DEEPFAKE IN SCIENCE EDUCATION. WHY NOT?

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In 1995, the journal "Education and Upbringing" published my paper titled "Genealogical Method in Education and Its Computer Support." I explored the value and importance of creating and studying family trees to learn about the values and cultural heritage of one's nation. I expressed an idea that for better immersion, in the future, animated ancestors would be able to interact with their descendants via computer screens.

Nearly 30 years later, we see this vision materializing in remarkable ways. A young man from Shanghai used artificial intelligence (AI) to "resurrect" his late grandmother, who raised him and with whom he shared a profound bond. At just 24 years old, he created a virtual version of her that he can converse with (Yan, 2023). Another touching example is a video capturing a World War II veteran's reaction to an animated photo of his deceased wife, Lola. The man looks at Lola smiling and blinking and cannot believe his eyes (Papa Jake, 2021). While some developers praise this kind of software as a source of comfort and openly advertise apps like StoryLife (PIX11 News, 2023), others express ethical concerns about 'deathbots' and suggest classifying them as medical devices (Lindemann, 2022).

This clash of opinions naturally leads to the idea that we should cherish people while they are alive. However, for those who never met their ancestors, such a possibility does not exist. The same holds true for many famous scientists who are no longer with us. So why not use AI-generated images, audio, and videos (deepfakes) to bring these historical figures to life in an educational context?

Consider Linus Carl Pauling, a Nobel Laureate in Chemistry and Peace. His life and work offer numerous educational benefits:

1. *Excellence in chemistry*. Often called the central science, chemistry connects various scientific disciplines. A search in the JBSE archive (http://www.scientiasocialis.lt/jbse/?q=node/80) shows 204 articles related to chemistry and 218 related to physics, compared to 126 for biology and 18 for geography. This highlights the paramount importance of chemistry and physics in science education (Brown et al., 2023).
2. *Eponymous legacy*. As any eponym, *Pauling electronegativity scale* is not just a popular form of recognition in scientific community but also an essential tool in science education (Slabin, 2017, 2019).
3. *Chemical bond theory*. Pauling's work in this area is rich with profound analogies and metaphors, making it especially valuable for teaching complex scientific concepts (Slabin, 2022).
4. *Activism for peace and nuclear disarmament*. Pauling's political activism demonstrated that scientists could be both pragmatic and moral. Introducing values and ethics into science education is crucial for developing well-rounded students (Lakhvich, 2013). I recall when I began lecturing at the University of Oregon, a student mentioned that his father knew Pauling and described him as a "badass." At that time, I found this characterization very inappropriate for a renowned scholar. It took me some time to understand that in American slang, "badass" refers to someone courageous, straightforward, and energetic, which indeed described Pauling well.

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Figure 1

Linus Carl Pauling. Graduation Photo from Oregon State University

Note. Unknown university portrait photographer, 1922. Public domain.

Imagine a video in which Pauling addresses today's students to explain the concept of his name and the structure of the ammonia molecule NH_3.

> *Dear students,*
>
> *Today, I want to share with you the fascinating world of chemical bonds, focusing on the molecule of ammonia, NH_3. As you may know, my research on the nature of the chemical bond earned me the Nobel Prize in Chemistry in 1954, and I also developed the electronegativity scale. Understanding ammonia involves these very concepts.*
>
> *Ammonia consists of one nitrogen atom bonded to three hydrogen atoms. To understand these bonds, let us first explore electronegativity. It is a measure of an atom's ability to attract and hold onto electrons. Pauling electronegativity scale, which ranges from 0.7 to 4.0, helps us understand how different atoms share electrons when forming chemical bonds.*
>
> *In ammonia, nitrogen's electronegativity is 3.0, while hydrogen's is 2.1. This difference means nitrogen attracts the shared electrons more strongly, leading to polar covalent bonds. The electrons are pulled closer to nitrogen, giving it a slight negative charge (δ^-), while hydrogen gets a slight positive charge (δ^+).*
>
> *The ammonia molecule has a trigonal pyramidal shape, a result of nitrogen's five valence electrons. Three electrons form bonds with hydrogen, and the remaining two form a lone pair. This lone pair repels the bonded pairs, creating the pyramidal shape.*
>
> *The H-N-H bond angle in ammonia is about 107 degrees, slightly less than the ideal tetrahedral angle of 109.5 degrees. This reduction is due to the lone pair, which repels the bonding pairs more strongly.*
>
> *The polarity of the N-H bonds makes ammonia a polar molecule, meaning it has a positive and a negative end. This polarity allows ammonia to form hydrogen bonds with water and other molecules, explaining its high solubility in water. Hydrogen bonds are crucial for many of ammonia's properties.*
>
> *Understanding the ammonia molecule exemplifies how electronegativity differences lead to polar covalent bonds, influencing the molecule's shape and properties. Pauling electronegativity scale allows you to predict atomic interactions and understand a molecule's structure and behavior.*

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In conclusion, the study of chemical bonds, such as those in ammonia, is foundational to chemistry. My work on the nature of the chemical bond has helped us understand these interactions at a deeper level. I encourage you to explore these concepts further, as they are fundamental to understanding the molecular world.

Sincerely,

Linus Pauling

A video with such a narrative would be primarily didactic, focusing on teaching and encouraging studying chemistry as a subject. Another video, in which Pauling addresses war and peace, would be more axiological, upbringing, focusing on values and morals as it should be in science education (Chowdhury, 2016).

Dear students,

As I address you today, we are reminded of the profound responsibility we hold in shaping a peaceful and just world. My work in chemistry and my activism in nuclear disarmament have underscored the necessity of scientific knowledge and moral conviction in addressing global challenges. Today, we face significant conflicts that demand our attention and action.

The ongoing conflict between a nuclear imperialist power and a European country that has made a democratic choice is a stark reminder of the dangers of unchecked aggression and the importance of national sovereignty. This new independent country, striving for democracy and independence, faces a formidable adversary in the expansionist nation. We must support their right to self-determination and freedom. By providing support—be it diplomatic, economic, or military—we affirm our commitment to global stability and peace.

The potential conflict between a dictatorial power and a nation that has chosen democracy presents a significant threat to global peace. This new independent country, like others striving to maintain their independence and democratic values, faces a powerful adversary. We must stand firm in supporting this nation's sovereignty. This involves not only military preparedness but also fostering economic and cultural ties. By doing so, we can deter aggression and promote stability in the Asia-Pacific region.

Throughout my career, I have emphasized the interplay between scientific progress and ethical responsibility. My research into the nature of the chemical bond was driven by a quest for knowledge, but my advocacy for nuclear disarmament stemmed from a profound sense of moral duty. Similarly, as we navigate these complex geopolitical issues, we must rely on both our intellect and our ethical compass.

We, as a global community, must reject the proliferation of weapons of mass destruction and work tirelessly towards disarmament. The devastation wrought by nuclear weapons in Hiroshima and Nagasaki serves as a grim reminder of the catastrophic consequences of such arms. My work, alongside many others, has shown that persistent and informed advocacy can lead to significant strides in reducing the nuclear threat.

I implore you to engage with these issues with the same rigor and passion that you bring to your studies. Advocate for policies that promote peace, support nations striving for democracy and independence, and oppose aggression and tyranny. Use your scientific knowledge to inform your actions and your moral convictions to guide them.

Sincerely,

Linus Pauling

Teachers and instructors can create didactic and upbringing narratives for various chemists using AI or their own knowledge of the history of science. After downloading videos of chemists from YouTube, they can provide an AI app with samples of the chemists' voices and motions. The AI can then generate deepfake videos in which these chemists narrate the prepared texts. This method allows educators to bring historical figures to life in an engaging and informative manner, enhancing the learning experience for students.

Choosing the right technologies to match student learning outcomes in today's technology-integrated classrooms presents educators with multiple instructional design challenges including selecting appropriate technologies to match desired student learning outcomes. As such, the era of deepfakes in images, audio, videos, and digital texts is more prevalent than ever as numerous programs using AI can significantly alter original content to fundamentally change the intent of original content (Blankenship, 2021).

Concerns about deepfakes in scientific knowledge dissemination are growing. AI-based methods for altering videos and photos have significantly lowered the barriers to creating and distributing realistic, manipulated digital content. As learners and educators increasingly rely on videos to obtain and share information, the risk of exposure to deepfakes among education stakeholders has risen (Doss et al., 2023). However, the initiative described here

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focuses on educational materials, not spreading scientific misinformation. The term "deepfake," coined in 2017, is used in this context merely provocatively and traditionally.

Yes, in AI-generated videos, one should prioritize scientific truth and ethics over striving for authenticity. When creating similar addresses from eponymous chemists to students, it is essential to consider both their scientific achievements and their personal attitudes. For example, having Wilhelm Ostwald (eponym *Ostwald law of dilution*) discuss atomic theory would be inappropriate, given his initial skepticism. It would be a reliable way to confuse students. Similarly, Dmitri Mendeleev (eponym *Mendeleev periodic system*) should not speak about ion behavior in solutions or *Arrhenius theory of electrolytic dissociation*, as he did not accept these concepts (Slabin, 2019). Additionally, an address from Johannes Stark (eponym *Stark effect*), despite his Nobel Laureate status, should be avoided due to his affiliation with Nazi ideology. Content selection in educational materials must be handled with care, ensuring that the integrity and full context of the scientist's contributions and beliefs are maintained.

These educational materials resemble cinematographic artwork. When watching films featuring currently living or deceased actors, general audiences perceive them as characters, while cinema professionals (a minority) may see them as real people, evaluating their performances from an artistic perspective. In the provided examples, Linus Pauling plays a character—himself—and the authenticity of his portrayal is less critical. This is similar to the AI-manipulated Salvador Dalí welcoming visitors at the museum named after him (Dalí Home–Salvador Dalí Museum, 2019).

A recent search in the mentioned JBSE archive reveals 11 publications focusing on AI. As we venture further into the age of digital innovation, it is imperative for the JBSE authors to embrace the potential of AI in educational contexts while remaining vigilant about ethical considerations. The integration of AI-generated images, audio, and videos of historical figures like Linus Pauling can revolutionize our teaching methods, making science more engaging and accessible. Such innovations offer unparalleled opportunities to enrich our curriculum, provided we handle the content with care, preserving the accuracy and context of scientific achievements.

Let us consider how we can collectively navigate the ethical dilemmas and leverage AI to its fullest potential in science education. Let us remain pioneers in this digital age, pushing the boundaries of what's possible while steadfastly upholding the values of truth and authenticity.

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