# To improve literacy, improve equality in education, not large language models

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Huettig and Christiansen (2024) argue that large language models (LLMs) are beneficial to address declining cognitive skills, such as literacy, through combating imbalances in educational equity. However, we warn that this technosolutionism may be the wrong frame. LLMs are labour intensive, are economically infeasible, and pollute the environment, and these properties may outweigh any proposed benefits. For example, poor quality air directly harms human cognition, and thus has compounding effects on educators' and pupils' ability to teach and learn. We urge extreme caution in facilitating the use of LLMs, which like much of modern academia run on private technology sector infrastructure, in classrooms lest we further normalise: pupils losing their right to privacy and security, reducing human contact between learner and educator, deskilling teachers, and polluting the environment. Cognitive scientists instead can learn from past mistakes with the petrochemical and tobacco industries and consider the harms to cognition from LLMs.

In a recent article, Huettig and Christiansen (2024, hereafter: H&C) argue that cognitive science can play an important role in how large language models (LLMs) could arrest a decline in literacy. The call to arms for cognitive scientists is a welcome one (cf. Avraamidou, 2024; van Rooij et al., 2024) — as H&C rightly point out, the future of literacy is too important to be left in the hands of tech firms motivated by profit. H&C argue that under the guidance of cognitive scientists, LLMs could address declining literacy levels noted in multiple countries (Ahonen, 2021). Below we argue that while cognitive scientists are certainly required to address declining literacy levels, the effects of focusing on developing LLMs to improve literacy, could in fact exacerbate the root causes of its decline. In sum, we argue that H&C suggestions could be in fact perilous since: *a*) almost all our distributed computational infrastructure is owned by the big three technology companies (Amazon, Google, and Microsoft) and any large model will run on these ecosystems (e.g. OpenAI models run on Microsoft), thus escape is structurally impossible (with worrying effects on academic freedom, privacy, and security Birhane et al., 2022; OHCHR, 2021; Fiebig et al., 2023); *b*) companies have a history of inflating claims of benefits and downplaying or hiding known downsides (O'Brien, 2024; Stolley, 1991), which says nothing of yet-to-be-seen negative effects of their products and services; and *c*) the root causes of declining literacy should be uncovered, or at least, first outlined since it appears that LLMs and related technologies contribute to harmful conditions for pupils' learning. In this letter, we focus on the last point: uncritical technosolutionism.

Among the suggested areas for cognitive scientists to use LLMs to improve literacy, H&C single out educational equity (see also Berdejo-Espinola & Amano, 2023). Concern about the effects of inequity on literacy levels is well-founded: disparities in socioeconomic status have been linked to literacy outcomes both as general effects on development (see e.g. Romeo, Uchida, & Christodoulou, 2022) and as specific effects (Dolean, Melby-Lervåg, Tincas, Damsa, & Lervåg, 2019). It is, however, worth noting that for children, the socioeconomic effects of the *school* affect literacy even when accounting for individual socioeconomic effects (Salas & Pascual, 2023). This of course makes

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sense in the context of literacy being a skill that is (over)learned (e.g. Huettig & Hulstijn, 2024).

Unfortunately, LLMs are created and employed at a substantial economic (Smith, 2023), human (Bender, 2024; Perrigo, 2023; Williams, Miceli, & Gebru, 2022), and environmental cost (Bender, Gebru, McMillan-Major, & Shmitchell, 2021; Crawford, 2024; Ren & Wierman, 2024; O'Brien, 2024). While a focus of ongoing research is to make these models environmentally sustainable (Jiang, Sonne, Li, You, & You, 2024; Stojkovic, Choukse, Zhang, Goiri, & Torrellas, 2024), these advancements at this stage are some way off (Blunt & Hiller, 2024), if at all possible (van Rooij et al., 2024). With due consideration for the scale at which LLMs need to operate, the effect of investing resources in LLMs rather than education could have multiple negative effects. The direct effect of time and money being spent on A and not B might be simplistic, but the downstream effects of the investment look set to widen economic disparities (Alonso, Kothari, & Rehman, 2020).

The above examples demonstrate that it may be that LLMs exacerbate, rather than alleviate, inequality (Kalluri, 2020). But what of an increase in equality as to who can access literacy, despite a potential rise in economic and environmental inequality? H&C argue that LLMs may be claimed to encourage writing, and specifically-tailored texts created to reach — and engage — more people, improving both writing and literacy. This appears to be an attractive solution, even considering the wider inequality, if we were to just focus on literacy. This purported solution too, though, must be approached with a degree of scepticism and caution (recall *a* and *b* above). An LLM — even one guided by cognitive scientists with expertise in literacy — is no replacement for explicit instruction in reading, human contact, and the pedagogical process of reading and writing independently (Buijzen, Van Reijmersdal, & Owen, 2010; Marriott & Pitardi, 2024). Careful, explicit, and tailored instruction from a human teacher is needed to ensure that literacy reaches the level of proficiency required to not be at a disadvantage in education, employment, and daily life. A carefully-curated LLM might appear to be able to provide enough instruction to bridge that gap, but equally, we must first ensure that due to inbuilt biases or a lack of quality controls, the LLM does not have the opposite effect, producing unhelpful or harmful materials for learners and normalising the lack of human contact during education (Bender et al., 2021; Birhane et al., 2022; Weidinger et al., 2022). It is noteworthy here that in all likelihood, the wealthy would still continue to receive high-quality personal instruction while the less wealthy would be taught by these potentially problematic LLMs due to resource constraints. Any potential positive effects of LLMs could be annulled, when we notice that it shuts out people with lower literacy from access to high-quality personal instruction (see e.g. Coghlan et al., 2023, for related discussion on chatbots and therapy).

H&C also suggest LLMs might be used to create more diverse materials; we share the enthusiasm of H&C for diverse materials, but again must urge caution. An LLM cannot create material vastly more diverse than its training set, and so diverse texts must first exist in order to be able to be created (Birhane et al., 2022; Dornis & Stober, 2024). An LLM derivative of these texts might be able to be used alongside the originals, or might be examples of poor writing or other problems outlined above when trained on a comparatively small sample. The option to train these models on their own output to eventually create entirely different and diverse texts is likely not an option, as the evidence points to models losing all diversity of output when trained on their own input (Shumailov et al., 2024). Using automated techniques like LLMs also risks deskilling the creators of these diverse materials, i.e. educators, from having the required training to produce more of them (Thrall et al., 2018; Whittaker, 2020; Wood, 1987).

Extra caution should be taken by cognitive scientists in looking to align with technology companies to shape LLMs as their goals may not be directly aligned. In fact, we may be duty bound to determine if we have aligned goals and to abstain if those principles are not reflected in the companies we collaborate with, e.g. respect for the ecosystems and the environment and therefore to minimise pollution, respect for society and cultural heritage and therefore to minimise our teaching materials containing inaccuracies or garbled text, and a responsibility for AI and related technologies, if used in research, to be verifiable and replicable and therefore to specify our conflicts of interest openly (ALLEA, 2023; KNAW and NFU and NWO and TO2-federatie and Vereniging Hogescholen and VSNU, 2018).

Even something seemingly indirect such as environmental costs of LLMs may also harm literacy. Poor air quality has been demonstrated to have deleterious effects on cognition in adults (Chen et al., 2023) and young children (Spencer et al., 2023). As literacy relies on these general cognitive foundations, a decline in literacy could mirror a decline in air quality — indeed H&C point to an existing overall decline in cognition, for which poor air quality may bear part of the blame. It is worth highlighting that poor air quality also bears economic costs as above, and these are not

borne equally (Pandey et al., 2021), since automation (cf. Bainbridge, 1983) is likely to increase, rather than decrease economic disparities. What applies to child learners also applies indirectly for caregivers working in harmful or low-paying jobs in the Global South. In other words, if your caregivers and broader community are subject to adverse working conditions, described as "toxic" (Williams et al., 2022; Perrigo, 2023), and harmful to their mental health, the attention parents and others can provide to children is likely negatively affected. These environmental costs might be addressablle through emerging or different technologies — indeed the history of AI in Education (AIED) shows innovations can be made without the environmental costs (Azevedo & Gašević, 2019), though other ethical issues remain (Holmes et al., 2022).

> *Your scientists were so preoccupied with whether they could, they didn't stop to think if they should.* —Dr Malcolm, *Jurassic Park*

H&C sound a call to arms for cognitive scientists to involve themselves in the development of LLMs for improving reading, lest it be left to large technological companies. Above we argue that although enthusiasm about new technology is welcome, the intrinsic harms of LLMs in the classroom — and in general — are such that cognitive scientists need to tread carefully before determining how — or whether — they should be employed to this purpose (Avraamidou, 2024). We argue not that the technology should or can be ignored, but that we must think carefully about the costs to be certain this is the best chance of benefiting learners. The positives that LLMs may bring are attractive, but due to the economic, environmental, human, and educational costs of routinely employing LLMs in a classroom context, the costs and harms should be weighed up by cognitive scientists, who are indeed uniquely equipped for this role.

## References


Ahonen, A. K. (2021). Finland: Success Through Equity—The Trajectories in PISA Performance BT - Improving a Country's Education: PISA 2018 Results in 10 Countries. In N. Crato (Ed.), (pp. 121–136). Cham: Springer International Publishing.

ALLEA. (2023). *The European Code of Conduct for Research Integrity – Revised Edition 2023* (Tech. Rep.).

Alonso, C., Kothari, S., & Rehman, S. (2020). How Artificial Intelligence Could Widen the Gap Between Rich and Poor Nations. *IMF blog*. Retrieved from https://www.imf.org/en/Blogs/Articles/2020/12/02/blog-how-artificial-intelligence-could-widen-the-gap-between-rich-and-poor-nations

Avraamidou, L. (2024). Can we disrupt the momentum of the AI colonization of science education? *Journal of Research in Science Teaching*, *61*(10), 2570–2574.

Azevedo, R., & Gašević, D. (2019). Analyzing Multimodal Multichannel Data about Self-Regulated Learning with Advanced Learning Technologies: Issues and Challenges. *Computers in Human Behavior*, *96*, 207–210.

Bainbridge, L. (1983). Ironies of automation. *Automatica*, *19*(6), 775–779.

Bender, E. M. (2024). Resisting Dehumanization in the Age of "AI". *Current Directions in Psychological Science*, *33*(2), 114–120.

Bender, E. M., Gebru, T., McMillan-Major, A., & Shmitchell, S. (2021). On the dangers of stochastic parrots: Can language models be too big? *FAccT 2021 - Proceedings of the 2021 ACM Conference on Fairness, Accountability, and Transparency*, 610–623.

Berdejo-Espinola, V., & Amano, T. (2023). AI tools can improve equity in science. *Science*, *379*(6636), 991.

Birhane, A., Kalluri, P., Card, D., Agnew, W., Dotan, R., & Bao, M. (2022). The Values Encoded in Machine Learning Research. *ACM International Conference Proceeding Series*, 173–184.

Blunt, K., & Hiller, J. (2024). *Big Tech's Latest Obsession Is Finding Enough Energy.*

Buijzen, M., Van Reijmersdal, E. A., & Owen, L. H. (2010). Introducing the PCMC model: An investigative framework for young people's processing of commercialized media content. *Communication Theory*, *20*(4), 427–450.

Chen, Y. C., Hsieh, P. I., Chen, J. K., Kuo, E., Yu, H. L., Chiou, J. M., & Chen, J. H. (2023). Effect of indoor air quality on the association of long-term exposure to low-level air pollutants with cognition in older adults. *Environmental Research*, *233*(1), 115483.

Coghlan, S., Leins, K., Sheldrick, S., Cheong, M., Gooding, P., & D'Alfonso, S. (2023). To chat or bot to chat: Ethical issues with using chatbots in mental health. *Digital Health*, *9*.

Crawford, K. (2024, 2). Generative AI's environmental costs are soaring — and mostly secret. *Nature*, *626*(8000), 693–693.

Dolean, D., Melby-Lervåg, M., Tincas, I., Damsa, C., & Lervåg, A. (2019). Achievement gap: Socioeconomic status affects reading development beyond language and cognition in children fac-

ing poverty. *Learning and Instruction*, *63*(June), 101218.

Dornis, T. W., & Stober, S. (2024). Urheberrecht und Training generativer KI-Modelle - technologische und juristische Grundlagen. *SSRN*(August). Retrieved from https://papers.ssrn.com/abstract=4946214

Fiebig, T., Gürses, S., H. Gañán, C., Kotkamp, E., Kuipers, F., Lindorfer, M., ... Sari, T. (2023). *Heads in the Clouds? Measuring Universities' Migration to Public Clouds: Implications for Privacy & Academic Freedom* (Vol. 2023) (No. 2).

Holmes, W., Porayska-Pomsta, K., Holstein, K., Sutherland, E., Baker, T., Shum, S. B., ... Koedinger, K. R. (2022). Ethics of AI in Education: Towards a Community-Wide Framework. *International Journal of Artificial Intelligence in Education*, *32*(3), 504–526.

Huettig, F., & Christiansen, M. H. (2024). Can large language models counter the recent decline in literacy levels? An important role for cognitive science. *Cognitive Science*, *48*(8).

Huettig, F., & Hulstijn, J. (2024, 3). The Enhanced Literate Mind Hypothesis. *Topics in Cognitive Science*, *00*, 1–10.

Jiang, P., Sonne, C., Li, W., You, F., & You, S. (2024). Preventing the Immense Increase in the Life-Cycle Energy and Carbon Footprints of LLM-Powered Intelligent Chatbots. *Engineering*, *40*, 202–210.

Kalluri, P. (2020, 7). Don't ask if artificial intelligence is good or fair, ask how it shifts power. *Nature*, *583*(7815), 169–169.

KNAW and NFU and NWO and TO2-federatie and Vereniging Hogescholen and VSNU. (2018). *Nederlandse gedragscode wetenschappelijke integriteit* (V1 ed.). DANS Data Station Physical and Technical Sciences. Retrieved from https://doi.org/10.17026/dans-2cj-nvwu

Marriott, H. R., & Pitardi, V. (2024). One is the loneliest number... Two can be as bad as one. The influence of AI Friendship Apps on users' well-being and addiction. *Psychology and Marketing*, *41*(1), 86–101.

O'Brien, I. (2024, 9). *Data center emissions probably 662% higher than big tech claims. Can it keep up the ruse?*

OHCHR. (2021). *The right to privacy in the digital age: report (2021)* (Tech. Rep.).

Pandey, A., Brauer, M., Cropper, M. L., Balakrishnan, K., Mathur, P., Dey, S., ... Dandona, L. (2021). Health and economic impact of air pollution in the states of India: the Global Burden of Disease Study 2019. *The Lancet Planetary Health*, *5*(1), e25-e38.

Perrigo, B. (2023, 1). Exclusive: OpenAI Used Kenyan Workers on Less Than $2 Per Hour to Make ChatGPT Less Toxic. *Time*.

Ren, S., & Wierman, A. (2024, 7). The Uneven Distribution of AI's Environmental Impacts. *Harvard Business Review*, 1–8. Retrieved from https://hbr.org/2024/07/the-uneven-distribution-of-ais-environmental-impacts

Romeo, R. R., Uchida, L., & Christodoulou, J. A. (2022). Socioeconomic status and reading outcomes: Neurobiological and behavioral correlates. *New Directions for Child and Adolescent Development*, *2022*(183-184), 57–70.

Salas, N., & Pascual, M. (2023). Impact of school SES on literacy development. *PLoS ONE*, *18*, 1–17.

Shumailov, I., Shumaylov, Z., Yiren Zhao, Gal, Y., Papernot, N., & Anderson, R. (2024). The Curse of Recursion: Training on Generated Data Makes Models Forget. *arXiv*.

Smith, C. S. (2023). What Large Models Cost You – There Is No Free AI Lunch. *Forbes*.

Spencer, J. P., Forbes, S. H., Naylor, S., Singh, V. P., Jackson, K., Deoni, S., ... Kumar, A. (2023, 4). Poor air quality is associated with impaired visual cognition in the first two years of life: A longitudinal investigation. *eLife*, *12*, 1–19.

Stojkovic, J., Choukse, E., Zhang, C., Goiri, I., & Torrellas, J. (2024). Towards Greener LLMs: Bringing Energy-Efficiency to the Forefront of LLM Inference. , 1–6. Retrieved from http://arxiv.org/abs/2403.20306

Stolley, P. D. (1991, 3). When Genius Errs: R. A. Fisher and the Lung Cancer Controversy. *American Journal of Epidemiology*, *133*(5), 416–425.

Thrall, J. H., Li, X., Li, Q., Cruz, C., Do, S., Dreyer, K., & Brink, J. (2018). Artificial Intelligence and Machine Learning in Radiology: Opportunities, Challenges, Pitfalls, and Criteria for Success. *Journal of the American College of Radiology*, *15*(3, Part B), 504–508.

van Rooij, I., Guest, O., Adolfi, F., de Haan, R., Kolokolova, A., & Rich, P. (2024, 9). Reclaiming AI as a Theoretical Tool for Cognitive Science. *Computational Brain & Behavior*, *7*, 616–636.

Weidinger, L., Uesato, J., Rauh, M., Griffin, C., Huang, P. S., Mellor, J., ... Gabriel, I. (2022). Taxonomy of Risks posed by Language Models. *ACM International Conference Proceeding Series*(Lm), 214–229.

Whittaker, M. (2020, 11). *Who am I to decide when algorithms should make important decisions?* Retrieved from https://

www.bostonglobe.com/2020/11/02/opinion/who-am-i-decide-when-algorithms-should-make-important-decisions/

Williams, A., Miceli, M., & Gebru, T. (2022). The Exploited Labor Behind Artificial Intelligence. *Noēma*.

Wood, S. (1987). The Deskilling Debate, New Technology and Work Organization. *Acta Sociologica*, *30*(1), 3–24.