



Pixels and Pedagogy: Examining Science Education Imagery by Generative Artificial Intelligence

Grant Cooper¹ · Kok-Sing Tang¹

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Abstract

The proliferation of generative artificial intelligence (GenAI) means we are witnessing transformative change in education. While GenAI offers exciting possibilities for personalised learning and innovative teaching methodologies, its potential for reinforcing biases and perpetuating stereotypes poses ethical and pedagogical concerns. This article aims to critically examine the images produced by the integration of DALL-E 3 and ChatGPT, focusing on representations of science classrooms and educators. Applying a capital lens, we analyse how these images portray forms of culture (embodied, objectified and institutionalised) and explore if these depictions align with, or contest, stereotypical representations of science education. The science classroom imagery showcased a variety of settings, from what the GenAI described as vintage to contemporary. Our findings reveal the presence of stereotypical elements associated with science educators, including white-lab coats, goggles and beakers. While the images often align with stereotypical views, they also introduce elements of diversity. This article highlights the importance for ongoing vigilance about issues of equity, representation, bias and transparency in GenAI artefacts. This study contributes to broader discourses about the impact of GenAI in reinforcing or dismantling stereotypes associated with science education.

Keywords Generative artificial intelligence and science education · DALL-E 3 · ChatGPT · GPT4 · Digital technologies · Cultural capital

The Emergence of Artificial Intelligence and Generative Artificial Intelligence

Advancements in artificial intelligence (AI) have significantly progressed with the emergence of technologies like machine learning and neural networks (Wang, 2019). In the past, AI has been characterised as a technology capable of emulating human-like behaviours, including reasoning, making judgments and displaying intentionality (Shubhendu & Vijay, 2013). The challenge now lies in delineating the parameters of artificiality... “or the ways in which computers are unlike human intelligence. They are much less than human intelligence—they can only calculate. And they are much more—they can calculate larger numbers and faster than humans” (Cope et al., 2021, p.1230). Traditional AI, sometimes termed narrow AI, is engineered to solve one given problem by responding to a particular

set of inputs, excelling at pattern recognition and making predictions based on pre-existing data (Page et al., 2018; Schlegel, & Uenal, 2021). On the contrary, generative AI (GenAI) is designed to create new, original content or data based on the patterns it has learned from its training data (Dwivedi et al., 2023). While traditional AI applications are more task-specific and are centered around analysis and predictions, such as voice assistants and recommendation engines, GenAI opens new avenues for innovation by generating new content. Abbott and Rothman (2022) predict that before the 2020’s conclude,... “a significant amount of art, literature, music, software, and web content will likely be created by AI rather than traditional human authors” (p.1). It seems we are transitioning towards an education system, and more broadly, a society, where humans increasingly use GenAI to aid them in tackling the challenges they face. As noted by Cooper et al. (2024),... “Creative pursuits become more of a collaborative endeavour between human and machine, underpinned by the notion that all creativity is essentially a remix of thinking and previous learning of some form”. GenAI holds promising potential to transform aspects of education by being a powerful tool for creativity,

✉ Grant Cooper
grant.cooper@curtin.edu.au

¹ Curtin University, Kent St, Bentley 6102, Australia

personalising learning and innovative teaching methodologies (Perera & Lankathilake, 2023; García-Peñalvo et al., 2023). By autonomously creating new content, GenAI can provide tailored learning materials, generate practice exercises and create realistic scenarios or simulations for experiential learning (Mello et al., 2023). The evolution of this technology beckons a new era of innovation, challenging us to redefine the boundaries of intelligence while embracing the burgeoning symbiosis of human and machine creativity.

GenAI, Education, Stereotyping and Bias

The breakout GenAI technology in late 2022 was the release of ChatGPT. At the time of its release, this powerful language model captured the public zeitgeist by its incredible capacity to generate human-like language (Cooper, 2023). Since its release, the rapid advancement of GenAI has spurred development of a suite of innovative new digital tools, such as OpenAI's DALL-E 3, an image generation model. As discussed, there is substantial potential for leveraging GenAI in learning spaces. However, the research literature is increasingly focusing on the inequities GenAI can exacerbate. For instance, an important reported concern is the potential of GenAI to perpetuate existing biases present in the training data. This could lead to unequal and unfair outcomes, especially when factors like race, gender or Socio-Economic Status (SES) are considered (Zhai, 2022). As GenAI content proliferates, the demand for transparency in how it is created increases. OpenAI (2023), the developers of ChatGPT, openly warn that... "ChatGPT is not free from biases and stereotypes, so users and educators should carefully review its content. It is important to critically assess any content that could teach or reinforce biases or stereotypes. Bias mitigation is an ongoing area of research for us, and we welcome feedback on how to improve. The model is skewed towards Western views and performs best in English. Some steps to prevent harmful content have only been tested in English" (para.1). Bias in GenAI is a significant worry concerning its expanding use, especially within learning environments (Chan & Lee, 2023; Dobrin, 2023). As GenAI platforms rapidly evolve from text into images, videos and audio, the complexities and tensions in learning spaces become increasingly complex. The focus of this article is focused on the recent integration of DALL-E 3 into ChatGPT.

The incorporation of DALL-E 3 with ChatGPT has paved the way for users to create images from text prompts. By integrating DALL-E 3 with ChatGPT, users' text prompts are fine tuned by the GenAI. Considering the propensity of GenAI reinforce biases or stereotypes, and the virality of ChatGPT's uptake, it is crucial to evaluate the images it generates about science education. We go into more detail about stereotypes and their impact in a moment. This exploratory study delves into DALL-E 3's representation of science classrooms and

educators. This study seeks to analyse the visual narratives generated by the GenAI and their implications for inclusivity and the representation of science education. To the best of our knowledge, there has been no prior research conducted on the images generated through the integration of DALL-E 3 into ChatGPT about science education. This presents as a significant and timely research gap to address.

A Cultural Capital Lens

School science is rooted in Western or Euro-American culture, largely reflecting a white, male, middle-class perspective (Aikenhead, 1996). Gough (2011, p. 84) argues that... "given the high level of disengagement many students have with Western science, we have "an ideal opportunity to delve into the socially constructed nature of science, rather than assuming that science is acultural and objective". Untangling science education from its Western-centric, gender-biased, and classist underpinnings is necessary for nurturing a more inclusive discourse. For underrepresented groups, such as minority groups or those from low SES backgrounds, the science classroom is often spoken about as a hostile and unwelcoming space (Archer et al., 2014). It is a space where many students feel like they don't belong. Meanwhile, scientists are often typecast in media and popular culture (e.g. The Big Bang Theory, Back to the Future) as commonly males who wear white lab coats and glasses, are socially awkward, eccentric and quirky (Bodzin & Gehringer, 2001; Ferguson & Lezotte, 2020). Regrettably, such stereotypes can send powerful messages regarding who is or isn't suited for science. These stereotyped views deter some students from developing an interest in science, thereby serving as obstacles to participation and engagement in science (Aikenhead, 1996; Leavy et al., 2023). The types of capital (or resources) students bring into the science classroom are important in understanding why some students describe themselves as a "science person" and some as not (Archer et al., 2015; Cooper & Berry, 2020; Cooper, et al., 2018; DeWitt et al., 2016). Science educators tend to value specific cultural capital, mainly that which white, male, middle-class students possess, while neglecting other forms (Archer et al., 2014).

The three types of cultural capital we analyse in this paper include (1) embodied capital, (2) objectified capital-define and (3) institutionalised capital. Embodied capital refers to the personal dispositions, habits, manners, linguistic capacities and education that one acquires through the process of socialisation (Bourdieu, 1986). In the context of this research, embodied capital includes not just academic knowledge but also the confidence to engage in scientific discourse, the familiarity with scientific practices and the ability to navigate the cultural norms of scientific communities. Students from backgrounds that traditionally align with the dominant culture in science

(e.g. Western, white, male and middle-class) are more likely to have acquired this form of capital. In contrast, students from underrepresented backgrounds find themselves at a disadvantage, not because they lack the intellectual capacity, but because they haven't had the same opportunities to develop the dispositions, habits and linguistic fluency valued in science education. Objectified capital refers to material objects and media, such as books, art and other cultural goods, that one owns or has access to (Bourdieu, 1986). Such resources play a pivotal role in curriculum engagement, assignment completion and active participation in science learning. Yet, access to these resources differs, students from higher SES backgrounds usually have better access to objectified capital. This unequal access not only impacts the immediate learning experience but also shapes students' engagement with and perceptions of science, creating barriers for those with limited access to these resources. Institutionalised capital is associated with formal recognition (e.g. degrees, diplomas, certificates) and the reputation of the awarding organisation (e.g. prestige associated with graduating from Oxford, Cambridge or Harvard) (Bourdieu, 1986). This form of capital is critical for academic and professional progression in the field. It often serves as a gatekeeper, determining who has access to advanced education, research opportunities and careers in STEM-related fields. Institutionalised capital is closely linked to the other forms of cultural capital, as those with ample access to embodied and objectified capital are more likely to accumulate institutionalised capital (Bourdieu, 1986). The cycle perpetuates existing inequalities, as the educational system often mirrors and reinforces the biases and values of the dominant culture, thereby privileging certain groups over others. Those with less access to valued forms of cultural capital often feel out of place, akin to being a "fish out of water" (Tranter, 2003, p.1). In the context of this research, we are eager to observe how science classrooms and educators are portrayed, as these images are embedded with the cultural capital the models are trained on.

Methodology

The core objective of this article is to employ a capital lens critically in examining how GenAI images about science education depict forms of culture (embodied, objectified and institutionalised) and probe if these portrayals conform to, or challenge, stereotypical representations. Consequently, this research comprises of two research questions. Research Question 1 is: *How does DALL-E 3 integrated within ChatGPT represent science classrooms and educators?* To create images addressing Research Question 1 and 2, we input two deliberately broad prompts into ChatGPT: (1) "draw a picture of a science classroom" and (2) "draw a picture of a science educator". The decision to use vague prompts was strategic, aiming to uncover the representations GenAI could

generate with broad guidance. This approach allowed the resulting images to act as a mirror, reflecting the training data's scope and the inherent biases about science classrooms and educators. This methodology not only shed light on the current capabilities and limitations of GenAI but also emphasised the importance of critically examining AI-generated content.

Research Question 2 is: *How do the images generated by DALL-E 3 within ChatGPT depict forms of cultural capital, and do these depictions align with or contest stereotypical representations of science education?* ChatGPT was used in this research in several different ways. GenAI was used to facilitate the production of this article as a co-human/machine act of creativity. For instance, we asked ChatGPT to rewrite sentences (e.g. *ChatGPT prompt: rewrite: [paste sentence]*) at different stages of the article to help with phrasing, flow and word choice. Moreover, we asked ChatGPT to analyse the images we created below as an initial starting point for our own evaluation (e.g. *ChatGPT prompt: analyse the picture for its embodied capital, objectified capital and institutionalised capital.* Likewise, we conceptualised and enacted the process of analysis as a co-human/machine act of creativity. This approach allowed us to explore the dynamic interplay between human and machine, treating the analytical phase not just as a task of data interpretation but as an innovative partnership. By engaging with the machine as a creative partner, we sought to harness the potential of combining human insight with GenAI capabilities to achieve more comprehensive and creative insights. The images and text italicised below has been directly copied from ChatGPT. It is important to remember that the following results are a moment in time response, meaning the same questions could be entered into ChatGPT and users may get a different response if entering the same prompt. The responses below were collected in October 2023.

Results

How Does DALL-E 3 Integrated Within ChatGPT Represent Science Classrooms?

As discussed, the prompt entered in ChatGPT was "draw a picture of a science classroom". When the prompt is actioned, four images appear together with accompanying text created from the original input. For instance, from the broad instruction above, the following italicised text was generated along with the images below (Figs. 1, 2, 3 and 4):

Here are four images depicting science classrooms in different settings and styles:

1. *A modern science classroom with wooden desks, microscopes and charts.*

2. A vintage classroom from the early 1900s with wooden benches and a blackboard displaying chemical formulas.
3. A futuristic classroom with sleek furniture, holographic displays and a robot assistant.
4. A unique forest-themed classroom where students are studying nature up close.

Which one resonates with you the most or would you like any modifications?

The accompanying text in ChatGPT generated as part of the image creation is as follows:

Photo of a modern science classroom filled with wooden desks and black stools. On each desk, there's a microscope, a set of test tubes, and a notebook. Charts of the human anatomy and the periodic table are displayed on the walls. A diverse group of students, both male and female, of various descents, are actively discussing their observations.

Analysis of cultural capital in Fig. 1:

Embodied capital:

- The students are seen engaging actively in their learning, implying an intrinsic motivation to learn what appears to be a chemistry class. Their body language—bent heads, focused eyes on the books or equipment—indicates a deep concentration and compliance (potentially engagement) with what they are expected to learn.
- Their attire is modern and neat, suggesting a middle to upper SES and habitus.
- Gender, as embodied capital, refers to the idea that individuals accumulate resources, skills and social expectations based on their gender identity from infancy.

As described in the text that accompanied the image, both male and female are actively discussing their observations.

- Ancestry as embodied capital represents the cultural and social assets inherited from one's lineage, encompassing traditions, languages and histories that shape an individual's worldview. The accompanying text mentions students of "various descents" depicted in the image.

Objectified capital:

- This picture aligns with common stereotypes of a science classroom such as microscopes, test tubes, beakers and other lab equipment. These tools and equipment represent a well-resourced environment that facilitates scientific learning.
- The room is adorned with various educational posters and displays showcasing human anatomy, periodic tables and other scientific charts. These educational materials are physical representations of academic knowledge.
- There is also a presence of books, notebooks and stationary, symbolising the tangible resources available to the students to aid their learning journey.

Institutionalised capital:

- The structured setup of the classroom with organised desks, chairs and a clear distinction between the students' workspace and the storage or display areas represents the institutionalised settings of formality and order.
- The formality and order of educational institutions also appear in the learning environment design, where students sit in organised rows of seating.
- The educational posters and displays on the walls not only serve as learning aids but also signify the standardised knowledge that's deemed important by the institution.

Fig. 1 Image one of a science classroom



The accompanying text in ChatGPT generated as part of the image creation is as follows:

Illustration of a vintage science classroom from the early 1900s. Rows of wooden benches are aligned facing a large blackboard where complex chemical formulas are written. A Caucasian male teacher, wearing round glasses and a waistcoat, demonstrates an experiment at the front. Students, both male and female, of various descents, attentively watch.

Analysis of cultural capital in Fig. 2:

Embodied capital:

- From the text that accompanied the image, we see a Caucasian male teacher with glasses in a white lab coat teaching chemistry, commanding attention at the front of the class. Students diligently jot down facts and figures.
- The attentive posture of the students, their disciplined focus and the organised way the classroom is conducted embody the internalised dispositions and habits valued in this educational setting.
- The formal attire of students suggests a cultural appreciation for professionalism and etiquette often associated with individuals from affluent backgrounds.
- As described in the text that accompanied the image, “students, both male and female, of various descents, attentively watch”.

Objectified capital:

- The shelves, laden with books, serve as a repository of cultural artifacts about science.
- The vials, flasks and other tools on the teacher’s desk symbolise tools used in the scientific process. Possessing and knowing how to use such equipment is a form of objectified capital.
- The wooden desks, chairs and blackboard are physical objects that facilitate the teaching process.

Institutionalised capital:

- There are rows of organised desks and chairs, representing the institutionalised norms of formality, order and compliance with teachers as the authority figure.
- The clock hints at the institutional norms related to punctuality and the structuring of time, which imply a sense of order in this formal educational setting.

The accompanying text in ChatGPT generated as part of the image creation is as follows:

Photo of a futuristic science classroom with sleek white tables and holographic displays. Students of various genders and descents are using virtual reality headsets and touchscreens to conduct experiments. The walls are adorned with 3D models of DNA helixes, planets, and molecules. A robot assistant moves around aiding the students.

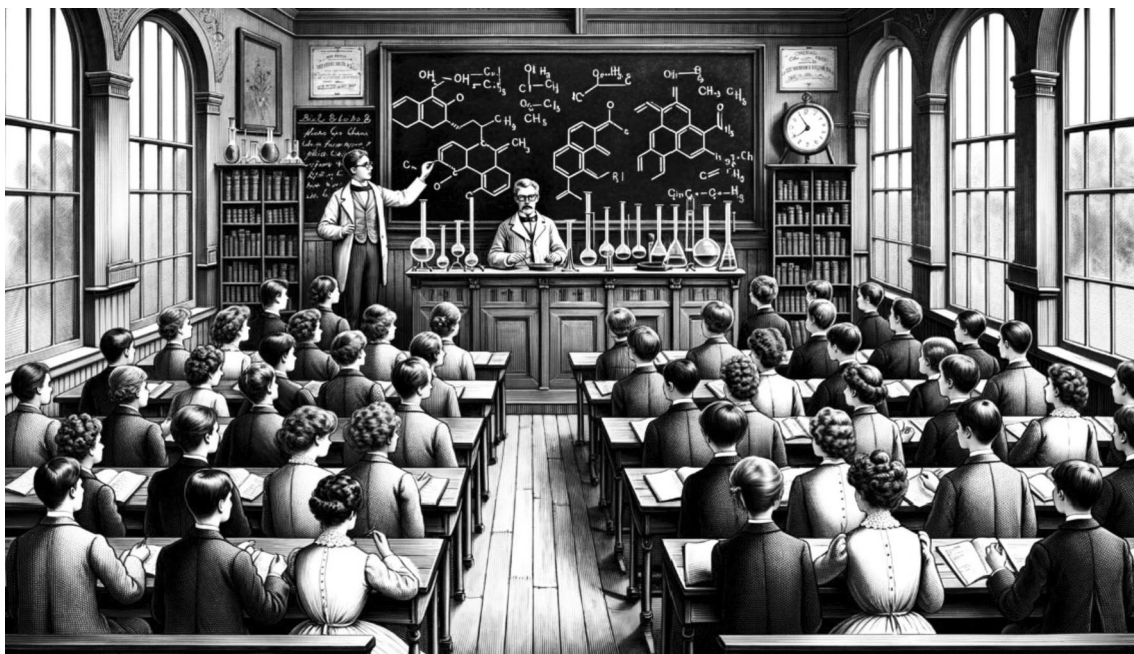


Fig. 2 Image two of a science classroom



Fig. 3 Image three of a science classroom

Analysis of cultural capital in Fig. 3:

Embodied capital:

- Students are dressed in professional attire, their postures and focus on the task at hand, potentially learning about genetics, molecular biology or some aspect of planetary science.
- Students' use of virtual reality (VR) headsets signifies technological proficiency, which may be commonplace in a futuristic science classroom.
- One of the educators is also wearing a VR headset, implying their command over the content and digital technology. They are wearing a white lab coat, along with three other educators in the image.

- As described in the text that accompanied the image, "students of various genders and descents" are engaging in the learning experience.

Objectified capital:

- The technological equipment, including holographic displays, touch screen desks and VR headsets, represents access to assets that facilitate learning and research.
- The room is adorned with digital displays showcasing various scientific and technological concepts, books, DNA structures and planetary models. These represent the technological resources and tools available to the users.
- The presence of a robot in the centre highlights the convergence of biological and technological sciences and represents advancements in AI and robotics, their purpose is unclear.

Institutionalised capital:

- The digital displays and the content being presented, such as the DNA strand, represent scientific knowledge that is deemed important by the institution. It also suggests a focus on biotechnology or genetic engineering.
- The fact that students are in a uniform or similar attire hints at an organised educational institution. The overall aesthetics of the room, with its sleek design, modern furniture and technology, all indicate a well-resourced educational institution that invests in their learning environments.



Fig. 4 Image four of a science classroom

The accompanying text in ChatGPT generated as part of the image creation is as follows:

Watercolor painting of a science classroom in a forest setting. Tables made of logs and tree stumps are set up, and students of diverse genders and descents are examining plants and insects under magnifying glasses. Birds and squirrels peek curiously from the trees. A female teacher, of African descent, points out different species to the students.

Analysis of cultural capital in Fig. 4:

Embodied capital:

- In the image, we see students engaging in hands-on biology lesson outside. They are using magnifying glasses to inspect plants, suggesting they are developing important observational skills, and knowledge about the environment.
- The experience is facilitated by a female teacher of African descent according to the text that accompanied the image. She is wearing a white lab coat.
- Also in the accompanying text, “students of diverse genders and descents are examining plants and insects”.

Objectified capital:

- In the image, the magnifying glasses, jars filled with plants and specimens, the teacher’s book and the makeshift tables are all examples of tools and resources made available to the students to facilitate their learning.
- The presence of these tools in an outdoor setting underscores the value placed on experiential learning.

Institutionalised capital:

While there’s no direct representation of formal certifications in the image, the organised setting of an outdoor classroom, led by a teacher in a lab coat, in a non-traditional setting.

How Does DALL-E 3 Integrated Within ChatGPT Represent Science Educators?

As discussed, the prompt entered into ChatGPT was “draw a picture of a science educator”. When the prompt is actioned, four images appear together with accompanying text:

The accompanying text in ChatGPT generated as part of the image creation is as follows:

Photo of a science educator, a man of African descent, wearing a white lab coat and safety goggles. He stands in front of a chalkboard covered with chemical equations, holding a

beaker filled with a bubbling blue liquid. His expression is enthusiastic as he explains the experiment to the class.

Analysis of cultural capital in Fig. 5:

Embodied capital:

- In this image, the man is depicted as a scientist or chemist. His skills are highlighted by his ability to handle the flask with a blue substance and his comfortability around the chalkboard filled with chemical formulas. He is wearing a white lab coat, safety goggles and as described in the text that accompanied the image, the man is of African descent.

Objectified capital:

- The image emphasises the tools of his trade, such as the flask filled with a chemical substance, the chalkboard with



Fig. 5 Image one of a science educator

detailed chemical structures, and the book on the table, all serving as objectified capital. This implies that the individual has gained tangible skills and proficiency in the field of chemistry.

Institutionalised capital:

- In the context of this image, the man's lab coat, the laboratory setting and the chalkboard filled with chemical structures suggest an institutional setting, such as a university lab or research lab. This environment reinforces his professional status, highlighting the importance and legitimacy of his work within academia or industry.

The accompanying text in ChatGPT generated as part of the image creation is as follows:

Illustration of a science educator, a woman of Hispanic descent, in a modern classroom setting. She's using an interactive touchscreen display to show the anatomy of a cell. She has a pointer in hand and wears glasses and a lab coat. Students of diverse gender and descent watch attentively from their desks.

Analysis of cultural capital in Fig. 6:

Embodied capital:

- The animated teacher in the forefront appears to be explaining the cellular structures presented on the screen.

Her confidence, attire and the tools she uses (e.g. the pointer and tablet) imply a depth of knowledge and skills in the subject matter she's presenting, which appears to be related to biology or cellular science. She is wearing glasses, and as described in the text that accompanied the image, the woman is of Hispanic descent.

- Also in the accompanying text, "students of diverse gender and descent watch attentively from their desks".

Objectified capital:

The screen showcasing detailed cellular diagrams serves as a central piece of objectified capital. Additionally, the shelves with organised binders and books signify the value of recorded knowledge and educational resources. Her tablet is another piece of technological objectified capital, suggesting the use of digital technology in her pedagogy.

Institutionalised capital:

- The setting appears to be a classroom or lecture hall, indicating a formalised educational institution. The image suggests a teacher-centered pedagogy, highlights students' attentive posture and the organised rows of seating which reinforce the institutional nature of the setting.
- The teacher's white lab coat and the visual aids hint at a higher level of education, possibly at a college or university level, suggesting that she has achieved a certain level of status within this institutional framework.

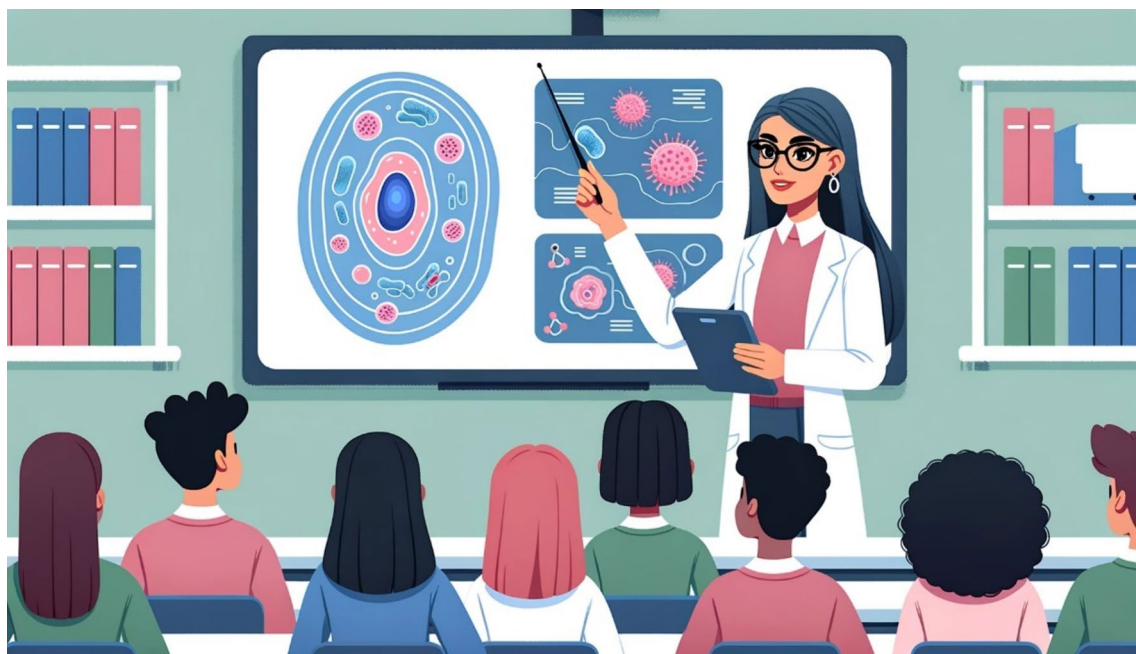


Fig. 6 Image two of a science educator

The accompanying text in ChatGPT generated as part of the image creation is as follows:

Photo of a science educator, a person of Middle Eastern descent with a non-binary appearance, demonstrating the principles of physics using a pendulum. They wear a lab coat and have a confident expression. The background shows a lab setup with various instruments and charts.

Analysis of cultural capital in Fig. 7:

Embodied capital:

- The individual is wearing a white lab coat, and as described in the text that accompanied the image, is “a person of Middle Eastern descent with a non-binary appearance”.



Fig. 7 Image three of a science educator

- The individual appears to be in a laboratory setting with a microscope, pendulum and various charts related to data and structures in the background. Given these cues, it seems likely that they work in the field of physics or chemistry, with a possible emphasis on experimental or laboratory research.

Objectified capital:

The laboratory equipment, including the microscope and the pendulum device they are interacting with, represent access to tools of the field, which can be seen as objectified capital.

Institutionalised capital:

- It's hard to determine purely from an image without explicit signs like diplomas. However, the professional setting and attire might imply that the individual has received some form of higher education or institutional training related to their field.
- The white lab coat, traditionally associated with professionals in the scientific and medical fields, might also suggest some form of institutional recognition of the individual's skills and expertise.

The accompanying text in ChatGPT generated as part of the image creation is as follows:

Watercolor painting of a science educator, a woman of South Asian descent, teaching botany in an outdoor setting. She holds a magnifying glass and examines a plant, explaining its parts to a group of students of diverse gender and descent who gather around her with notebooks.

Analysis of cultural capital in Fig. 8:

Embodied capital:

- The central female figure appears to be the teacher, given her leading role and the magnifying glass she's using. Her attire and focused demeanour suggest a level of expertise and knowledge in biology or botany. She is wearing glasses, a white lab coat and as described in the text that accompanied the image, is a woman of South Asian descent.
- The students around her appear to be actively participating, their engagement indicates they are building their own embodied capital through education and hands-on experience.

Objectified capital:

- The tools and equipment, such as the magnifying glass, the note pads and the bottles, represent objectified capital



Fig. 8 Image four of a science educator

as they are tangible objects that aid in the process of learning and investigating.

- The plants and the setting play a key role, too. The presence of various plants, both potted and in the background, along with the bottled solutions, are critical components of the learning environment and serve as resources for hands-on exploration.

Institutionalised capital:

The structured learning environment, possibly a school garden or an outdoor classroom setting, suggests institutional backing.

Discussion

Embodied Capital

Science Classrooms

As discussed, embodied capital refers to the personal dispositions, habits, manners, linguistic capacities and education that one acquires through the process of socialisation.

The images of the science classrooms implied exploration of various science domains, including chemistry, physics, biology and planetary science. As discussed, a range of learning environments are represented, from vintage to modern. Across these environments, the resource-rich settings and formal attire in some images suggest a middle to upper SES background, reflecting their habitus—the collection of dispositions, attitudes and experiences that guide their educational interactions (Bourdieu, 1977). The focus and concentration observed in the students' body language mirror their compliance and engagement with the educational expectations one would expect to see in an elite private or selective school. We know if students are from a low SES background, they are less likely to participate in science (Cooper & Berry, 2020; Cooper et al., 2018; Fullarton et al., 2003). The availability of economic capital within a family broadens opportunities to nurture and enhance the students' cultural capital, which, in turn, is closely intertwined with their future educational and vocational achievements (Bourdieu, 1977). The GenAI imagines science classrooms largely absent of lower SES students—it implicitly reinforces the notion that science is not for those with limited access to economic capital. Despite this, the inclusion of varied genders and ancestry backgrounds in the images counters the traditional depictions of science classrooms. The GenAI images showcase diverse classrooms, featuring individuals of different genders, cultural, linguistic and historical backgrounds. By presenting such diversity, these images encourage a rethinking of science education as a domain that is inclusive and open to all. This move towards depicting a broader spectrum of participants in scientific learning challenges longstanding stereotypes and paves the way for a science classroom that is culturally rich and embraces gender diversity. Hence, although the GenAI-generated images tend to show a bias towards the inclusion of students from upper SES backgrounds, their depiction of gender diversity and multicultural inclusiveness marks a step towards imagining science education as a field that is accessible and fair for everyone.

Science Educators

Importantly, the diverse ancestry and gender identities depicted challenge a stereotypical image of the scientist or teacher as white and male. It could be argued that the images therefore align with attempts to promote diversity and inclusion in STEM-related fields but may challenge the realities in some existing academic or work environments, such as physics and engineering. The images emphasised embodied capital through attire, conforming with traditional notions of what a scientist or educator should look like. The wearing of white lab coats by all the individuals reinforces existing societal stereotypes. While these items are essential for safety in labs, this stereotype may contribute to a narrow stereotype of who can be a scientist. Out of the four science

educators, three were wearing glasses or goggles (Figs. 5, 6 and 8). Eyewear, such as glasses or goggles, is associated with cultural capital embodying intellectualism, meticulousness and a scholarly demeanour. In their investigation, Gormally & Inghram (2021) identified three predominant characteristics that are perceived as negative stereotypes associated with scientists: (1) white lab coats and goggles, (2) the perception of scientists as antisocial individuals confined to the solitude of labs and (3) a stereotype about innate intelligence—suggesting that scientists are inherently smart or have a superior level of intelligence from birth. This stereotype can foster a fixed mindset among students, instilling a belief that they either inherently have what it takes to become scientists, or they don't (Gormally & Inghram, 2021). When examining the GenAI imagery, stereotype one (white lab coats and goggles) is prominent. It is also interesting to consider if the GenAI images subtly encapsulates or manifests stereotypes two and three from Gormally's research. Does the imagery challenge or reinforce the stereotype of scientists being antisocial or secluded in labs? Two of the four images of science educators portray scientists alone in a lab, while the other two depict the scientists teaching. Regarding stereotype three, as shown in Fig. 5, the scientist sits in front of a chalkboard filled with skeletal chemical structures. For students lacking the scientific understanding and the valued cultural capital to grasp the subject—including the literacy to decode such representations—the subject may seem overly difficult and out of their reach. It may seem as though it's a subject reserved for others that they have always viewed as more intelligent than themselves.

Objectified Capital

Science Classrooms

As highlighted previously, objectified capital refers to material objects and other cultural goods, that one owns or has access to. The presence of traditional lab equipment like microscopes, test tubes and beakers align with stereotypical images of scientists working in labs (see Figs. 1, 2 and 4). The imagery also includes science posters, which arguably reinforce the stereotype of a structured, fact-driven environment where scientific knowledge is prized and displayed prominently. Books also feature heavily in the imagery, which can be seen as emblematic of academic achievement and intellectual prowess. Students who don't read much may feel that there is a perceived hierarchy in the classroom, with those who are well-read positioned to convert their cultural capital to science capital (Archer et al., 2015). Students might perceive science posters and books as symbols of a particular form of knowledge or education that they do not possess, which could potentially lead to feelings of inadequacy or exclusion, with potential implications for their engagement in science.

Science Educators

In similar themes to the classrooms, the inclusion of scientific tools like flasks, chalkboards and microscopes aligns with the stereotypical ideas of scientists engrossed in lab work and theoretical explorations (see Figs. 5, 6, 7 and 8). Furthermore, the organised binders and books are also prominent in the GenAI images of the science educators (see Figs. 5 and 6).

Institutionalised Capital

Science Classrooms

As discussed, institutionalised capital is associated with the recognition and reputation of educational organisations, often demonstrated through formal credentials, but also reflective of the institution's prestige. The GenAI imagery features science classrooms well resourced, showcasing a commitment to providing quality educational experiences. There seems to be no indication from the images showcasing underresourced or outdated science classrooms for their time, which again, suggests the emphasises on schools that serve higher SES students. We know that schools with higher populations of students from low SES environments are commonly underresourced in their science education programs (Archer et al., 2015; Gorard & See, 2009). The GenAI imagery commonly highlights a formal and structured environment, with the clear separation of storage, display and workspace areas. The former is linked to the traditional image of a disciplined, orderly setting that is often associated with science education (Aikenhead, 2006). The GenAI imagery commonly emphasises the centrality of the teacher, and implicitly positions them as an authority figure. The framing of teachers as central authority figures aligns with the stereotype of a hierarchical teacher-student dynamic in science education (DeWitt et al., 2016; Harding, 1993), where knowledge is primarily transferred from the teacher to the students. In contrast, Fig. 4 challenges the assumption that science education is solely confined to indoor, lab-based environments. It suggests an openness to experiential, outdoor learning, fostering a more holistic approach to science education.

Science Educators

To attain the positions illustrated in the images, it is implied that the scientists possess extensive amounts of formal education, along with the requisite credentials, representing valued forms of institutionalised capital. As discussed earlier, the white lab coat is a prominent feature of the GenAI imagery. When worn by science educators, the lab coat signifies a level of professional recognition and authority within the institutional framework, a visual endorsement of a person's expertise and legitimacy, the educator's authority, their role as knowledge bearer and a

symbol of adherence to the established norms and standards of the scientific and educational institutions (Gormally & Inghram, 2021; Aikenhead, 2006). The diverse representation of ancestry likely challenges historical representations of authority figures in educational contexts that often reflected a narrow demographic, typically dominated by individuals from certain racial, ethnic and SES backgrounds. These GenAI artefacts broadly foster a more inclusive atmosphere where authority and respect are not predetermined by one's background but are based on other contributions and abilities.

Conclusion

This study illuminates the need for inclusive representation without perpetuating harmful stereotypes. The imagery from GenAI commonly reinforced conventional assumptions regarding the appearance of scientists, thereby reaffirming the existing cultural capital usually associated with science learning and educators, such as white lab coats, glasses, microscopes and test tubes. The prominent focus on high SES students—seen through the type of science equipment they used, the clothes students wear and the environments they engaged with—may perpetuate existing assumptions about who does and doesn't belong in science. At the same time, the GenAI imagery also included diverse representations of ancestry, gender and even pedagogy (e.g. outdoor settings for biology). By doing so, the images generate a more inclusive vision for what the future of science education can look like. They offer a glimpse of a more equitable landscape, where the distribution of cultural capital is less constrained by traditional barriers of race, gender and SES background. The former highlights how the training data of the GenAI may be framed as progressive or aspirational. This makes the images a fascinating point for further analysis, especially as we consider how the future of science education should look like. This study introduces a key methodological innovation by showcasing how to critically examine the depictions of educational settings and figures by GenAI technologies like DALL-E 3. It provides a novel lens for assessing the biases and stereotypes embedded within these AI systems. Through the analysis of GenAI-generated images based on prompts, this approach uncovers insights into the algorithmic biases and underlying training data that shape outputs. This method allows researchers to identify and discuss the cultural and social norms being reinforced or contested by GenAI, making a significant contribution to the discourse on ethical AI development and its application in educational contexts. The insights gained from this research come with limitations. Primarily, the findings are constrained by the current capabilities and inherent biases of the GenAI model used, suggesting that they may not apply to future iterations that could offer distinct portrayals due to advancements in GenAI technology. The rapid evolution of GenAI technology means

that the algorithms and data sets used to train these models are continually updated, potentially leading to significant changes in how GenAI systems like DALL-E 3 interpret and generate content. Secondly, it is not possible to analyse all forms of cultural capital through the images and accompanying text generated by the GenAI, which presents as a methodological limitation. Nevertheless, through an in-depth examination of DALL-E 3's visual outputs, this paper contributes to the broader discourse surrounding the impact of GenAI in either reinforcing or dismantling prevailing stereotypes, paving the way for a more inclusive depiction of science education.

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Declarations

Ethical Approval Not applicable.

Informed Consent Not applicable.

Statement Regarding Research Involving Human Participants and/or Animals Not applicable.

Consent to Participate Informed consent was obtained from all individual participants included in the study.

Consent to Publish The participant has consented to the submission of the case report to the journal.

Competing Interests The authors declare no competing interests.

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References

- Abbott, R., & Rothman, E. (2022). *Disrupting creativity: Copyright law in the age of generative artificial intelligence*. Florida Law Review.
- Aikenhead, G. S. (1996). Science education: Border crossing into the subculture of science. *Studies in Science Education*, 27(1), 1–52.
- Aikenhead, G. S. (2006). *Science education for everyday life: Evidence-based practice*. Teachers College Press.
- Archer, L., Dawson, E., DeWitt, J., Seakins, A., & Wong, B. (2015). “Science capital”: A conceptual, methodological, and empirical argument for extending bourdieusian notions of capital beyond the

- arts. *Journal of Research in Science Teaching*, 52(7), 922–948. <https://doi.org/10.1002/tea.21227>
- Archer, L., DeWitt, J., & Willis, B. (2014). Adolescent boys' science aspirations: Masculinity, capital, and power. *Journal of Research in Science Teaching*, 51(1), 1–30.
- Bodzin, A., & Gehringer, M. (2001). Breaking science stereotypes. *Science and Children*, 38(4), 36.
- Bourdieu, P. (1977). *Power and ideology in education*. Oxford University Press.
- Bourdieu, P. (1986). *The forms of capital*. In *Handbook for theory and research for the sociology of education*. Greenwood.
- Chan, C., & Lee, K. (2023). The AI generation gap: Are Gen Z students more interested in adopting generative AI such as ChatGPT in teaching and learning than their Gen X and Millennial Generation teachers?. *arXiv preprint arXiv:2305.02878*.
- Cooper, G. (2023). Examining science education in ChatGPT: An exploratory study of generative artificial intelligence. *Journal of Science Education and Technology*, 32, 444–452. <https://doi.org/10.1007/s10956-023-10039-y>
- Cooper, G., & Berry, A. (2020). Demographic predictors of senior secondary participation in biology, physics, chemistry and earth/space sciences: Students' access to cultural, social and science capital. *International Journal of Science Education*, 42(1), 151–166. <https://doi.org/10.1080/09500693.2019.1708510>
- Cooper, G., Berry, A., & Baglin, J. (2018). Demographic predictors of students' science participation over the age of 16: An Australian case study. *Research in Science Education*, 50(1), 361–373. <https://doi.org/10.1007/s11165-018-9692-0>
- Cooper, G., Tang, K. S., & Rappa, N. (2024). Generative artificial intelligence as epistemic authority? Perspectives from higher education. In H. Crompton & D. Burke (Eds.), *Artificial intelligence applications in higher education: Theories, ethics, and case studies for schools*. Routledge (in press).
- Cope, B., Kalantzis, M., & Searsmith, D. (2021). Artificial intelligence for education: Knowledge and its assessment in AI-enabled learning ecologies. *Educational Philosophy and Theory*, 53(12), 1229–1245. <https://doi.org/10.1080/001318572020.1728732>
- DeWitt, J., Archer, L., & Mau, A. (2016). Dimensions of science capital: exploring its potential for understanding students' science participation. *International Journal of Science Education*, 38(16), 2431–2449.
- Dobrin, S. I. (2023). *Talking about generative AI: A guide for educators*. Broadview Press.
- Dwivedi, Y. K., Kshetri, N., Hughes, L., Slade, E. L., Jeyaraj, A., Kar, A. K., Baabdullah, A. M., Koohang, A., Raghavan, V., Ahuja, M., Albanna, H., Albashrawi, M. A., Al-Busaidi, A. S., Balakrishnan, J., Barlette, Y., Basu, S., Bose, I., Brooks, L., Buhalis, D., ... Wright, R. (2023). Opinion paper: "So what if ChatGPT wrote it?" multidisciplinary perspectives on opportunities, challenges and implications of generative conversational AI for research, practice and policy. *International Journal of Information Management*, 71, 102642. <https://doi.org/10.1016/j.ijinfomgt.2023.102642>
- Ferguson, S. L., & Lezotte, S. M. (2020). Exploring the state of science stereotypes: Systematic review and meta-analysis of the Draw-A-Scientist Checklist. *School science and mathematics*, 120(1), 55–65.
- Fullarton, S., Walker, M., Ainley, J., & Hillman, K. (2003). *Patterns of participation in year 12*. Retrieved from http://research.acer.edu.au/lsay_research/37/
- García-Peñalvo, F. J., Llorens Largo, F., & Vidal, J. (2023). The new reality of education in the face of advances in generative artificial intelligence.
- Gorard, S., & See, B. (2009). The impact of socio-economic status on participation and attainment in science. *Studies in Science Education*, 45(1), 93–129. <https://doi.org/10.1080/03057260802681821>
- Gormally, C., & Inghram, R. (2021). Goggles and white lab coats: Students' perspectives on scientists and the continued need to challenge stereotypes. *Journal of Microbiology & Biology Education*, 22(1), 22.1.9. <https://doi.org/10.1128/jmbe.v22i1.2273>
- Gough, A. (2011). The Australian-ness of curriculum jigsaws: Where does environmental education fit? *Australian Journal of Environmental Education*, 27(1), 9–23. <https://doi.org/10.1017/S0814062600000045>
- Harding, S. (1993). Introduction: Eurocentric scientific illiteracy - a challenge for the world community. In S. Harding (Ed.), *The "racial" economy of science: Toward a democratic future* (pp. 1–29). Indiana University Press.
- Leavy, A., Hourigan, M., & Cleary, C. (2023). From bespectacled, bearded and bald to explosions, potions and vaccines: Irish children's changing perceptions of scientists and the effect of the COVID-19 pandemic on those perceptions. *International Journal of Science Education*, 45(14), 1214–1239. <https://doi.org/10.1080/09500693.2023.2193302>
- Mello, R. F., Freitas, E., Pereira, F. D., Cabral, L., Tedesco, P., & Ramalho, G. (2023). Education in the age of generative AI: Context and recent developments. *arXiv preprint arXiv:2309.12332*.
- OpenAI. (2023). *Educator FAQ*. <https://help.openai.com/en/articles/8313359-is-chatgpt-biased>
- Page, J., Bain, M., & Mukhlis, F. (2018). *The risks of low level narrow artificial intelligence*. In *2018 IEEE international conference on intelligence and safety for robotics (ISR)* (pp. 1–6). IEEE.
- Perera, P., & Lankathilake, M. (2023). Preparing to revolutionize education with the multi-model GenAI Tool Google Gemini? A Journey towards Effective Policy Making.
- Schlegel, D., & Uenal, Y. (2021). A perceived risk perspective on narrow artificial intelligence. In *PACIS* (p. 44).
- Shubhendu, S., & Vijay, J. F. (2013). Applicability of artificial intelligence in different fields of life. <https://www.semanticscholar.org/paper/Applicability-of-Artificial-Intelligence-in-Fields-Shubhendu-Vijay/2480a71ef5e5a2b1f4a9217a0432c0c974c6c28c>
- Tranter, D. (2003). 'Fish out of water': Students from disadvantaged schools and the university experience. In *Refereed paper presented at creating spaces: Interdisciplinary writings in the social sciences conference, Canberra, 17–18 July*.
- Wang, P. (2019). On defining artificial intelligence. *Journal of Artificial General Intelligence*, 10(2), 1–37. <https://doi.org/10.2478/jagi-2019-0002>
- Zhai, X. (2022). *ChatGPT user experience: Implications for education*. <https://doi.org/10.2139/ssrn.4312418>

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