THE "MARVEL"-OUS NATURE OF SCIENCE

Using superhero movies to teach methods and values in science

DANIEL BERGMAN
Few film franchises have enjoyed the level of success of the Marvel Cinematic Universe (MCU), starring Iron Man, Captain America, Thor, Black Panther, Ant-Man, and several more Avengers and Guardians of the Galaxy. In just over 10 years, 21 MCU movies have made more than $17 billion worldwide (Pallotta 2019).

Many Marvel superheroes have a strong connection to science and STEM-related fields. As a result, these popular films are a growing resource for increasing student engagement and enhancing science instruction. My students, for example, earnestly analyze and debate the latest movie rumors (no spoilers!). Teachers are wise to harness this enthusiasm and direct it toward science learning. Specifically, we can use scenes and examples from MCU movies to explicitly address themes related to the nature of science.

The nature of science (NOS) is defined as “a way of knowing, or the values and beliefs inherent to the development of scientific knowledge” (Lederman, Lederman, and Antink 2013, p. 140). Clough (2006, p. 463) notes that NOS refers to “what science is, how it works . . . how scientists operate as a social group and how society itself both influences and reacts to scientific endeavors.” Studies have found that students with stronger NOS understanding are better at problem-solving strategies and goal-setting (Lin and Chiu 2004; Cavallo et al. 2003). While more difficult to ascertain, students’ improved understanding of science content has also been connected to more informed views of NOS (Michel and Neumann 2016; Papadouris and Constantinou 2014; Peters 2012).

Unfortunately, NOS is often overlooked, untaught, or misrepresented in many science classrooms (Clough 2018). Teachers who do plan for NOS content often relegate it to implicit instruction via experiments (“doing science”) or use of historical examples (Lederman, Lederman, and Antink 2013).

The Next Generation Science Standards feature NOS as a distinct chapter, outlining how to incorporate this topic with two of the three NGSS dimensions: crosscutting concepts, and science and engineering practices (NGSS Lead States 2013). In addition to discussing the rationale and research for emphasizing NOS instruction, the NGSS documents present a “NOS Matrix,” with eight major themes and grade-level learning outcomes that extend the dimensions (see Figure 1).

The following pages provide examples of using Marvel films and specific scenes to address these NOS themes and NGSS dimensions. Please note that use of movies does not replace contextualized science content or NOS instruction. Rather, consider this as another resource to stimulate students’ thinking about both science and NOS concepts. Similar to any video clip used to supplement instruction, these superhero examples are tools for teachers to engage students by introducing questions, drawing out misconceptions, assessing comprehension, applying content, and considering plausibility.

In my classroom, students are eager to scrutinize a fictional scene and analyze its relative accuracy to real life. Like numerous Hollywood films, superhero movies often present egrotious scientific errors. Where appropriate, teachers can apply such depictions to specific science content; there are several resources to support this (Blickenstaff 2019; Brake 2018; Kakaliacos 2009; Rogers 2007). The examples provided here, however, have particular relevance for the equally important portrayal of the nature of science, including its values and methods.

One important NOS topic connected to multiple Marvel movies is the representation of scientists and individuals in science-related fields. Readers may be familiar with research into students’ stereotypical scientist images, often studied through the Draw-a-Scientist Test (DAST). The DAST was originally designed by David Chambers (1983), who collected data in the 1960s and 70s. Over 50 years of DAST studies find common elements in participants’ drawings: lab coats, glasses or goggles, laboratory instruments, and technology (Miller et al. 2018).

A survey of Marvel films reveals science-related characters with the same accessories, as well as predominantly white males. These features conform to conventional and stereotypical images frequently shared by K–12 students and teachers, male and female alike (Miele 2014; Miller et al. 2018). Nevertheless, teachers can point out that in addition to Tony Stark, Hank Pym, and Bruce Banner, Marvel movies feature diverse characters such as Bill Foster, Helen Cho, and Princess Shuri.

My classes have also deliberated to what extent these individuals are truly scientists, technicians, or other trades. Regard-

![FIGURE 1](Image)

**Nature of science (NOS) themes extending NGSS dimensions (NGSS Lead States 2013).**

**Science and Engineering Practices**

- Scientific investigations use a variety of methods
- Scientific knowledge is based on empirical evidence
- Scientific knowledge is open to revision in light of new evidence
- Scientific models, laws, mechanisms, and theories explain natural phenomena

**Crosscutting Concepts**

- Science is a way of knowing
- Scientific knowledge assumes an order and consistency in natural systems
- Science is a human endeavor
- Science addresses questions about the natural and material world
less of a character’s exact profession, students appreciate seeing applications of science from multiple ethnicities and nationalities—real or otherwise. Marvel Studios executives have prioritized inclusion in upcoming films (Yamato 2019), and teachers should also watch for potential STEM connections.

Figure 2 lists several science-related characters portrayed in Marvel films. In reviewing this array of individuals, students may find faces similar to their own, as well as a wide range of ages, cultures, personalities, and more. Additionally, students may relate to younger characters such as tech-savvy preteen Harley Keener in Iron Man 3, or Peter Parker’s diverse classmates at Midtown High in Spider-Man: Homecoming. Even though these examples are fictional, teachers could highlight noteworthy behaviors that align with NGSS practices such as questioning, investigating, and communicating information.

Teachers can also transition from cinematic representations to historical and contemporary examples of diversity, where pertinent in the context of science instruction. Real-world resources are readily available from organizations such as NASA (2017), the American Physiological Society (2018), National Geographic (Lee 2013), and others. This can explicitly promote NOS understandings such as Science is a Human Endeavor (“individuals and teams from many nations and cultures have contributed”) and Science is a Way of Knowing (“many people, from many generations and nations, have
Movie scene and instructional prompts aligned with NOS themes and high school learning outcomes (NGSS Lead States 2013)

Ant-Man (2015)

| Disc Chapter: 1 (The Pym Particle) | Start: Hank Pym enters. (0:00:00)  
End: Hank: “As long as I’m alive, no one will ever get that formula,” leaves room. (00:01:40) |
|-----------------------------------|--------------------------------------------------------------------------------------------------|
| Key quote                         | Hank Pym: “I’m a scientist.”  
Howard Stark: “Then act like one. The Pym Particle is the most revolutionary science ever developed. Help us put it to good use.” |
| Discussion prompts and assessment questions | 1. What does it mean to “act like a scientist?” (According to the movie? How does this compare with notions in our real world?)  
2. To what extent should scientists be required to share their work?  
3. What are some examples from history? Now?  
4. What would you say is the “most revolutionary science ever developed” in our real world? |
| Targeted NOS themes and learning outcomes | Human Endeavor: Scientific knowledge is a result of human endeavor, imagination, and creativity. Questions about the Natural/Material World: Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. |

Marvel movies provide many more opportunities for explicit instruction of various categories and understandings about the nature of science. Figure 3 presents an example of Marvel films teachers can use to foster NOS learning and reflection; an expanded list of Marvel films can be found as an online supplement to this article (see “On the web.”) Included with each specific scene are suggested instructional prompts (discussion, reflection, assessment), along with targeted themes and high school learning outcomes in the NOS Matrix (NGSS Lead States 2013).

To reiterate, teachers should use such film segments as a supplement or springboard for further NOS instruction. Moreover, many scenes directly apply to specific science content. For example, the Iron Man 2 clip features Tony Stark synthesizing a new element to replace his arc reactor’s poisonous palladium power source. This connects to lessons on the Periodic Table of Elements, and teachers can guide students to propose properties of this fictional element based on what they know of palladium and related metals (e.g., color, density, reactivity, etc.). In conceiving predictions, students replicate the thinking process Dmitri Mendeleev used to describe undiscovered elements in the 1860s, when he was organizing his table according to observed patterns in chemical properties (Serico 2012). Students can also be asked, “What would it mean to actually synthesize a new element. Has this ever happened?”
While there are certainly issues with *Iron Man 2*’s portrayal of synthesizing a new element (McCarthy 2010), there should be similar concerns with presenting how information is confirmed in the scientific community. As with science concepts, teachers must draw students’ attention to NOS themes such as the tentative but durable nature of scientific knowledge and the need for ample empirical evidence (NGSS Lead States 2013). Teachers can use suggested prompts in Figure 3 to begin these conversations and elicit student ideas.

As displayed in Figure 3 and the online supplement, each video clip is shorter than five minutes. Showing only the necessary segment avoids wasting limited class time, focusing instead on key issues and questions. Using selected scenes also helps teachers bypass potentially inappropriate moments of violence, profanity, or sexuality. Even so, teachers will want to pre-screen the scenes and check with their school administration and media specialists regarding approval and copyright issues. Typically, educators have rights of “fair use” to show media during school hours, so long as the intent is instruction—not simply entertainment—and only a small portion of the entire work is used (Starr 2010).

Ultimately, these superhero examples provide a spark for further conversation, examination, and application among students. In the same way that teachers insert movie clips during lessons to engage students, they should also frequently revisit NOS themes throughout the entire year of science class. In doing so, we help students not only learn, but truly marvel at the nature of science.

**ON THE WEB**

Full list of movie scenes and instructional prompts aligned with NOS themes and high school learning outcomes: www.nsta.org/highschool/connections.aspx.

**REFERENCES**


**THE “MARVEL”-OUS NATURE OF SCIENCE**

Daniel Bergman (daniel.bergman@wichita.edu) is the Science Education Program Chair and a Professor in the School of Education at Wichita State University in Wichita, Kansas. He also writes at https://teachlikeasuperhero.blog.