the library or an instructor in a face-to-face setting.

A few teachers told us that they were initially prepared to dislike the talk because it related to popular culture, but that they enjoyed the deep connections to mathematics and our thoughtfulness about effective use in the classroom. They say that they had not realized that popular culture could be a legitimate area of inquiry and investigation. On occasion, teachers send us their worksheets as well as feedback on the effectiveness of our worksheets. This has helped us improve our activities and we greatly appreciate the interaction.

Mathematical writers from *The Simpsons* and *Futurama* have been extremely positive and supportive, especially David X. Cohen, Ken Keeler and Jeff Westbrook. Westbrook has a PhD in computer science. In addition to their degrees, they have participated in the Joint Mathematics Meetings and a math club for adults. Popular science author Simon Singh interviewed us about our work and included it in a chapter of his book on the mathematics of *The Simpsons* (Singh 2013). His book has been well-received; for example the Joint Policy Board for Mathematics awarded Singh its 2016 Communications Award in part for this publication. The Mathematical Association of America honored me with a 2005 Alder teaching award based to some extent on the fact that Nestler's and my work had influenced others beyond my own classrooms, a criterion for the award.

24.3.2 Departmental and Institutional Challenges and Support

Overall, ASU has been very supportive of my work. Department and university documents recognize Boyer's model of scholarship (Boyer 1990), and they note that the scholarship of teaching is as significant and worthy a subject of inquiry as traditional research. The documents highlight public activities, forums, and presentations as valid forms of scholarship as long as there is indication of external validation. Hence, even though Nestler and I began sharing our work while I was an assistant professor, I felt encouraged to do so as a part of what would count as scholarship for my tenure portfolio.

One example of support from my colleagues in mathematical sciences occurred when my *Futurama* webpages indirectly overloaded our department server for an entire day in 2004. Slashdot, a website which advertises itself as "News for nerds, stuff that matters," linked to my *Futurama* pages as part of a discussion of the mathematics on the show. The sheer volume of users attempting to use the links resulted in too many page views per second, causing our server to come to a standstill, a phenomenon known as being "slashdotted." I stayed in communication with the department chair who helped diagnose the issue and explained the concept of the slashdot effect. The system administrator wrote to me: "No problem. At least I know what caused it. I'm going to look into what I can do to help... the next time it occurs," which seemed to me a very generous response. If there were any unhappy faculty, I never heard a word about it.

Another example of support from my department chair occurred when a member of the intellectual property department at Twentieth Century Fox called to ask Nestler and me to respond to their questions about our use of *The Simpsons* within and beyond our classrooms. Twentieth Century Fox was known for sending copyright infringement letters designed to shut down fan websites. My chair wrote a letter of support highlighting that this work was an integral part of my job at ASU and thus fell under educational fair use. Twentieth Century Fox never sent us a cease and desist letter.

I have been quite careful to explain to my colleagues that I only use *Futurama* or *The Simpsons* in the classroom when it relates to course goals and content I would have treated anyway, rather than using the shows themselves as the focus of investigation. For this reason when colleagues in other departments have suggested that I should teach a first-year seminar on *The Simpsons*, I have declined. I think that course would be hard to justify to mathematical sciences faculty. Instead, I created and regularly teach a first-year seminar on breakthroughs and controversies in science and mathematics, where I can still share my work as a small portion of the class. I am a faculty affiliate of the Gender, Women's and Sexuality Studies program and the director of the program requested that I design a new class on gender and popular culture. I am scheduled to teach this class in Fall 2016. Mathematical sciences chairs and colleagues have allowed me to teach outside of the department, partly because the university returns the credit hours to mathematical sciences and supports replacement costs.

That is not to say that there has always been universal support from the mathematical sciences department. In one of my departmental reviews, I was advised not to focus my scholarship on only one area. The faculty members were concerned that if *The Simpsons* ended, then my work would become obsolete long before the end of my career. None of us could have guessed at the time of the review that *The Simpsons* would still be on television today, and with the advent of streaming video sites, even cancelled shows like *Futurama* continue to be relevant to college students.

Outreach to the local community and beyond is a part of the university mission statement, so the university values my work on *The Simpsons* and *Futurama*. My department chair recently recommended that I be profiled as an example of a successful faculty member to prospective students. The university also referenced my outreach activities in a number of my teaching awards, giving some indication of its significance in this context.

24.3.3 Reception from Students and General Audiences

Ongoing reflection and analysis of student responses is fundamental for my SoTL work because it is the primary mode I use to assess and improve the activities. The best part of the work is that it helps me motivate students and better connect with them. I have seen shy students energized and students afraid of mathematics become willing to explore an activity just because the question is related to a cartoon. The sample 40,000th digit of π activity above is a good example of this. Discussion of the digits of π usually begins before I even ask any questions. It is also quite common for students who have been silent up to that point to approach me after I first use popular culture, to speak with me about their enjoyment of it, and this usually leads to increased participation overall. Of course, there is excitement from fans of *The Simpsons* or *Futurama*, but even among those who have never seen a show, many students are interested in anything connected to the entertainment world.

I have given expository talks all over the US and in Canada, and have been invited to speak at programs for specific groups of mathematics students, including career days at various high schools or colleges. Once in a while students at other venues I speak at are forced to attend as a part of their course grade. This is a more challenging setting, especially because some large lecture halls do not have desks, making certain activities impossible. The expository talks work best when audience members are willing and able to participate.

Happily, that has been the case the vast majority of the time. A number of talks and interviews are designed for a general audience rather than groups of students, such as the National Museum of Mathematics (MoMath) and National Public Radio's (NPR) *Science Friday* program. Audiences have almost always responded extremely well in these settings, laughing, answering my questions and engaging in the mathematics.

Unsolicited comments or emails from students are not a great way to evaluate the success of activities, because I usually hear just positive comments in that context. Typical comments are that they never knew mathematics could be so fun and interesting, and that they are inspired to study further. Some faculty have done their own student evaluations in outreach programs at which I have spoken, and have provided me with summative feedback. I can judge the reception in my classes through comments in course evaluations. I have had a few negative comments from students who do not like the discussion of my work on *Futurama* in the context of a first-year seminar class. The same students indicated that they prefer classes whose teachers regularly let them out early. However, other students have noted that this was one of their favorite parts of class, and one of the course goals is for faculty members to introduce their research. It would be easy to dismiss the negative comments as those coming from non-serious students, but as part of SoTL I think it is imperative to ask what I can do better. The next time I teach the class I plan to have even more explicit discussions about the goals of the course and the point of sharing my work in that context. Humor is subjective and the more Nestler and I have to explain why a joke is funny, the less funny it is. For example, a non-native English speaker may not understand the reference to 'hardy har har' in the calculus joke from "Bart the Genius." The vast majority of the comments have been extremely positive, but only time will tell whether this continues to be true. Future students may connect less with these popular culture references than today's students do.

I evaluate my classes each semester to make improvements and modifications. Sometimes the improvement is to eliminate an activity from class or switch to a new technique. For example, early on some of the faculty teaching an introduction to mathematics for liberal arts asked students to fill out tax returns, so I tested Homer Simpson's taxes. Many of the students enjoyed it, but some did not. Upon SoTL assessment and reflection, it felt like I was drifting too close to making Homer the focus of investigation rather than the mathematics, so I removed the activity completely. I have learned that a cartoon does not actually have to be very funny for the majority of students to appreciate the reference. The key is that it relates to course content and will work at least as well as another pedagogical technique for that context. For instance, the *Futurama* episode "I, Roommate" (Horsted and Haaland 1999), brings M.C. Escher's 1953 *Relativity* lithograph to life in a humorous way as the robot Bender falls "down" staircases. The students label gluing instructions for the quotient space to identify the places on the edges of the room that are equivalent, by following Bender's path. The combination of dynamic movement and humor helps students visualize a finite universe in three dimensions better than other techniques. I could imagine a time in the future when I will need to reduce the activities in Introduction to Mathematics, which is the class where I utilize these references the most. I will continue to assess their use, but for now they work very well to engage the majority of my students. I actually deem the semester successful when I have some complaints from the student fans that we should have investigated more mathematical references from the shows, because I think it is good to underutilize, leaving them wanting more.

Overall, high school students and college students are usually much more excited about my work with *Futurama* than with *The Simpsons*, because *Futurama* has retained its cult status among that age group. Students I have never met before have come to my office or approached me around campus, even in the grocery store. One student was so excited that he interrupted a class he was not attending to ask for my autograph. It can be challenging to set boundaries with the students who are so excited about my work.

24.3.4 Impact on My Career

My contributions in this area are ongoing because *The Simpsons* is still airing new episodes, and these episodes sometimes contain new mathematical references for us to consider. As part of SoTL, I spend a lot of time thinking about how to best help students learn and understand course material, and in implementing diverse ways in order to help the class succeed, and so I regularly evaluate the effectiveness of pedagogical techniques to refine them. There is always something new and interesting to explore in this context.

When I try to reflect on direct and indirect impacts on my career, it is hard to measure the recognition and opportunities arising from our work. For instance, while it is easy to count the invited talks on this subject—currently there are 78—how do I interpret the teaching awards I have earned at least in part due to the outreach? Another example of how my career has been affected was being asked to co-edit the *PRIMUS* special issue on popular culture with Nestler. I co-edited a second issue with Chris Goff. We also wrote and published refereed articles focusing on SoTL (Goff and Greenwald 2007; Greenwald 2007; Greenwald and Nestler 2004a,b), which in turn led to an invitation to serve on the editorial board of *PRIMUS*. I have extended humor to linear algebra, where I have begun to develop and test comics I create myself. The content is not directly related to *The Simpsons* or *Futurama*, but it arose out of that work. My Erdős-Bacon number is a direct consequence of the activities. Mathematicians measure collaboration distance through an Erdős number, named for Paul Erdős. It is defined inductively using paper collaborations, with an Erdős number of one assigned to those who wrote a paper with Erdős and an Erdős number of k+1 assigned to those who wrote a paper with collaborators having an Erdős number k. Similarly, people measure connectivity in the Hollywood film industry using film roles and the actor Kevin Bacon. My work has possibly given me a Bacon number. A standard measure for Bacon numbers is inclusion on the Internet Movie Database (IMDb). By this measure, if you count documentaries, I have a Bacon number of three through David X. Cohen to Edward Asner to Bacon. My Erdős number is four. The Erdős-Bacon number is the sum of both, and is seven in my case, for those who count documentaries, and infinity otherwise. In turn, this has led to consulting work on a planned Erdős-Bacon number documentary.

Our mathematical outreach activities have allowed us to connect with many people, and in this way have enriched my own professional experiences. For instance, I participated in Raytheon's MathMovesU program for middle grade students at Upper Senate Park on Capitol Hill in Washington, DC, where I was delighted to speak alongside Senator Edward Kennedy, Representative Jo Ann Davis, mathematician Jonathan Farley and Olympic gold medalist Apolo Ohno. I am obviously a great fan of *The Simpsons* and *Futurama* and this work provides me with an outlet to enjoy the shows at a deeper level. My mother used to worry that all those hours I spent watching television were a waste of my time, so I find it especially

rewarding to combine my interests in mathematics teaching and cartoons in this creative endeavor. It is a great intellectual challenge to use cartoons in outreach activities in a meaningful and effective manner. The rewards are well worth the substantial time and effort.

References

Appelbaum, P. (1995). *Popular culture, educational discourse, and mathematics*. Albany, NY: State University of New York Press.

Bailey, D., Borwein, P., & Plouffe, S. (1997). On the rapid computation of various polylogarithmic constants. *Mathematics of Computation*, *66*(218), 903–913.

Boyer, E. (1990). *Scholarship reconsidered: Priorities of the professoriate*. Princeton, NJ: Carnegie Foundation for the Advancement of Teaching.

Cohen, D. X., & Groening, M. (Executive Producers). (1999–2009). *Futurama* (television series). Boston, MA: Twentieth Century Fox.

Cohen, D. X., Groening, M., & Keeler, K. (Executive Producers). (2007). *Futurama: Bender's big score* (DVD). Boston, MA: Twentieth Century Fox Home Entertainment.

Entin, C. (2003). Math on *The Simpsons*. *Scholastic Math*, *23*(9), cover, 4–5.

Georgoulias, T., Greenwald S., & Wichterich M. (2004). *Futurama* πk: Mathematics in the year 3000. *Math Horizons*, *11*(4), 12–15.

Goff, C., & Greenwald, S. (2007). To boldly go: Current work and future directions in mathematics and popular culture. *PRIMUS*, *XVII*(1), 1–7.

Greenwald, S. (2004). *Futurama* Math: Mathematics in the Year 3000. http://cs.appstate.edu/~sjg/futurama/. Accessed 10 May 2016.

Greenwald, S. (2007). Klein's beer: *Futurama* comedy and writers in the classroom. *PRIMUS*, *XVII*(1), 52–66.

Greenwald, S., & Nestler, A. (2001). Simpsonsmath.com. http://simpsonsmath.com. Accessed 10 May 2016.

Greenwald, S., & Nestler, A. (2004a). r dr r: Engaging students with significant mathematical content from *The Simpsons*. *PRIMUS*, *XIV*(1), 29–39.

Greenwald, S., & Nestler, A. (2004b). Using popular culture in the mathematics and mathematics education classroom. *PRIMUS*, *XIV*(1), 1–4.

Groening, M., & Brooks, J. L. (Executive Producers). (1989–present). *The Simpsons* (television series). Boston, MA: Twentieth Century Fox.

Horsted, E. (Writer), & Haaland, B. (Director). (1999, April 6). I, Roommate (television series episode). In D. X. Cohen & M. Groening (Executive Producers), *Futurama*. Boston, MA: Twentieth Century Fox.

Long, T. (Writer), & Kruse, N. (Director). (2010, October 10). MoneyBart (television series episode). In M. Groening & J. L. Brooks (Executive Producers), *The Simpsons*. Boston, MA: Twentieth Century Fox.

McKinney, K. (2006). Attitudinal and structural factors contributing to challenges in the work of the scholarship of teaching and learning. *New Directions for Institutional Research*, *129*, 37–50.

McKinney, K. (2012). Making a difference: Application of SoTL to enhance learning. *Journal of the Scholarship of Teaching and Learning*, *12*(1), 1–7.

Morrell, E. (2002). Toward a critical pedagogy of popular culture: Literacy development among urban youth. *Journal of Adolescent & Adult Literacy*, *46*(1), 72–77.

Oakley, B., (Writer), Weinstein, J. (Writer), & Reardon, J. (Director). (1993, May 6). Marge in chains (television series episode). In M. Groening & J. L. Brooks (Executive Producers), *The Simpsons*. Boston, MA: Twentieth Century Fox.

Price, M. (Writer), & Polcino, M. (Director). (2015, May 17). Mathlete's feat (television series episode). In M. Groening & J. L. Brooks (Executive Producers), *The Simpsons*. Boston, MA: Twentieth Century Fox.

Schacht, S., & Stewart, B. (1990). What's funny about statistics? A technique for reducing student anxiety. *Teaching Sociology*, *18*(1), 52–56.

Selman, M. (Writer), & Kruse, N. (Director). (2006, April 30). Girls Just Want to Have Sums (television series episode). In M. Groening & J. L. Brooks (Executive Producers), *The Simpsons*. Boston, MA: Twentieth Century Fox.

Singh, S. (2013). *The Simpsons and their mathematical secrets*. New York: Bloomsbury.

Summers, L. H. (2005). Remarks at NBER conference on diversifying the science & engineering workforce. http://www.harvard.edu/president/speeches/summers 2005/nber.php. Accessed 11 May 2016.

Takahashi, M., Shimizu, H., Saito, S., & Tomoyori, H. (2006). One percent ability and ninety-nine percent perspiration: A study of a Japanese memorist. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *32*(5), 1195–1200.

Vitti, J. (Writer), & Silverman, D. (Director). (1990, January 14). Bart the genius (television series episode). In M. Groening & J. L. Brooks (Executive Producers), *The Simpsons*. Boston, MA: Twentieth Century Fox.