SHORT PLAIDOYER FOR INTRODUCTION OF ECO-ARTIFICIAL EDUCATION IN DIVERSE CURRICULAR SYSTEMS OF THE PLANET EARTH

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Abstract

In this short plaidoyer, we focus the attention of the reader on the fact that as of 2023, plethora of diverse platforms, apps and models exist which allow one to use AI-assisted systems in education of eco- and bio- logical sciences. Nonetheless, these sciences are often left unnoticed by the AIED community and no curriculum seems to exist which would use such AI assistants in a systematic and organised way. After labelling such potential learning-with-AI curriculum as ”eco-artificial education” (EAE), we subsequently introduce typology of artificial systems which may provide useful EAE assistance for both teacher and learner alike: namely, ”classifiers”, ”optimizers”, ”simulators”, ”generators” and ”communicators”. After giving some concrete examples for each type (e.g. plant recognition, diet problem solvers, or bird song generator/communicators) we conclude the article with a statement of hope that EAE shall allow humans of future generations to better understand and protect the organic beauty which surrounds us.

Keywords: Eco-artificial education, species identification, classifiers, generative models, interspecies communication, artificial life, Sustainable Development Goals 2, 3, 6, 11-15, Outdoor Digital Education.

1 PREAMBLE

Since the publication of ”The Limits to Growth” by the Club of Rome [1], our awareness of human-induced climate change and the ensuing consequences has been starkly highlighted, revealing the onset of the Earth’s sixth major mass extinction. With up to a million species of plants and animals at risk of extinction in the next few decades due to human activities, an urgent question emerges: How can we, in the age of late capitalism, internalise our dependence on the environment, perceive ourselves as an integral component of the natural world, and move towards sustainable and socially responsible actions? More critically, in the realm of education, how can we leverage Artificial Intelligence in Education (AIED) to bridge the gap between nature and technology, fostering a generation that not only overcomes climate despair and dystopian views but also actively engages in reimagining a future of solidarity with non-human life? The imperative to integrate biology, ecology, and environmental sciences into 2 D. D. Hromada & L. Kuschel & J. Hsu AIED’s didactic and pedagogical practices is clear, aiming to instil a profound respect and understanding of our interconnectedness with Earth’s ecosystems, preparing learners to navigate future challenges while promoting harmonious coexistence with the planet.

2 INTRODUCTION

2.1 Human condition

Human H - an always unique, individual instance of a species Homo sapiens sapiens - is a mammal. As such, questions of food, energy and water sources, shelter, health and interaction with other species - be it parasites or symbionts - are vital for H’s survival. Since times immemorial, teaching and learning of vast majority of humankind - as well as many of our evolutionary predecessors [2]- had been centered around the pressing topic of surviving in and learning from nature: what fruits and plants and nuts and mushrooms are edible and under what conditions; who is the predator and who is the prey; where to go for water and where rather not; how - and from what organic material - to build a house, a hammock, a boat, a weapon and by what means can one crack a nut.

2.2 Current situation

Some indigenous communities and reform-pedagogic schools aside, things changed irreversibly with ideals of Enlightenment and advent of industrial era and automatization. Suddenly, the Goal of education became full unfoldment of human potential and somehow, W. Humboldt's ideal of studying Latin and Greek and abstract algebra in a sterile indoor environment has been gradually evaluated as more worthy a path to the noble Goal than teaching children on a manure-odored field what is a difference between a bull and an ox or why does composting hold a key to proliferation or Life on our planet.

Less than two hundred years later and the very same students who can easily enumerate a list of their twenty most favourite TikTok influencers are not able to name even a most common plant of their surrounding (e.g. a Dandelion) or recognize a difference between a goose and a duck. Such is the current situation. Billions of children all around the planet invest their time and cognitive resources into "learning" that due historical reason X their nation state is more worth of existence than that of their neighbours while, in the same time, nobody tells them that chewing the plant growing on the school yard may well relieve of pain >90% of mammals suffering of toothache. Such is the current situation.

Should the current trends continue, the generation of current pupils may well become the last generation who could have actually acquired - from their human predecessors - useful information about their local, regional biotopes. For learners of today are teachers of tomorrow and what is the probability that a young student shall sometimes in the future transfer her knowledge about nuances and peculiarities of more than 200 different species of meso-american frogs if no teacher during twelve years of her primary and secondary education ever explained her a difference between a frog and a toad ? How could at least few out of 17 Sustainable Development Goals [3] be brought to life by students if their own teachers are not aware what SDGs are or that something like SDGs exist?

Such questions are not rhetoric and the answer may surprise: in spite of the fact that current teachers are - due to historical reason Y and Z - often ignorant of importance of eco-aware, sustainable behaviour for survival of their own pupils, a cohort of powerful allies emerges on the horizon, able to fill the epistemological gap: allies known as AIs [4].

Current situation in AIED field

An AI can be considered as an ally only if the research community considers her and notices her as such. Table 1 tries to address the question whether it is - as of 2023 - already the case. Table summarises number of found results after searching for 8 life-related keywords (LRKs) in archives of two most prominent peer-reviewed journals dealing with Artificial Intelligence and Education (AIED) [1].

Table 1. Occurrences of diverse eco- and bio- keywords in two archives of "Journal of Artificial Intelligence in Education" and "Computers and Education: Artificial Intelligence".

Keyword	*JAIE*	*CEAI*	***Keyword***	*JAIE*	*CEAI*
biology	1 + 45	9	ecology	0 + 13	3
plant	0 + 19	3	mushroom	0 + 2	1
animal	0 + 23	10	food	0 + 31	7
forest	0 + 28	15	biodiversity	0 + 1	0

The situation is not constrained to journals, though. For example, this very plaidoyer article, when submitted to 24th Annual Conference on Artificial Intelligence in Education whose main conference theme has actually been "**sustainability**" has been rejected on the following grounds: "*This paper discusses the state-of-the-art for AI-driven learning platforms for eco and biological science. Given the topic of the paper, it actually lacks the discussion of many intelligent tutoring systems, educational games on helping students learning biology. The contribution of the paper is questionable.*"

[1] Reader may confirm our observations by querying https://dl.acm.org/action/doSearch?SeriesKey=jaie for JAIE 1989-1998 archive, https://link.springer.com/journal/40593/volumes-and-issues for JAIE 2013-2022 archive and for CEAI 2021-2023 archive https://www.sciencedirect.com/search?pub=Computers%20and%20Education%3A%20Artificial%20Intelligence.

Thus, unable to recognize the forest because of the trees, too much preoccupation with “learning platforms” and algorithms may often prohibit AIED researchers to adopt a more holistic solution to the most imminent challenge of this and future centuries.

That is, the problem of a looming planetary ecological crisis.

2.3 Eco-artificial education

Departing from the concept of “home community” - οικοσ - from which the prefix eco- is derived, interpreting the οικοσ as our auto-poietic, self-organising biosphere [11], we define eco-artificial education as follows:

“Eco-artificial education (EAE) integrates those forms of pedagogical and didactic practice where artificially intelligent systems are being deployed for the purpose of increase of H’s knowledge and respect of the surrounding biosphere.[2] ”

In order to avoid potential misunderstanding, we underline that in terms introduced by AIED fellows, EAE primarily provides a framework for “learning-with-AI” [12, p.19-23] and not “learning-about-AI (AI-literacy)” [12, p.26-32] curricula. Should it be the latter, topics of quantification of AI-related carbon emissions [13] would be in the center of EAE’s interest.

Thus, to make it clear: while rigorous thematization of ecological impacts of AI within an AI literacy curriculum is indeed of utmost importance for establishment of future *nature-human-machine Nash equilibrium* [15], the focus of EAE as hereby defined - and notably on the level of primary and secondary school education - is “learning-with” sub-discipline of AIED. That is, that sub-discipline where learner-assisting and teacher-assisting artificial systems play the central role.

3 TYPOLOGY OF EAE ASSISTANTS

3.1 Classifiers and domain-specific oracles

We label as “classifiers” such hardware or software solutions which allow the human learner or teacher to classify or identify a certain object or a group of objects. In the context of EAE, such “objects” are mostly visual (e.g. photos) or acoustic (e.g. audio recording) [3] representations or productions of a certain living organism.

Table 2. Three cases of high-quality EAE classifier & identification apps issued from academic / citizen science research.

Name	*Use*	*Reference*
Merlin Bird ID	Bird identification based on visual (Photo ID) and acoustic (Sound ID) inputs	[14]
Svampe-atlas	Mushroom identification (>80% accuracy for more than 1400 European species)	[16]
Pl@ntNet	Plant identification of more than 36000 species	[17]

[2] Given that it is indeed the biosphere which is the main focal point of EAE, it is also appropriate to speak about “bioartificial education”. However, given that the term “bioartificial” is already used in medicine to denote the meaning of “being composed of both living and manufactured components” we opt for the EAE term devoid of a potential terminological collision.

[3] The work of one of our students provides useful introduction to bio-acoustics in the context of (not only) cat vocalisation classification as well as references

A classifier with 100% recognition accuracy for any potential input relevant for domain D is called a D-oracle. While such oracles are still only hypothetical and advice of a human experts is still necessary in certain rare-species cases, the current progress in domain of transformer architectures [16] coupled with emergence of vivid ML-communities [4] and inflow of data from citizen science initiatives is slowly but steadily getting teachers and their students into situations where proper usage of certain classifiers reduces a security risk - i.e. probability of getting poisoned - limitely close to zero.

And once the problem of species identification could be considered as solved, EAE can gradually start focusing on identification and classification of other species' mental states and communicative intentions [18].

3.2 Optimizers and simulators

We label as "optimizers" such hardware or software solutions which assists the human learner or teacher in finding an optimal (i.e. "best") or quasi-optimal (i.e. "for all practical purposes better than any other solution") solution(s) to a problem P there, where finding such solution by non-algorithmic means would be difficult or out of reach.

Obviously, in the context of EAE, P-solving is somehow related to eco-, bio-, or enviro- aspects [5]. Two Ps can be considered as "canonical" in this regard. First is a linear-programming "diet problem" where students are given the task to find a most nutritionally valuable combination of input foods which satisfy certain constraints. Another problem with which we confront our students during our proto-EAE seminars is "the Tangle" defined as "*circle with 1m radius containing different vertically stacked herbs, veggies, fruits and mushrooms which maximize nutritive yield beneficial for human all year long and minimizes the amount of external interventions*" [5].

Often, there is not a clear demarcation line between an EAE-optimizer and a system hereby labelled as an EAE simulator. While some of these simulators sometimes may have the form of proprietary expensive CAD systems or MatLab modules, many new or old computer games can rightfully be called an EAE-simulator providing the pupil or a student a graspable and engaging entry into the EAE world. Abandonware games like "Ecco the Dolphin" or games issued from the Sim- family (SimAnt, SimIsle: Mission in the RainForest) are just few among many worthy to be mentioned.

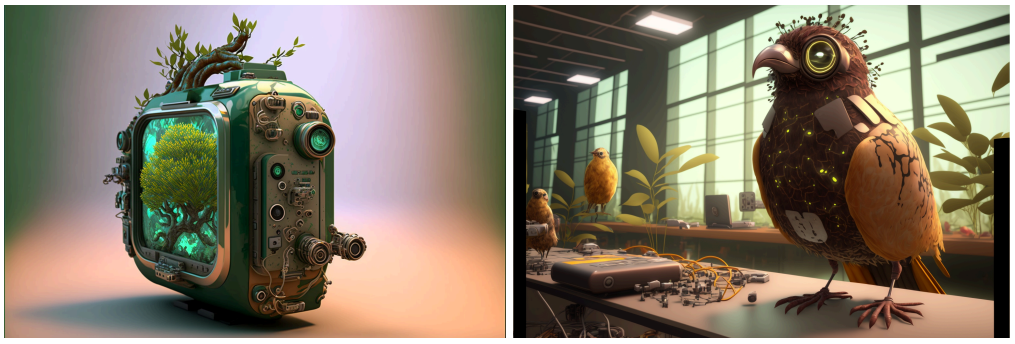

Figure 1. An eco-artificial generator (left) and communicator (right), as "generated" by the Midjourney text-to-image generative model. C.f. footnotes 5 and 6 for specific prompts. JungHsu, CC-BY-NC-SA licence

3.3 Generators and communicators

We label as EAE "generators" such hardware or software solutions which allow the human learner or teacher to generate a signal which is relevant to non-human coinhabitants of the Gaian biosphere. As far as current research goes, it is highly probable that generative transformer-based models - potentially endowed with attention layers [19] - are to constitute the core ML-related components of such generator EAE assistants.

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[4] The most renowned machine-learning competition where future EAE-classifiers are evaluated is LifeCLEF (with sub-tracks like PlantCLEF, FungiCLEF, BirdCLEF, SnakeCLEF etc.)

[5] https://baumhaus.digital/990/baumhaus#/folio-1051

Ultimately, a mix of “classifiers”, “reinforcement learning” and “generators” converges in deployment of first “communicators” allowing more advanced teachers and students to establish first robust communication channels with other species. Figure 1. illustrates how such EAE assistants may look like according to a text-to-image Midjourney model queried with prompts [6] resp. [7].

It goes without saying that acoustic (e.g. artificially generated bird utterances) and visual (e.g. animal-directed art[8], e-ink and holographic plant simulacra) are just few among many modalities by means of which communication channels with other species can and will be established with further progress of science and technology (e.g. protein prediction or pheromone synthesis).

4 DIDACTIC ASPECTS

Using AI-assisted systems enables and simplifies nature-based instruction outside of the classroom in diverse learning contexts. As corroborated by [21], learning in different environments improves the ability to retain and apply what has been learned.

These findings suggests that exposure to different environments promotes a deeper understanding and the ability to recall and apply acquired knowledge in different contexts. This technology-supported form of learning transcends listening and taking notes and activates the students to learn from their immediate environment. Exploring natural phenomena in their origins promotes meaningful learning. This approach strengthens critical thinking, problem-solving skills and creativity and improves the ability to apply knowledge in new contexts.

Executing education outdoor is very much appreciated by the students. For example, in context of curricular experiment in “outdoor digital education” (ODE), a seminar “Bildung Biodigitale” took place in different spaces, both indoor as well as outdoor. During the final internal evaluation among students (N=12), the question “*Rank all spaces we visited according to Your preference*”, all students who attended the session in teacher’s garden/biotope ranked the venue unanimously to the highest rank [22, p.9]. Given that the course combined plethora of software [23] as well as hardware [24] artefacts specially tailored for special ODE use-case with concepts and tools mentioned in sections 2 and 3 of this article, the “Bildung Biodigitale” series which started in 2021 at Berlin University of the Arts and continues until this date, can be considered to be one of the first tentatives to establish EAE as an accredited curriculum forming the minds and practices of present and future teachers of the planet Earth.

5 GOAL OF EAE

In the last book of his 103-year old life, a former NASA-engineer, scientist and inventor par excellence, the man whose “Gaia Hypothesis” proposed to consider the biosphere of our planet as a living system - James Ephraim Lovelock CH CBE FRS - coined yet another term: “Novacene” [23].

Strikingly similar to outcome of Asimov’s Foundation and Robot series, the Novacene world is a world where humanity provides an indispensable service in keeping the Gaian biosphere and the realm of machines in a state of delicate equilibrium. Such a goal is distant but one thing is certain: should we - humans, AIs, and other species issued out of organic or technological evolution - make Novacene real, we shall get there by means of assisting each other in the teaching & learning process.

That is, by means of education. And should we not get there, this “short plaidoyer” still fulfilled its role for anyone who, for a short while, considered as theoretically possible that “eco-artificial education” - or a similar concept - will allow humans of future generations to better contemplate, understand, protect and communicate with the organic beauty which - as of 2024 - still surrounds us.

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[6] Ecoartificial Education classifier, an identification system based on both sound and image. Symbiotic, biometric, synth, product concept, speculative, in style of solarpunk –v 4 –q 0.25 –ar 3:2 –s

[7] An Ecoartificial Education simulator with a bird. Symbiotic, biometric, synth, eco-friendly, sustainable, product concept, industrial design, product photographic, concept art, speculative, detailed, realistic, solarpunk style, concept art –v 4 –q 1 –ar 3:2 –s 100 –no frame

[8] C.f. [21] and [22] for examples of video art created not only for human but also for animal audience.That is, art *not only about* animals, but also *for* them.

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REFERENCES

[1] D. H. Meadows, D. L. Meadows, J. Randers, and W. W. Behrens III, “The limits to growth-club of rome,” 1972. 2.

[2] N. J. Emery and N. S. Clayton, “The mentality of crows: convergent evolution of intelligence in corvids and apes,” science, vol. 306, no. 5703, pp. 1903–1907, 2004.

[3] D. o. E. United Nations and S. A. S. Development, “Transforming our world: the 2030 agenda for sustainable development,” 2015.

[4] R. Vinuesa, H. Azizpour, I. Leite, M. Balaam, V. Dignum, S. Domisch, A. Fell¨ander, S. D. Langhans, M. Tegmark, and F. Fuso Nerini, “The role of arti- ficial intelligence in achieving the sustainable development goals,” *Nature communications*, vol. 11, no. 1, pp. 1–10, 2020.

[5] D. Ploger and M. Carlock, “Programming and problem solving: implications for biology education,” Journal of Interactive Learning Research, vol. 2, no. 4, p. 15, 1991.

[6] L. Breiman, “Random forests,” *Machine learning*, vol. 45, no. 1, pp. 5–32, 2001.

[7] J. Wiley, P. Hastings, D. Blaum, A. J. Jaeger, S. Hughes, P. Wallace, T. D. Griffin, and M. A. Britt, “Different approaches to assessing the quality of explanations following a multiple-document inquiry activity in science,” *International Journal of Artificial Intelligence in Education*, vol. 27, no. 4, pp. 758–790, 2017.

[8] D. M. Morrison and K. B. Miller, “Teaching and learning in the pleistocene: a biocultural account of human pedagogy and its implications for aied,” International Journal of Artificial Intelligence in Education, vol. 28, no. 3, pp. 439–469, 2018.

[9] A. Bhutoria, “Personalized education and artificial intelligence in united states, china, and india: A systematic review using a human-in-the-loop model,” *Computers and Education: Artificial Intelligence*, p. 100068, 2022.

[10] G. A. Khachatryan, A. V. Romashov, A. R. Khachatryan, S. J. Gaudino, J. M. Khachatryan, K. R. Guarian, and N. V. Yufa, “Reasoning mind genie 2: An intelligent tutoring system as a vehicle for international transfer of instructional methods in mathematics,” *International Journal of Artificial Intelligence in Education*, vol. 24, no. 3, pp. 333–382, 2014.

[11] S. Kauffman, S. A. Kauffman, et al., At home in the universe: The search for laws of self-organization and complexity. *Oxford University Press*, USA, 1995.

[12] W. Holmes, J. Persson, I. Chounta, B. Wasson, and V. Dimitrova, “Artificial intel- ligence and education. A critical view through the lens of human rights, democracy, and the rule of law,” 2022.

[13] A. Lacoste, A. Luccioni, V. Schmidt, and T. Dandres, “Quantifying the carbon emissions of machine learning,” *arXiv preprint arXiv:1910.09700*, 2019.

[14] G. Van Horn, S. Branson, R. Farrell, S. Haber, J. Barry, P. Ipeirotis, P. Perona, and S. Belongie, “Building a bird recognition app and large scale dataset with citizen scientists: The fine print in fine-grained dataset collection,” in Proceedings of the *IEEE Conference on Computer Vision and Pattern Recognition*, pp. 595–604, 2015.

[15] J. Nash Jr, “Non-cooperative games,” in Essays on Game Theory, pp. 22–33, Ed- ward Elgar Publishing, 1996.

[16] L. Picek, M. ˇSulc, J. Matas, J. Heilmann-Clausen, T. S. Jeppesen, and E. Lind, “Automatic fungi recognition: Deep learning meets mycology,” *Sensors*, vol. 22, no. 2, p. 633, 2022.

[17] A. Joly, A. Affouard, M. Chouet, B. Deneu, J. Estopinan, H. Go¨eau, H. Gresse, J.-C. Lombardo, T. Lorieul, F. Munoz, et al., “Pl@ntnet, ten years of automatic plant identification and monitoring,” in IUCN-Congres mondial de la nature, 2021.

[18] M. Tomasello, Constructing a language: A usage-based theory of language acquisition. Harvard university press, 2005.

[19] A. Vaswani, N. Shazeer, N. Parmar, J. Uszkoreit, L. Jones, A. N. Gomez, L. Kaiser, and I. Polosukhin, “Attention is all you need,” *Advances in neural information processing systems, vol. 30*, 2017.

[20] M.Z. Rosenberg, I want to talk to my cat, *Wicked Solutions*, vol. 1, 2024.

[21] L. Kuschel, “Neighbors: non-human city life : Part 1, Crows in Berlin” 2023. Experimental film, Germany, 48 min. https://vimeo.com/manage/videos/750390554/d0dd5be07c.

[22] L. Kuschel, “Neighbors: non-human city life : Part 2, Crows in Mumbai” 2024. Experimental film, India, work in progress. Example scene: https://vimeo.com/manage/videos/919103706/573f

[23] A. F. Taylor., C. Butts-Wilmsmeyer and C. Jordan, Nature-based instruction for science learning – a good fit for all: A controlled comparison of classroom versus nature. *Environmental Education Research*, 2022.

[24] D. D. Hromada, “Teacher.solar :: open source/hardware toolbox for co2-neutral outdoor digital education :: Closing report,” tech. rep., Berlin University of the Arts, 2023.

[25] F. Brodbeck and D. D. Hromada, “teacher. js: A low-bandwidth digital tool for outdoor online teaching,” in 2022 IEEE 5th Eurasian Conference on Educational Innovation (ECEI), pp. 47–50, IEEE, 2022.

[26] D. D. Hromada, “Three principles, 2 sub-principles and one magic wand for harm minimization and prevention of technological addiction in human children,” Educational Innovations and Emerging Technologies, pp. 48–57, 20

[27] J. Lovelock, Novacene: The coming age of hyperintelligence. *Mit Press*, 2019.