Chapter 10

Pedagogical Techniques Employed by the Science Television Show *MythBusters*

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Additional information is available at the end of the chapter

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Abstract

The long-running Discovery Channel science television show MythBusters has proven itself to be far more than just a source of weekly entertainment. The popular cable program employs an array of sophisticated pedagogical techniques to communicate scientific concepts to its audience. These techniques include: achieving active learning, accommodating different learning styles, avoiding jargon, employing repetition to ensure comprehension, anthropomorphizing physical phenomena, using captivating demonstrations, cultivating an enthusiastic disposition, and increasing intrinsic motivation to learn. In this content analysis, episodes from the show's 10-year history were methodically examined for these instructional techniques. MythBusters represents an untapped source of pedagogical techniques educators at all levels may consider availing themselves of in their tireless effort to better reach their students. Science educators in particular may look to MythBusters for inspiration and guidance in how to incorporate these pedagogical techniques into their own teaching and help their students in the learning process.

Keywords: science education, television, science entertainment, educational programming, popular science, *MythBusters*, active learning, learning styles, demonstrations, intrinsic motivation

1. Introduction

MythBusters, the long-running Discovery Channel science television show, has proven itself to be far more than just a highly rated cable program [1–5]. While its focus is on entertainment, the show employs an array of sophisticated pedagogical techniques to communicate scientific concepts to its audience. These techniques include: achieving active learning, accommodating different learning styles, avoiding jargon, employing repetition to ensure comprehension, anthropomorphizing physical phenomena, using captivating demonstrations, cultivating an

enthusiastic disposition, and increasing intrinsic motivation to learn. In this content analysis, episodes from the show's 10-year history were methodically examined for these techniques. *MythBusters* represents an untapped source of pedagogical techniques science educators may consider availing themselves of in their tireless effort to better reach their students. Physics educators in particular may look to *MythBusters* for inspiration and guidance in how to incorporate these techniques into their own teaching and help their students in the learning process.

The premise of *MythBusters* involves the hosts (Adam Savage, Jamie Hyneman and build team members Tory Belleci, Kari Byron, and Grant Imahara) testing the validity of various urban legends, folk tales, common idioms, historical accounts, and internet viral videos using thinking and processes that are grounded in the scientific method [6]. A myth can be deemed "confirmed," "busted," or "plausible," if possible though highly improbable.

2. Methodology

Complete seasons of *MythBusters* were downloaded from Apple's iTunes Store and the episodes systematically analyzed in chronological order. The most commonly employed pedagogical techniques quickly became evident, and examples illustrating those techniques were sought in the content analysis of the remaining episodes. Narration and dialogue were transcribed and in cases of ambiguity, subtitles were consulted. The examples contained in this treatment should not be taken as exhaustive nor necessarily the most compelling, i.e., cherry-picked. For the sake of brevity, many equally illustrative examples could not be included. Examples were taken from across the show's decade-long span. Episode content varied, with episodes employing a different number of pedagogical techniques and to varying effect. Some techniques, such as achieving active learning, feature prominently in nearly every episode. Other techniques, such as anthropomorphizing scientific phenomena, are employed only when certain topics, e.g., inertia, are discussed. The analysis conducted was qualitative (descriptive) in nature [7–9]. Further work would be needed to treat the show in a quantitative manner (such as determining the frequency of certain techniques per episode and season) and was beyond the intended scope of this text, which was to acquaint educators at all levels with *MythBusters* as a valuable pedagogical resource.

3. Achieving active learning

First, *MythBusters* gets audience members learning in an active manner. Learning styles are broadly classified as either active or passive: "Passive learning takes place when students take on the role of 'receptacles of knowledge' … Active learning is more likely to take place when students are doing something besides listening" [10]. The lecture is the quintessential passive learning technique: "The lecture … is passive learning, with very low student involvement … Students are expected, and even encouraged, to sit quietly, listen, and perhaps take notes" [11]. The lecture is a "one-way mode of communication, giving the student little or no control over the nature, rate, and flow of information" [12]. Indeed, the lecture's "prioritization of facts and memorization over critical analysis, synthesis, and discussion" has been implicated in deterring otherwise bright and competent students from careers in science [13].

Conventional wisdom holds that a television show is unable to encourage active learning among viewers: "The flood of uncontrollable images onto the TV screen … tends to generate a passivity … that suffocates the questioning and examination necessary for education" [14]. Traditional thought also holds that watching a television show is as passive an experience as attending a lecture: "When used as a platform for delivering content, visual-based instruction has not yet been shown to be significantly better than lecturing – perhaps because simply viewing a 50-minute film … does not actively involve students any more than listening to a 50-minute lecture" [15].

However, *MythBusters* cleverly complements its passive learning narration with several techniques designed to get the audience involved in meaningful ways. Indeed, *MythBusters* is unique among science television shows for the two-way, responsive, give-and-take relationship that exists between the hosts and the viewers.

First, the MythBusters break the fourth wall, speaking directly to the audience. They routinely anticipate questions and objections that those watching at home may have: "I know what you're saying. You're saying, 'Adam, your see-through manhole cover doesn't weigh near as much as a cast-iron manhole cover. How can this be an accurate test?' And you're right, except that we've already thought of it" ["Indy Car Special" – Original Air Date (OAD): 5/22/2013].

The MythBusters routinely solicit suggestions for myths to test from the viewers. Nearly every episode concludes with the hosts inviting fans to visit the Discovery Channel website and contribute their suggestions: "[P]lease keep your good ideas flowing toward us and we'll take the best ones, we'll test them out, and we'll put them on the air" ["Viewer Special 2" – OAD: 2/13/2008]. When introducing the "Gorn Cannon" myth ["Mini Myth Mayhem" – OAD: 12/28/09], Grant notes the overwhelming online response it elicited: "Fans have been requesting it for years and when I announced that we were doing this on the internet, the reaction was massive." The outpouring of ideas and suggestions from fans has been so great in fact, that the MythBusters have produced nearly a dozen episodes devoted exclusively to viewer-suggested myths ["Viewer Special 1" – OAD: 8/15/2007, "Viewer Special 2" – OAD: 2/13/2008, "Viewer's Special Threequel" – OAD: 11/19/2008, "Mini Myth Mayhem" – OAD: 12/28/09, "Mini Myth Madness" – OAD: 11/10/2010, "Wheel of Mythfortune" – OAD: 11/23/2011, "Mailbag Special" – OAD: 5/20/2012, "Mini Myth Medley" – OAD: 11/4/2012]. The response from fans was so astounding in fact, that it prompted Adam to remark, "I am so overwhelmed. We have so many responses to our request for ideas from viewers" [Viewer Special 2: OAD: 2/13/08].

In addition, fans routinely take issue with the results of an experiment or critique the methodology employed in testing a myth. They vociferously voice their objections by inundating the hosts with their observations, complaints, and suggestions, as Adam observes, "Every time we air a new episode of *MythBusters*, hundreds, thousands of fans write to us to comment on that episode … Some of them want to say things we screwed up, others want to suggest other tests we missed, and some of them just want us to go down different tangents of stories we've already done because they have other ideas about things we could explore" ["Myth Evolution" – OAD: 11/18/2009]. In response, the hosts are obliged to re-open or revisit these seemingly closed myths ["Myths Revisited" – OAD: 6/8/2004, "MythBusters Revisited" – OAD: 10/12/2005, "Myths Reopened" – OAD: 4/26/2006, "More Myths Revisited" – OAD: 10/25/2006, "More Myths Reopened" – 3/21/2007, "Myth Revolution: OAD – 9/5/2007, "Myth Evolution" – OAD: 11/18/2009, "Revenge of the Myth" – OAD: 5/6/2012, "Failure Is Not an

Option!" – OAD: 2/13/2016] in an attempt to mollify meticulous fans. For example, in "Salami Rocket" ["More Myths Revisited" – OAD: 10/25/2006], fans objected to an earlier result the MythBusters had obtained, claiming that the thrust evolved by a particular rocket motor was solely from escaping oxidizer gas and not from the actual combustion of fuel (**Table 1** Entry 1). The MythBusters examined this claim but showed that the thrust was indeed from combustion. **Table 1** provides a brief summary of all myths discussed herein for convenient reference.

Moreover, the MythBusters have actually invited fans onto the show to engage in testing myths firsthand. Most notably, in the first revisit of Archimedes' fabled weapon ["Archimedes' Death Ray" – OAD: 1/25/2006], several fans were invited to participate in a series of competitions that pitted their contraptions against one another (**Table 1** Entry 2). In the second revisit of Archimedes' death ray ["President's Challenge" – OAD: 12/8/2010], the Discovery Channel sponsored a Science, Technology, Engineering, and Math (STEM) academy in which 500 local middle and high school students were involved in retesting the myth, helping to aim mirrors and focus the sun's rays on a target (**Table 1** Entry 3). When testing various everyday household items for bacteria, Adam and Jamie employed microbiology students at UC Berkeley to help collect samples ["Hidden Nasties" – OAD: 12/28/2009]. Fans of the show have been recruited as volunteers to help test everything from gender stereotypes ["Battle of the Sexes" – OAD: 4/22/2012, "Battle of the Sexes: Round 2" – OAD: 5/29/2013, "Laws of Attraction" – OAD: 8/7/2014] to the most efficient airplane boarding strategies ["Plane Boarding" – OAD: 8/21/2014] to zombie survival techniques ["Zombie Special" – OAD: 10/17/2013]. Educators seeking to promote active learning in their classrooms should note that, "No teaching approach has greater potential for student involvement and engagement than student-directed investigation" [16].

The hosts routinely encourage fans to visit the *MythBusters* website to view bonus footage or material that did not make it into the episode due to editing or time constraints. As Jamie explains, "*MythBusters* is all about experimentation but that means that there are a lot of things that don't make it on air so if you want to see some of that stuff, log onto Discovery.com/MythBusters" ["Bug Special" – OAD: 12/1/2010]. In addition, immediately after a new episode airs, fans can visit the website to chat in real-time with each other and with the cast members themselves about the very episode they just watched. As Grant entices, "[D]o you want to know why we did what we did and didn't do what we didn't do? Well go to Discovery.com/MythBustersaftershow and watch our aftershow" ["Bubble Trouble" – OAD: 4/27/2011].

Until recently, the Discovery Channel website featured a *MythBusters* forum where fans could create a profile, post comments, and share messages with fellow fans. This message board had well over half a million postings before its format was overhauled. The message board was organized into several categories where fans could discuss recent episodes and post ideas for myths. These postings often involved fans utilizing physics and chemistry – or their understanding (sometimes flawed) of physics and chemistry – in an attempt to justify what they thought would be the result of myths yet to be tested or of extensions of myths that had already been tested. Even if the postings betrayed incomplete or flawed understanding of scientific principles, these "prior concepts" need to be elicited before being supplanted with correct understanding of scientific phenomena [17]. In addition, defending a position or viewpoint

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Myth	Episode Title	OAD	Description	Result
1. Salami Rocket	More Myths Revisited	10/25/2006	A hybrid rocket motor can use salami deli meat as the fuel source	Re-Confirmed
2. Archimedes Death Ray Burn-Off	Mailbag Special	1/25/2006	The famed Greek inventor Archimedes set fire to invading Roman ships using reflected sunlight	Re-Busted
3. Archimedes Solar Ray 3.0	President's Challenge	12/8/2010	The famed Greek inventor Archimedes set fire to invading Roman ships using reflected sunlight	Re-Busted
4. 22,000 Foot Fall	22,000 Foot Fall	12/13/2006	A pilot jumps out of his plane, has his parachute malfunction, but survives by having his fall cushioned by an explosion on the ground	Busted
5. Underwater Blow Dart	Ninjas 2	8/29/2008	A medieval Japanese warrior could launch a blow dart from underwater with the blow gun doubling as a breathing tube	Plausible
6. Does Alcohol Warm You Up	Viewer's Special Threequel	11/19/2008	Hypothermia can be staved off by imbibing alcohol	Busted
7. Toothbrush Surprise	Breakstep Bridge	1/25/2004	Bacteria can be deposited onto a toothbrush if placed in proximity to a toilet	Confirmed
8. Down with the Titanic	Goldfish Memory	1/25/2004	A sinking ship generates a vortex powerful enough to suck people in the surrounding water down with it	Busted
9. Which is Better for You: Breakfast Cereal or the Box?	Steam Cannon	7/19/2006	A cereal box can be as nutritious as the cereal itself	Busted
10. Gas Room Boom	Inverted Underwater Car	11/24/2010	In a room filled with flammable gas, firing a gun through a milk carton will prevent the muzzle flash from igniting the gas	Busted
11. Cell Phone Destroys Gas Station	Cell Phone Destroys Gas Station	10/3/2003	An electrical discharge from a cell phone can ignite gasoline vapor present in the air around a gas pump	Busted
12. Lead Plunge	Mini Myth Mayhem	12/28/2009	A person can briefly dip his hand into molten lead without injury if his hand is wet	Confirmed
13. Motorcycle Flip	Motorcycle Flip	10/29/2008	Thrusting a stick into the spokes of a motorcycle's front wheel will cause it to launch into the air end over end	Busted

Myth	Episode Title	OAD	Description	Result
14. Phonebook Friction	Phonebook Friction	9/10/2008	It is impossible to separate two phonebooks that have their pages interleaved	Partly-Busted
15. Underwater Car Escape	Underwater Car	1/24/2007	If a car becomes submerged in water, the door cannot be opened until the interior is flooded	Confirmed
16. The Squeeze	Dumpster Diving	11/25/2009	If the line to the surface air compressor breaks, a diver in an old-style suit can be crushed into his helmet	Confirmed
17. 7 Paper Fold	Underwater Car	1/24/2007	It is impossible to fold a piece of paper in half more than seven times	Partly-Busted
18. Rat Pee Soda	Hidden Nasties	12/28/2009	Drinking from soda cans contaminated with rat urine can be fatal	Busted
19. Bottle Bash	Bottle Bash	4/14/2010	An empty beer bottle will cause more damage than a full one when used as a weapon	Busted
20. Swinging Pirates	Swinging Pirates	4/15/2012	When trapped in a freely suspended cage, a group of people can swing themselves over to the cliff wall	Busted

Note: Myths appear in the order in which they are discussed.

Table 1. Synopsis of myths discussed herein to be consulted by the reader for clarification.

with logical reasoning fosters an internalization of scientific concepts: "One of the best ways to develop confidence and comprehension of issues is to convince others your ideas warrant consideration" [18]. In this way, involvement well beyond the one hour a week the show is on the air was achieved: "While classroom discussion typically take one or two hours, [electronic] threaded discussions can last an entire semester because the Internet allows the interactions to transcend the time-and-place restrictions of meeting in a classroom" [19].

MythBusters has shown that a science television show can achieve a high degree of active learning among its viewers. It does so by breaking the fourth wall and utilizing the unique communication means provided by the Internet.

4. Accommodating different learning styles

MythBusters also accommodates different learning styles in its attempt to communicate scientific concepts to viewers. *MythBusters* realizes that its viewers have different preferred ways of absorbing information: "[S]ome students prefer to learn through visual means … Other students may have auditory strengths and perform better when something is presented to them orally" [20].

In the "22,000 Foot Fall" myth ["22,000 Foot Fall" – OAD: 12/13/2006], the consideration of different learning styles is well demonstrated. The myth involves a pilot who jumps out of his plane at an altitude of 22,000 feet, has his parachute malfunction, but amazingly survives by having his fall cushioned by a fortuitous explosion on the ground (**Table 1** Entry 4). Testing of the myth hinges upon the pilot's terminal velocity. Following Adam's mention of terminal velocity, the narrator gives a precise definition: "The key to this myth is terminal velocity: the maximum speed at which an object can fall. It's reached when gravity is matched by the force of wind resistance." Synchronized with the narrator's explanation, an animation of a falling person depicts the opposing forces of gravity and wind resistance as vectors. These vectors become equal in magnitude but are directed in opposite directions, resulting in zero net force and hence zero acceleration. For those who are auditory learners, the narrator's description might suffice but for those who are visual learners, the animation solidifies their understanding of terminal velocity: "[D]ifferent people receive and create information using different physical modalities" [21].

In the "Archimedes Death Ray" myth, ["Archimedes' Death Ray"– OAD: 1/25/2006], the MythBusters attempt to determine whether the famed Greek inventor Archimedes could have set fire to invading Roman ships using reflected sunlight. In the myth, a polished parabolic surface concentrates sunlight to such intensity that the ignition temperature of wood is reached. "A parabola is hottest only where all the light meets – the fixed focal point. If the target moves slightly in front or just behind this, the death ray is rendered useless," explains the narrator. Accompanying this verbal description is an animation depicting a thermometer sliding back and forth along the focal axis of the mirror, from in front of the focal point (where the mercury drops) to the focal point (where the mercury rises), to behind the focal point (where the mercury drops again). Synchronizing the animation with explanatory dialogue serves to appeal to both visual and aural learners.

In the "Underwater Blow Dart" myth ["Ninjas 2" – OAD: 8/29/2008], different learning styles are again accommodated. The myth centers on whether medieval Japanese warriors were able to shoot blow darts from underwater (**Table 1** Entry 5). The build team members quickly realize that they will have to account for refraction, the bending of light as it passes between media of different densities. As the narrator explains, "Light travels at different speeds through water and air, getting bent out of shape as it passes from one to the other," an animation provides a visual understanding of refraction by showing how the apparent position of an object changes when viewed from underwater.

In the "Does Alcohol Warm You Up?" myth ["Viewer's Special Threequel" – OAD: 11/19/2008], the MythBusters test whether hypothermia can be staved off by imbibing alcohol (**Table 1** Entry 6). This myth was particularly good at accommodating different learning styles. As Adam intones, "The superficial blood vessels constrict, preventing heat loss through the skin and directing blood to critical internal organs," an animation is shown depicting the response of the vascular system to cold. This animation shows an internal view of the human body. The extremities – legs and arms – are shown blue to indicate lack of blood flow and resulting drop in peripheral body temperature, while the chest cavity is shown bright red to indicate blood surging to the organs and core body temperature being maintained. This animation is synchronized with the dialogue perfectly: "Link visual objects with classroom narrative" [22]. Later, the narrator concludes, "In summary, alcohol dilates your vascular system, which

sends blood to your extremities, where it loses its warmth and as a result your core body temperature quickly cools." This dialogue is synchronized with appropriate footage from the thermal imaging camera.

MythBusters regularly appeals to viewers' dissimilar styles of learning. In doing so, it increases the viewers' understanding of the science involved in a myth: "When we take advantage of these multiple intelligences, we increase the learning potentials of our students, and open up the possibilities and potentials that are in them all" [23].

5. Avoiding jargon

In addition to getting viewers learning in an active manner and accommodating different learning modalities, the MythBusters are also careful to only use words that the audience will understand; that is, they avoid using obfuscating jargon. When they do incorporate unfamiliar technical terms, they define them immediately.

In the "Toothbrush Surprise" myth ["Breakstep Bridge" – OAD: 1/25/2004], the MythBusters test whether bacteria can be deposited on a toothbrush placed in proximity to a toilet (**Table 1** Entry 7). The following excerpt of dialogue demonstrates the way in which a new term is typically introduced:

> *Jamie: "We should do a simple test to see whether the toilet actually produces an aerosol."*
>
> *Adam: "You mean like when it's flushing it actually makes little droplets and vapor that go everywhere."*
>
> *Jamie: "Exactly."*

In the "Down with the Titanic" myth ["Goldfish Memory" – OAD: 1/25/2004], the MythBusters test whether a sinking ship generates a vortex powerful enough to suck people in the surrounding water down with it (**Table 1** Entry 8). Before launching into a full-scale test by scuttling a boat, they carry out a small-scale test using a hydrometer in a swimming pool. For those unfamiliar with the term, the narrator enlightens: "They've made a hydrometer: a simple floatation device that measures the specific gravity, or density, of a liquid."

In the myth "Which is Better for You: Breakfast Cereal or the Box?" ["Steam Cannon" – OAD: 7/19/2006], Adam employs a calorimeter to determine the energy content of cereal and of the box it comes in (**Table 1** Entry 9). He explains the operation of the device to the audience: "I burn it underneath a pot full of water. If I know exactly how much water I have and what temperature it was when I began burning the food, by the time it's all done burning, I measure the temperature and that tells me with an equation, what the caloric content of that food was."

When testing the myth that the muzzle flash from a gun can lead to an explosion in a methane-filled room in "Gas Room Boom" ["Inverted Underwater Car" – OAD: 11/24/2010], the MythBusters first try to find the ideal ratio of air to natural gas (**Table 1** Entry 10). As the narrator explains, "The numerical balance of different substances to cause a reaction is called stoichiometry."

Using unfamiliar terms will make meaningful communication impossible: "[U]se vocabulary that students understand. That is, don't talk over your students' heads" [24]. *MythBusters* excels at communicating at a level its viewers can understand without being patronizing.

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6. Employing repetition to ensure comprehension

MythBusters also employs the pedagogical technique of repetition. After returning from a commercial break, it is common for the narrator or hosts to provide a quick summary of what has transpired and what results have been obtained, as Adam demonstrates, "Welcome back. Let me walk you through our setup" ["Paper Armor" – OAD: 6/29/2011]. In another episode, Tori brings viewers up to speed: "Just to recap, we are testing the myth from the James Bond movie where if a car is upside down and you use the ejector seat, you can flip that car back on its wheels" ["Bubble Pack Plunge" – OAD: 6/3/2012]. This recap is obviously an attempt to hook those just tuning in or flipping through the channels, yet it also serves the desirable end of ingraining certain concepts into the minds of viewers tuned in from the start: "If students are not following, then you need to revisit the content" [25].

MythBusters also intentionally uses repetition to clarify and ensure full understanding of arcane ideas. This is skillfully demonstrated in "Cell Phone Destroys Gas Station" ["Cell Phone Destruction" – OAD: 10/3/2003]. The myth centers upon the idea that an electrical discharge from static buildup can ignite gasoline vapor present in the air around a gas pump (**Table 1** Entry 11). To create this electric spark, Adam constructs a Leyden jar. He describes his creation for the audience: "This is called a Leyden jar and it's actually just Tupperware with foil on the inside and foil on the outside and it's an early capacitor, which is basically an energy storage device." Following Adam's introduction, the narrator elaborates: "Around 1750, in the Dutch city of Leyden, scientists discovered that two conductors, separated by an insulator, could store an electrical charge." The narrator provides a more technical description of the device as well as a historical context. The same message is conveyed but in slightly different ways.

This repetition is again demonstrated in the "Lead Plunge" myth ["Mini Myth Mayhem" – OAD: 12/28/09] (**Table 1** Entry 12). After heating a steel ball until it is red hot, Jamie plunges it into a tank of water and explains: "What you're seeing in this demonstration is known as the Leidenfrost Effect. It's interesting because the steam that's created when you expose a hot surface to water is actually insulating that surface and it makes sense because steam – being a gas – conducts heat less rapidly than the water itself does." Immediately after Jamie's description, the narrator gives a more detailed technical description of the phenomenon: "When cool water is exposed to an extremely hot surface, a layer of water vapor – which is a relatively poor heat conductor – provides a thin protective barrier." This repetition promotes viewer comprehension.

7. Anthropomorphizing physical phenomena

The MythBusters routinely utilize the instructional technique of anthropomorphizing physical phenomena. This technique is routinely employed in chemistry: atoms are spoken of as *wanting* a full octet of electrons. Alkali metals are spoken of as *wanting* to give up an electron while halogens *want* to gain an electron. Indeed, it is not at all uncommon in a chemistry lecture or recitation to hear subatomic particles, atoms, and molecules referred to as "guys" when their behavior is being described. When these phenomena are spoken of in terms of "wanting," it gives the impression that the phenomena are somehow internally directed or acting in a deliberate, thoughtful manner. While this is, of course, untrue, the anthropomorphized

wording facilitates understanding: it is easier to accept electron transfer as occurring as a result of desire for stability rather than as just the result of the immutable laws of nature.

In physics, this anthropomorphized terminology is commonly used when the topic of inertia is encountered. In the "Motorcycle Flip" myth ["Motorcycle Flip" – OAD: 10/29/2008], the MythBusters test the physics of a stunt from the movie *Indiana Jones and the Last Crusade* in which Indiana Jones thrusts a flagpole into the spokes of a pursuing motorcycle, causing the motorcycle to launch upward into the air and flip end over end (**Table 1** Entry 13). The validity (or lack of as it turns out) of the myth rests with inertia, an object's resistance to changes in its motion. When testing reveals that thrusting a pole into the spokes of a rotating wheel results in the motorcycle continuing forward rather than hurtling skyward, Jamie offers an anthropomorphized explanation: "There are hundreds of pounds in this bike plus the rider that *want to keep on going*" (emphasis mine). Inertia was anthropomorphized again in the "Chain Reaction" myth in which an internet viral video shows a chrome ball chain seemingly violating the laws of physics, leaping up and over the lip of a container in a gravity-defying arc after being given a starting tug ["Do Try This at Home" – OAD: 2/1/2014]. Using an anthropomorphized description, Jamie explains that this curious effect has a natural explanation: "It's clear from our testing that there are two key forces that are causing this effect. And the first is that mass moving in a particular direction *wants to continue moving in that direction*, so when we're yanking on the chain up out of the pot, it *wants to continue moving upward*, but shortly after, gravity starts to pull it down, and so that's where we get this arc" (emphasis mine). Using terms normally reserved to describe human thoughts and actions is a useful strategy to help convey difficult concepts.

8. Using captivating demonstrations

Good educators know not to underestimate the lasting impression of a spectacular demonstration [26]. The MythBusters utilize visually compelling demonstrations to communicate scientific concepts. In the "Phonebook Friction" myth ["Phonebook Friction" – OAD: 9/10/2008], the MythBusters test whether it is impossible to pull apart two phonebooks that have their pages interlaced (**Table 1** Entry 14). They attempt to separate two interleaved phonebooks first using teams of shop assistants in a tug of war competition, before moving onto using two sedans pulling in opposite directions, and finally onto using two tanks pulling in opposite directions. Of course, they could have just employed some drab industrial machine bolted to the floor, but this would not have been nearly as dramatic.

This demonstration bears a striking similarity to one particularly compelling demonstration of atmospheric pressure from the annals of history: "[I]n 1650, the German physicist Otto von Guericke invented a mechanical device that little by little sucked air out of a container. This enabled him to form a vacuum at will and to demonstrate the effects of an unbalanced air pressure. Such air pressure would hold two metal hemispheres together against the determined efforts of two eight-horse teams of horses (whipped into straining in opposite directions) to pull them apart. When the air was allowed to enter the hemispheres once more, they fell apart of their own weight" [27].

Several of the most arresting demonstrations from the show have also involved the awesome power of differential pressure. In the "Underwater Car Escape" ["Underwater Car" – OAD:

1/24/2007], Adam simulates the pressure differential that exists when a car is submerged under just two feet of water by stacking weights atop a car door window (**Table 1** Entry 15). Standing before a car door with a massive 350 pound stack of weights atop the window, Adam speaks directly to the camera: "I do not know of a more visual way to make clear how much pressure you're dealing with when you put things underwater."

In "The Squeeze" ["Dumpster Diving" – OAD: 11/25/2009], the MythBusters test a diving myth that holds that if the air line connecting an older style dive suit to the surface air compressor were severed, the diver would to be squeezed into the helmet owing to the extreme pressure differential (**Table 1** Entry 16). In one of the most vivid demonstrations from the show's ten year history, the MythBusters place an analog for a human body – "meat man" – in a dive suit and submerge it 300 feet before cutting the line to the surface. Instantly, "meat man" is crushed into his dive helmet, gruesomely demonstrating the power of differential pressure.

In the myth of the "7 Paper Fold" ["Underwater Car" – OAD: 1/24/2007], the MythBusters give a compelling demonstration of exponential growth. In testing the myth that it is impossible to fold a piece of paper in half more than 7 times, they join together several rolls of paper inside a hanger at NASA Ames Research Center, creating a sheet so enormous that it takes the combined effort of 10 people and a steamroller to help fold it (**Table 1** Entry 17). With each fold, the number of layers doubles, and the stack becomes twice as thick.

The experimental setups from the show are quite singular and create indelible memories for viewers. When testing whether it's possible for aluminum soda cans to become contaminated with rat urine and infect unsuspecting consumers with various pathogens ["Hidden Nasties" – OAD: 12/28/2009], the MythBusters devise a very memorable setup (**Table 1** Entry 18). As Jamie quips, "This is one of those sounds that you'll only hear on *MythBusters*: the sound of forty rats on a thousand cans."

Sometimes an experiment that returns qualitative results is far more memorable than one that returns quantitative values. When measuring the bodily harm that results from smashing a bottle over a person's head in the "Bottle Bash" myth ["Bottle Bash" – OAD: 4/14/2010], Adam and Jamie opt for a rig consisting of a gelatin brain mold (with red dye added for realism) placed within a transparent jar (**Table 1** Entry 19). They could have instead gone with an accelerometer, but the demonstration was made much more compelling and visceral through being able to see the concussion-generating lateral movement of a gelatin brain as it sloshed from side-to-side.

Not only do exciting demonstrations help motivate students, but they promote long-term retention of the underlying concepts: "Students can remember many of their science class demonstrations for countless years … This is a good testimony to the emotional impact of demonstrations" [28].

9. Cultivating an enthusiastic disposition

The hosts of *MythBusters* also have enthusiastic dispositions, essential for effective teaching: "The teacher's enthusiasm for teaching, learning, and for the subject matter has been shown to be an important part of effective teaching" [29]. The cast members routinely crack

jokes, engage in good-natured ribbing, and maintain a feeling of levity throughout the show despite strict deadlines and demanding builds. Adam Savage is portrayed as the perennial jokester and humorist, the polar opposite of the reserved and aloof Jamie Hyneman. But even Jamie is occasionally reduced to uncontrollable bouts of giggling at the sight of a particularly astonishing outcome. The friendly and enthusiastic personalities of the hosts are no small part of the reason why the show has proven so popular: "If teachers have warmth … enthusiasm, and humor, they are much more likely to be successful than if they lack these characteristics" [30]. Moreover, incorporating aspects of humor can improve learning, with studies finding an increase in retention of course content when exposed to relevant humor as compared to those who received the same course content without humor.

At the conclusion of a myth, cast members are often filmed walking into the sunset excitedly discussing possible extensions to the myth they just tested. In this way, viewers take away the impression that the cast members have a genuine passion for what they are doing, treating it as much more than just a job.

The cast members also maintain their enthusiastic dispositions in the face of adversity or unexpected results. Indeed, one of the defining hallmarks of the show is how it conveys the notion that it is alright to be wrong and that unexpected results need not be feared or dreaded. A running line on the show is that, "Failure is always an option." Such an accepting attitude helps students regard unexpected or counterintuitive results as having the potential to usher in scientific discoveries and breakthroughs. When testing a scene from *Pirates of the Caribbean 2* ["Swinging Pirates" – OAD: 4/15/2012] and finding it possible to ascend a cliff face while confined inside a cage (**Table 1** Entry 20), Adam irrepressibly remarks, "How about that? We were totally able to climb. I love being wrong!" In a similarly exuberant manner, Tory exclaims in another episode, "I love those moments on *MythBusters* when you think one thing is going to happen and then the exact opposite happens" ["Mailbag Special" – OAD: 5/20/2012].

10. Increasing intrinsic motivation to learn

In addition to the multitude of ways they have of conveying science to the audience, perhaps no pedagogical technique is more valuable than the way in which the MythBusters increase viewers' intrinsic motivation to learn. Motivation is classified as either intrinsic or extrinsic. Whereas extrinsic motivation relies on external inducements such as grades, rewards, and penalties, "Intrinsic motivation refers to motivation to engage in an activity because of the satisfaction derived from the activity itself. Students who are intrinsically motivated … genuinely want to understand the content" [31]. Of the two, intrinsic motivation is much more esteemed among educators: "Intrinsic motivation … leads to a deep approach and conceptual understanding and produces learning outcomes that are flexible and transferable" [32].

The MythBusters test myths from sources that are likely to excite the viewers, especially younger viewers. Over the years, the MythBusters have tested myths from a dizzying number of Hollywood movies including: *Austin Powers*, *Body of Lies*, *The Bourne Supremacy*, *Caddy Shack*, *Cliffhanger*, *The Green Hornet*, *The Grey*, *Hellboy*, *Indiana Jones*, *Jaws*, *Lethal Weapon 2*, *The Matrix*, *The Mummy*, *Pirates of the Caribbean*, *Point Blank*, *Robin Hood*, *Speed*, *Shrek*, *Star Wars*, *Titanic*, *Wanted*, *The*

Wizard of Oz, innumerable James Bond movies, among many others. In addition, the MythBusters have tested myths from popular television series, including gadgets and stunts from *MacGyver* and *Knight Rider,* chemistry exploits from *Breaking Bad,* and even zombie survival techniques from *The Walking Dead*. Given that many of the myths involve high speed collisions, explosions, and gooey liquids ("Swimming in Syrup" – OAD: 5/6/2009, "Walking on Water" – OAD: 4/25/2007), it is little wonder why the show has such a dedicated following among young people: "The intensity of the want to learn depends [on] students' interest in the particular topic being learned" [33]. Or more tersely: "Students learn what they care about" [34].

Taking myths from pop culture provides the much needed hook to draw viewers in long enough that they learn the underlying science [35–39]. Viewers are more likely to be interested in the science if it relates to some stunt or gadget from their favorite movie or television show than if introduced without any context: "The use of film clips to explore science is one of the more effective pedagogical tools to build interest in science, awareness of real science, and students' understanding of scientific principles through the identification of illustrations and violations of scientific principles depicted in film clips" [40].

In recent years, there has been a profusion of books examining popular movies and television shows for their scientific content: Lawrence Krauss' *The Physics of Star Trek* (1995), Anne Simon's *The Real Science Behind the X-Files* (1999), Jeanne Cavelos's *The Science of Star Wars* (2000), Philip Plait's *Bad Astronomy: Misconceptions and Misuses Revealed* (2002), William Shatner's *I'm Working on That: A Trek From Science Fiction to Science Fact* (2002), James Kakalios's *The Physics of Superheroes* (2006), Tom Rogers' *Insultingly Stupid Movie Physics* (2007), and Adam Weiner's *Don't Try This At Home!: The Physics of Hollywood Movies* (2007). These books help inspire fans to learn the fundamentals of biology, chemistry, and physics so that they can better understand their favorite movies and shows: "Science and physics education have long recognized science fiction films' intrinsic value for teaching basic principles … films can create lasting mental images that are correlated to the underlying scientific theory. This can help students better understand many of the abstract concepts that are covered in the sciences."

Motivating students is not an optional luxury to be indulged if time permits [41]. By relating to what students find personally meaningful, instructors are more likely to gain and hold their attention [42]. *MythBusters* is so successful at communicating scientific concepts due largely to the source of the myths it tests and the ability to spark the curiosity of its viewers [43].

11. Summary

MythBusters has proven itself to be far more than a source of weekly entertainment. Its lasting success is in no small part due to the use of an array of pedagogical techniques to adeptly communicate scientific concepts to its viewers. These strategies include achieving active learning and accommodating different learning styles. In addition, the MythBusters avoid using jargon, employ repetition to ensure comprehension, anthropomorphize physical phenomena, incorporate provocative demonstrations, and cultivate enthusiastic dispositions. Lastly, the MythBusters increase intrinsic motivation to learn by choosing topics that appeal to their viewers. Educators are encouraged to familiarize themselves with the show, starting

with the episodes mentioned herein. These episodes can be purchased on DVD from the Discovery Channel website. They can also be downloaded individually or by season from Apple's iTunes Store for immediate streaming. Science educators in particular may look to *MythBusters* for inspiration and guidance in how to incorporate these pedagogical techniques into their own teaching and further their classroom goals [44].

12. Postscript

After a run of 14 seasons and 282 episodes, the *MythBusters* finale aired in spring 2016; however, reruns continue to air on Discovery's sister network The Science Channel. In addition, The Science Channel has announced it is relaunching the show with new hosts to be determined through its new reality show *Search for the Next MythBusters*. Also, build team members Tory, Kari, and Grant will be investigating unusual events from pop culture, science, and history in the Netflix original *White Rabbit Project*. Lastly, a hands-on exhibition with artifacts from the show, interactive exhibits, and live demos called "MythBusters: The Explosive Exhibition" was installed at the Mall of America in Minneapolis, MN in 2016 and at the Liberty Science Center in Jersey City, NJ in 2017. With reruns, a reboot, a spin-off, and a touring exhibition, the final pedagogical legacy of *MythBusters* is not yet written.

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