Study points out errors in illustrations of one of the most famous scientific experiments

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Hand-colored lithograph published by Currier & Ives in 1876. This is probably the most widely distributed illustration of the experiment. Franklin is wrongly shown to be holding the string in one hand above the point to which the key is attached. Had he done so, he would have earthed the kite, and the experiment would not have worked. Credit: Bequest of A. S. Colgate, 1962

Illustrations of scientific experiments play a fundamental role in both science education and the dissemination of scientific knowledge to the general public. Confirming the adage that "a picture is worth a thousand words," these depictions of famous experiments remain in the minds of those who study them and become definitive versions of the scientific process. Archimedes in the bath discovering the law of buoyancy; Newton refracting sunlight with a prism and defining the principles of modern optics; Mendel cultivating peas and laying the foundations of genetics—these are just a few well-known examples.

Many of these depictions convey false information, either because the experiments never actually happened or because they were performed quite differently. People who try to reproduce them on the basis of what the illustrations depict might not get any results at all or could even face dangerous consequences.

A study conducted by Breno Arsioli Moura, a researcher at the Federal University of the ABC (UFABC) in São Paulo state, Brazil, has investigated depictions of one of these famous experiments, in which Benjamin Franklin (1706-1790) flew a kite to draw electricity from a thundercloud.

An article on the study is published in the journal *Science & Education*.

Franklin was one of the leaders of the American Revolution and the first United States Ambassador to France. He was a Deist, a Freemason, and one of the most renowned personifications of the Enlightenment in the eighteenth century. His many interests included religion, philosophy, politics, and moral and social reform, and he was one of the foremost inventors and scientists of his time.

"The kite experiment is Franklin's most famous scientific achievement. In the article I analyze seven illustrations of the event published later on,

in the nineteenth century," Moura told Agência FAPESP.

In fact, he added, the kite experiment was designed to be a simpler version of another experiment Franklin thought up in 1750 and which is now known as the "sentry box" experiment. "A kind of sentry box was to be set up on top of a tower, steeple or hill, and a man would stand inside it on an insulating dais made of wax, with a long, sharply pointed iron rod measuring some 10 meters inserted into it. Franklin expected the tip of the rod to 'draw fire' from the clouds. If the experimenter brought his knuckles close to the bottom of the rod, he would produce sparks," Moura said.

"It's important to note two things. The experiment wasn't to be performed during a storm to take advantage of lightning strikes, and the rod wasn't to be earthed but anchored by the insulating stand so that all the electricity extracted would be stored in it."

Franklin's proposal stayed on paper until a highly similar experiment was performed by French researchers in 1752. Its success drew even more international attention to his work on electricity. "When he heard about the French experiment, Franklin wrote to a correspondent in England that a simpler version of the experiment had been performed in Philadelphia, where he lived. This was in fact the kite experiment," Moura said.

The kite consisted of a "small cross made of two light strips of cedar, the arms so long as to reach to the four corners of a large thin silk handkerchief when extended," Franklin wrote. A "very sharp-pointed wire" was tied to the "top of the upper stick of the cross, rising a foot or more above the wood." The principle was the same as in the sentry box proposal. A key was fastened to the end of a silk ribbon, which in turn was tied to the end of the string (silk is an insulator).

"The experimenter held the apparatus by the silk ribbon so that electricity drawn down 'silently' from the clouds by the kite and conveyed along the string was stored in the key. As in the sentry box experiment, the kite was insulated, not earthed. By approaching a finger or knuckle, the experimenter could draw sparks," Moura explained.

Like other eighteenth-century natural philosophers, Franklin thought of electricity as a fluid built up and then discharged, flowing from one place to another. This fluid could be obtained in the laboratory by rubbing a glass tube with a piece of leather and stored in a Leyden jar, invented in mid-century by Dutch scientists. The general idea behind the sentry box and kite experiments was to show that the fluid could also be drawn from the clouds. Franklin was fascinated by the physics of cloud electrification and other aspects of meteorology.

For example, he thought seawater was full of electric fluid, and that when it evaporated to form storms high above the ocean, it took this fluid with it, so that the clouds were full of electricity.

"In Franklin's writings, there are no details showing whether he or someone else performed the experiment, but it does appear to have taken place. Another account of the experiment was produced 15 years later, in 1767, in a book by Joseph Priestley entitled 'The History and Present State of Electricity.' Franklin helped Priestley obtain materials for the book and is therefore assumed to have agreed with its contents. Priestley's account is far more detailed and includes participation in the experiment by Franklin's son. However, it differs from the original 1752 account on several points," Moura said.

In his study of the illustrations depicting Franklin's kite experiment, Moura argues that they were based on Priestley's account. Many show Franklin with his son as a small boy even though at the time he was actually 21. Some also contain more important errors.

"Many show the experiment being performed in the open air even though Franklin specified that the experimenter must be in a 'door or window, or under some cover, so that the silk ribbon may not be wet,' which would make it conductive. In most cases, the kite is being struck by lightning, or lightning bolts are very near it, although Franklin did not want to draw a lightning strike down upon himself. Most illustrations don't show the silk ribbon that was meant to insulate the kite. Franklin simply holds the string. If that had been the case, he would have earthed the kite and ruined the experiment. One illustration shows Franklin holding the key near or on the string, which isn't warranted by any account," Moura said.

The illustrations should not be used indiscriminately, especially in science classes, he argued. They embody messages that can be construed in a confusing or wrong manner, both historically and scientifically, if they are not treated critically. As noted at the outset, the images stay in the mind of the viewer and any errors they foster are hard to eradicate.

More information: Breno Arsioli Moura, Picturing Benjamin Franklin's Kite Experiment in the Nineteenth Century, *Science & Education* (2023). DOI: 10.1007/s11191-023-00421-y

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