Using superheroes such as Hawkeye, Wonder Woman and the Invisible Woman in the physics classroom

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"We find ourselves in an age when superhero films are immensely popular. With many students familiar with many of these characters and their superpowers, superheroes can facilitate a unique platform to aid in the dissemination of physics materials in the classroom," says scientist Barry W. Fitzgerald of Delft University of Technology (TU Delft, The Netherlands). In a paper published in *Physics Education* on 5th April 2018, he considers Wonder Woman, Hawkeye and Invisible Woman.

Key role for physics

"We present examples where superheroes can be used to motivate learning objectives in physics and, if desired, promote critical thinking on behalf of the student. We also reflect on how using the superhero genre in the classroom can be used to address underrepresentation of women, stereotyping, and diversity issues in physics," says Fitzgerald.

"While many people may dream about having superpowers, most are quick to dispel their hopes citing that such powers are fundamentally fictional. Nevertheless, current scientific research could be used in the future to develop technologies that mimic or even match the powers of characters such as the Invisible Woman, Wonder Woman and Spider-Man. Undoubtedly, the field of physics will play a key role in the development of these potential technologies."

Wonder Woman

In the new paper, Fitzgerald use instances from the films or superpowers to create fun exercises or experiments that link to specific learning objectives in physics. These examples apply to linear motion (Hawkeye, and see also this earlier related article), energy principles (Wonder Woman, below) and optics (Invisible Woman).

One such example would be to consider a bullet hitting one of Wonder Woman's bulletproof bracelets. "In a pivotal scene from the film, Wonder Woman uses one of her bracelets to deflect a bullet. Having studied the footage from the film, it is quite likely that the bullet was fired from a Colt New Service double action revolver, a weapon that was issued by the British War Department during World War I. Such a gun would normally fire a .45 Colt cartridge that would contain the bullet or slug, with a number of different cartridges available. You can estimate that the energy of the bullet is 8.712 kJ. When the bullet hits the bracelet it immediately comes to rest with the energy converted into a number of different forms of energy. First, when the bullet hits the bracelet there is an audible sound. The sound waves result from the conversion of some of the bullet us kinetic energy into vibrational energy that is transported through the molecules in the air. Second, a portion of the energy is converted to heat as demonstrated by Stephen Trevor's reaction when he catches the hot bullet after it hits the bracelet. Third, some of the energy is directly absorbed by the bracelet. When the bullet hits the bracelet the absorbed energy causes the atoms to vibrate about their positions, and effectively transmits thermal energy through the material. If the bracelet is made of a material that is a good conductor of heat (which is highly likely), then Wonder Woman might also have felt slightly uncomfortable by the increase in temperature of the bracelet."

Momentum

While this example can clearly be used to demonstrate forms of energy and energy conversion in the classroom, it can also be used to illustrate the principle of the conservation of momentum. "After the bullet becomes embedded in the bracelet, according to the conservation of momentum, Wonder Woman should start to move backwards. Filling in the values leads to a velocity of 0.877 meter per second."

Enthusiasm

Other aspects of popular culture can also be included in the physics classroom, says Fitzgerald, such as the computer game Angry Birds in relation to kinematics and projectile motion and Santa Claus in relation to the weather and advanced materials.

"We have integrated the superheroes paradigm in the teaching of physics , computer programming and fluid dynamics at third level institutions in the Netherlands. In addition, we have used superheroes as a powerful platform for scientific communication and outreach. The response from audiences to the material has been overwhelmingly positive. We encourage teachers and educators alike to consider merging the above superhero examples with their existing educational resources, while also taking into account representation issues."

According to Fitzgerald—who, after watching the movie Superman as a child 'wanted superpowers and wanted them as soon as possible' - every superhero film provides a gateway into a world of superhero adventures as well as real and advanced science and technology. Last year Fitzgerald launched the "Superhero Science and Technology" scientific open access journal, for which he is the editor-in-chief.

More information: Barry W Fitzgerald. Using superheroes such as Hawkeye, Wonder Woman and the Invisible Woman in the physics classroom, *Physics Education* (2018). DOI: 10.1088/1361-6552/aab442

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