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Peer Review File

Harnessing the Multimodal Features of Generative AI to Advance Ecological Engineering

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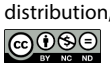

Associate Editor's Round 1 Review Summary:

All four reviewers have very positive comments about this paper, its timeliness, and its importance for the field of ecological engineering. However, several concerns were raised that should be addressed before considering this paper for publication. Three of the largest concerns raised by the reviewers are: Much of the paper focuses on the use of Chat GPT for educational purposes. It would be beneficial to strengthen the discussion of the use of this tool for ecological engineering design. There are several mentions of design applications, but no example design application analogous to the educational examples given. Please either include more discussion of design applications and/or add an example design application if possible. Some sections could benefit from restructuring and editing to improve the flow and readability of the paper, particularly the introduction and summary and conclusions. Multiple citations are missing ("cite" written in manuscript) Please address these concerns as well as the other concerns raised by the reviewers. You should provide a point-by-point response to reviewer comments indicating how you addressed the concern or describing why you disagree with a reviewer's suggestion. In addition, please note the following: Reviewer C suggests adding additional description of the mathematical basis of AI tools; however, this may add unnecessary length to the paper and distract from the main focus on application of these tools. An alternative suggestion is to add references that address this concern to the description of AI tools [in Section XXX] allowing a reader quick access to more detailed information. JEED requires the use of Council of Science Editors Name-Year citation style (https://www.scientificstyleandformat.org/Tools/SSF-Citation-Quick-Guide.html). Please update your citations to match this style. Plugins for this style are available for many citation manager software. Please combine the Summary and Conclusions into a single section (see Reviewer D comments).

Round 1 Reviewer Comments:

Reviewer A (David Austin, Jacobs Engineering Group):

Superb. Enlightening. This is the first paper review I have done that has zero editorial comments.

I am not an expert in AI. I have used machine learning tools previously teaming with others with the right programming skill sets. These tools have been most useful for ecological engineering. They have had the odd aspect of teasing out relationships that seem intuitively clear in hindsight but were not decidedly so at the onset. results suggested a clear path for future investigations.

This paper is an excellent survey of available tools, how they might be used, with appropriate cautions. It is clear to me that using some of these tools would have allowed me to go directly to AI tools for at least initial analysis.

It is also a delight to see that Odum diagrams can be coded by AI. That opens interesting possibilities. It has amazing implications for ecological engineering. Having taught modeling previously, I can see how this could work. For students, these tools could be world opening.

What I want to say is, "Accept this paper as is". The paper text has a word count of 7346 words. That is over the limit. In this case, we should make an exception given the timeliness and utility of this paper.

Reviewers are not supposed to "gush". Even though I have had a positive experience with early AI tools, I had a certain trepidation on the topic in general. My starting thought was something along the lines of, "yes this is going to be very well written, but what about the larger issues at play?" I can't help the gushing. I personally will follow up in my work using some of the suggested tools.

OK, those larger AI issues are out there. Obviously. The role of this paper is certainly not to tackle them. One might summarize the paper as presenting the tools, demonstrating potential, offering caveats, and then inviting the readers to where they might start in the AI smorgasbord. Those who are deeply worried with the development of AI may take issue with the positive tone of the paper. So be it. Let's not let that sort of ideological wrangling get in the way. That is another topic altogether. I say that a transdisciplinary field like ecological engineering will benefit enormously from these tools. We just need to learn how to use them.

Let's welcome this paper.

AUTHOR RESPONSE: What a refreshing review! This is most likely the most “gushing” review I have had in my 20+ career. I really appreciate it Reviewer A’s comments and encouragement. We all “work in the dark” sometimes, so it is helpful when an anonymous reviewer can add some positive reinforcement. Thanks!

Reviewer B (Chris Streb, Biohabitats):
The article is somewhat unexpected in that it is directed to the reader and provides examples the users themselves can follow for exploring ChatGPT. Rather than a technical peer review, it is more like a "how to" AI for ecological engineering guidance document. Overall, the document might open minds, provoke curiosity, and encourage individuals who skeptical or scared of LLM to explore.

AUTHOR RESPONSE: Thanks for sharing your thoughts on how the paper “might open minds, provoke curiosity, and encourage individuals who [are] skeptical or scared of LLM to explore.” My excitement for generative AI’s possibilities tend to cloud my empathy for those that are hesitant, so it is a timely reminder.

1. Document seemed to vary spacing between paragraphs and section breaks. I added spaces, and therefore, messed up line numbering.
AUTHOR RESPONSE: OK.

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2. Line 92 - not sure what "real" systems means. Is real represent things in our physical, biological world that are not digital?
AUTHOR RESPONSE: I clarified Real Systems by adding “systems (e.g. biological, ecological, physical, human systems)” to line 92 and to caption in Figure 1.

3. Figure 1. - Doesn't information directly feedback to Real World Systems stock?
AUTHOR RESPONSE: Good insight. I added feedback from all 3 information storages to Real Systems.

4. Ethics - Lines 195-201 - does not mention bias in algorithms, energy and water consumption (mentioned later)
AUTHOR RESPONSE: Good point. I rewrote section 2.4 and renamed it “Ethics and energy concerns for training and using Gen-AI” to capture a more comprehensive perspective on ethical, energy and environmental issues presented by gen-AI.
Here is the new text:

Generative AI introduces significant shifts in ethical considerations and energy consumption issues surrounding information and communication technology (Biden 2023). Training large-scale language models (LLMs) like GPT-4 involves using extensive GPU clusters, requiring vast amounts of publicly accessible data and substantial electric power, sourced from both renewable and non-renewable energy. Beyond training, the inference phase of LLMs raises more ethical and environmental concerns.

Ethical Issues During Training: The data used for training LLMs often involves publicly available content, which raises questions about copyright, fair use, and the ethical implications of using such data (Dwivedi et al 2023). Additionally, biases in the training data can inadvertently propagate into the models, reflecting societal inequalities and stereotypes. Addressing these biases necessitates careful curation of training data and implementing strategies to mitigate bias effects in AI outputs.

Ethical Issues During Inference: When AI models are deployed, they can perpetuate biases, generate harmful or misleading content, or reinforce stereotypes (Dwivedi et al 2023). Recognizing and addressing these biases is critical, along with ensuring the responsible and ethical use of AI to avoid perpetuating harm or misinformation. Privacy concerns also arise when handling sensitive data, requiring adherence to principles of confidentiality and data protection.

Energy Consumption for Training: Training AI models requires substantial power, affecting regional power grids and increasing carbon emissions (Luccioni et al 2024). Choosing locations for data centers, where LLM’s are trained, involves considerations about energy costs, carbon footprint, and the potential for future growth in demand. Emerging solutions include using new nuclear options like small modular reactors or co-locating data centers with existing nuclear plants to lower emissions (Kaack et al., 2022, Istrate et al. 2024), but more alternatives are needed.

Energy Consumption During Inference: The operational use of AI models (inference) also demands significant energy and water, contributing to environmental concerns (Istrate et al.. 2024). As AI adoption grows, understanding the ecological footprint of these systems becomes increasingly important (Duran et al. 2024). Sustainable AI deployment includes optimizing energy use, reducing reliance on non-renewable energy, considering the broader environmental impacts and improving the energy efficiency of software engineering (Bolon-Canedo et al 2024).

Reviewer C (Anonymous):
This manuscript reviews Generative AI tools and how those tools might be leveraged in an ecological engineering context. I find the scope of the article very exciting, particularly the examples that illustrate how GPT has actually been used. Because the material presented here slants towards ecological engineering education, the title should probably be modified to reflect this so that readers know what to expect. I also feel that the manuscript would benefit from careful proofreading, shortening (removing repetition) as well as some restructuring (details below) to make it clearer 1) why AI should be the next technology that is integrated into ecological engineering (i.e., why AI and not something else?) and 2) how each AI tool represents an advance over what is currently being done in ecological engineering? If the manuscript can do these things I think it will be a wonderful resource for educators and an inspiration for the next generation of ecological engineers.
AUTHOR RESPONSE: Good point.

Abstract
Lines 29-32: Most of this sentence presents abilities of GPT-4. Use as a virtual teaching assistant does not fit in well with the rest because use isn't really an example of an ability. Perhaps rewrite as: The paper demonstrates GPT-4's ability to create cartoons our of news articles, detect insect infestation of plant leaves, count stems in a forest image, and spatial reason from text. It also demonstrates how it might be used as a virtual teaching assistant by transcribing handwriting and giving personalized feedback to students.
AUTHOR RESPONSE: Good point. I rewrote as "The paper demonstrates GPT-4's ability to create cartoons from news articles, detect insect infestation of plant leaves, count stems in a forest image, reason spatially from text, transcribe student handwriting, and serve as a virtual teaching assistant by assessing student work and giving personalized feedback to them."

Line 35-37 – its not really clear what the knowledge gap is here. Perhaps add a sentence explaining why this would advance ecological engineering (what gap does it fill?)
AUTHOR RESPONSE: I incorporated the reviewer's comment and rewrote the sentence as: "The paper concludes by suggesting that the creation and application of AI Agents towards enhanced modeling, monitoring, design, sustainability assessment and public engagement, may be the next phase for harnessing GPT4's multimodal abilities to efficiently and effectively advance ecological engineering."

Introduction
General
I had to read the introduction a couple of times to understand the flow. I love all of the material that is covered but think that it could be restructured a bit. My recommendation would be to begin with Ecological engineering and the importance of technological integration to Ecological engineering. Then talk about AI the technology (what it is, its evolution, and its integration into reciprocal feedbacks for discovery and learning, which is really what makes AI the tool ecological engineers should be focusing on next.). This is, of course, just a suggestion, but one that I think would center the paper more on its ecological engineering context.
AUTHOR RESPONSE: I accepted this suggestion. I moved the paragraph on background of EE: "Ecological engineering, as the original…" to the beginning of the introduction.

I'd also like to have AI's role in learning elaborated on (see detail level comment about triple loop learning below).
AUTHOR RESPONSE: TBD

Line 44 – its no longer the last few months anymore…I'd suggest rewording this in a way that will age well.
AUTHOR RESPONSE: Accepted suggestion. Rewrote sentence: "The emergence of Large Language Models (LLMs) in 2023 that can seamlessly replicate human writing has opened up numerous new capabilities for professionals in technical fields such as ecological engineering."

Line 54 – there is a missing citation here (just reads cite)
AUTHOR RESPONSE: Corrected error. Added cit. (OpenAI 2023)

Line 54 – "the development of having" does not read well. Considder changing to "The ability of computers to generate long passages of…
AUTHOR RESPONSE: Accepted suggestion.

Line 77-78 – I love this question….it does make you want the next paragraph to focus on potential answers rather than additional background, however. It takes about 4 paragraphs (until line 127) to start to talk about answers.
AUTHOR RESPONSE: Thanks for the observation. I see the possibilities are large, but I don't have "the answers". A goal for sharing the paper is to get the EE society and others to consider how they might use gen-AI to contribute answers. With that in mind I thought it would be help to "prime the pump" with a few questions, so I added a new paragraph:

"Kurzweil's lavish optimism may lead an ecological engineer to ponder: "What does the future of gen-AI hold for us as a profession and field of investigation? Hopefully, readers will be able to seriously consider this question after learning about GPT4's multimodal capabilities. Here are few specific questions to prime their thinking:
1. Can generative AI enhance decision-making in ecological engineering by processing extensive datasets to optimize ecosystem management?

2. Might its code-writing abilities allow us to quickly and efficiently develop models to test hypotheses and revolutionize our understanding of system dynamics?
3. Could its ability for real-time data analysis offer more actionable and cost-effective monitoring programs?
4. Will gen-AI become the quintessential virtual teaching assistant that revolutionizes how we educate the next generation?
5. How might its image recognition improve restoration and conservation efforts?
6. Will gen-AI's rapid and realistic visualizations foster multidisciplinary collaboration and diverse stakeholder engagement?
7. Can specialized AI agents be developed that become proficient at ecological design and planning?
8. How could gen-AI optimize resource use for sustainability?
9. Does our knowledge of the innerworkings of complex natural systems inform the ethics of creating and using gen-AI?"

Line 92-93 – how does it (AI) develop this feedback? Presumably the feedback emerges at the intersection of AI and people (i.e., how it is used determines the nature of the learning, but that does not come through here)
AUTHOR RESPONSE: Edited sentence to address this point: "It develops a feedback loop that reinforces human learning and expansion of human intelligence by interacting directly with humans as they access knowledge and generate discoveries."

Line 105 – perhaps include some references to the social learning literature here…what you are discussing shares some important similarities with single, double, and triple loop learning….Perhaps AI helps get us to the triple loop or beyond?
AUTHOR RESPONSE: I incorporated your suggestion and rewrote the paragraph:

"Human intelligence has advanced greatly throughout the centuries as the vast shared-knowledge that it created has fed back into its process of discovery and learning. Generative AI represents the next phase in this co-evolution between information-communication technologies and human intelligence. It is poised to further accelerate humanity's ability to create, store, and learn new knowledge, potentially facilitating more profound forms of social learning, such as triple-loop learning (Barth et al. 2023), by enhancing our capacity for reflection, adaptation, and innovation in complex decision-making contexts."

Line 105-106 seems like a repeat of line 97-98.
AUTHOR RESPONSE: I deleted repetition in line 97-98. Thanks!

I recommend combining section 2.1 and 2.2 into a single section instead of separating them out with distinct headers
AUTHOR RESPONSE: I politely disagree. These sections represent 2 intellectually distinct steps in LLM development that the reader needs to consider so they can better appreciate the mathematical basis of gen-AI.

Lines 160-166 seems like a summary of material already presented in the second paragraph of the Introduction. It does not need to be repeated here.
AUTHOR RESPONSE: Accepted. Deleted the redundant sentence and modified the previous one as: "The training process relies on the transformer algorithm (Vaswani et al. (2017) and employs extensive datasets comprising text from diverse sources, including books, research papers, blog posts, and text messages."

Line 172 – I initially tripped on "plausible sounding but incorrect or nonsensical outputs" because it seemed to indicate that something could be plausible sounding and nonsensical…my brain grouped incorrect or nonsensical together instead of plausible sounding but incorrect. To avoid this, you could swap the terms and say: "nonsensical or plausible sounding, but incorrect, outputs".
AUTHOR RESPONSE: I simply removed nonsensical because GPT4 rarely produces nonsensical output. Rather the output always sounds realistic but can be false.

Please include references to support the material included in section 2.3.
AUTHOR RESPONSE: I added references.

I'd like to see section 2.4 expanded upon a bit. Although the emphasis of this manuscript is on the benefits of AI for Ecological engineering, there are many who worry about the ethical implications. Addressing ethics a bit more thoroughly at the outset may placate (or even sway) nonbelievers.
- This chapter has some interesting material that it might be valuable to touch on https://link.springer.com/content/pdf/10.1007/978-3-031-54144-5_188.pdf. It focuses on AI ethics for academics and teaching, and provides nice examples of some of the kinds of ethical concerns that might arise.
- Eaton's work might also be a good resource (I love her 6 tenants of postplagiarism…seems really applicable here). Eaton, S. E. (2023, February 24). 6 tenets of postplagiarism: Writing in the age of artificial intelligence. University of Calgary. http://hdl.handle.net/1880/115882
AUTHOR RESPONSE: I re-wrote and appreciably expanded Sect 2.4 as follows:

2.4 Ethics and energy concerns with training and using Gen-AI
Generative AI introduces significant shifts in ethical considerations and energy consumption issues surrounding information and communication technology (Biden 2023). Training large-scale language models (LLMs) like GPT-4 involves using extensive GPU clusters, requiring vast amounts of publicly accessible data and substantial electric power, sourced from both renewable and non-renewable energy. Beyond training, the inference phase (i.e., prompting) of LLMs also raises ethical and environmental concerns.
Ethical Issues During Training: The data used for training LLMs often involves publicly available content, which raises questions about copyright, fair use, and the ethical implications of using such data (Dwivedi et al 2023). Additionally, biases in the training data can propagate into the models, reflecting societal inequalities and stereotypes. Addressing these biases necessitates

careful curation of training data and implementing strategies to mitigate bias effects in AI outputs (OpenAI 2023).

Ethical Issues During Inference: When AI models are deployed, they can perpetuate biases, generate harmful or misleading content, or reinforce stereotypes (Biden 2023). Recognizing and addressing these biases is critical, along with ensuring the responsible and ethical use of AI to avoid perpetuating harm or misinformation. Privacy concerns also arise when handling sensitive data, requiring adherence to principles of confidentiality and data protection.

Eaton (2023) postulates how the ethics of writing and attribution may change in a post gen-AI world, calling them the "6 Tenets of Postplagiarism." They describe how human-AI hybrid writing will become the norm, transforming the traditional notions of authorship and blurring the definition of plagiarism. Generative AI will aid in overcoming barriers to communicating across languages and enhance human creativity. However, while humans may cede control of what they write, they will remain responsible for the accuracy and ethics of their AI-assisted writing. Attribution and accountability will continue to be essential, even as definitions of plagiarism adapt to these new technological realities.
Energy Consumption for Training: Training AI models requires substantial power, affecting regional power grids and increasing carbon emissions (Luccioni et al 2024). Choosing locations for data centers, where LLM's are trained, involves considerations about energy costs, carbon footprint, and the potential for future growth in demand. Emerging solutions include using new nuclear power options like small modular reactors or co-locating data centers with existing nuclear plants to lower carbon emissions (Kaack et al., 2022, Istrate et al. 2024), but more alternatives are needed.

Energy Consumption During Inference: The operational use of AI models (inference) also demands significant energy and water, contributing to environmental concerns (Istrate et al.. 2024). As AI adoption grows, understanding the ecological footprint of these systems becomes increasingly important (Duran et al. 2024). Sustainable AI deployment includes optimizing energy use, reducing reliance on non-renewable energy, considering the broader environmental impacts and improving the energy efficiency of software engineering (Bolon-Canedo et al 2024).

Multimodal Capabilities
General
This section is long and has many subsections. It would be helpful to start the section off with a brief summary that walks the reader through the various capabilities and examples that will be described. Ideally this would be supported by a flow diagram (that way people could look at the diagram and select particular sections to read if there is a skill/tool they are particularly interested in)
AUTHOR RESPONSE: I added a introductory paragraph that lists out the contents of the Section 3:
This section demonstrates a large sample of multimodal capabilities of GPT-4, including 1) helpful strategies and mindset for extraction meaningful output and responses, 2) interpreting

photos, diagrams, handwriting and other types to provide textual descriptions, 3) generating 2-D artistic, stylistic and realistic images from text descriptions, 4) using CustomGPT's within OpenAI's GPT-4 for specialized tasks, like creating a story based cartoon from a news article, 5) reasoning with its text-based logic on how elements are spatially arranged, 6) how transcription of handwriting can be combined with CustomGPT's to serve as a teaching assistant, 7) how its ability to write python code, read data files, and interpret energy systems diagrams can support numerical simulation modeling of ecosystems and statistical data analysis, 8) how to create personalized CustomGPT's that focus on a specific realm of knowledge and can take on explicit personas to improve utility and 9) how creating AI Agents is one of the next phases in advancing the application of gen-AI.

Most subsections begin by describing a particular GPT tool and an example of how it could be used in ecological engineering. Sometimes, however, the why is missing (i.e., why use this tool in an ecological engineering context (for teaching or practice)…what does it provide us with that is presently lacking?). Reading through each section and making sure the why is explicit, would be extremely valuable.
AUTHOR RESPONSE: I added multiple passages to address the "why" question:
Section 3.1 2nd to Last Paragraph
The application to ecological engineering design is broad, but some specific use-cases include leveraging GPT-4's conversational abilities to facilitate interdisciplinary collaboration and problem-solving. For instance, ecological engineers could use GPT-4 to engage in simulated dialogue that helps explore different perspectives on ecosystem management or restoration strategies, which is not available from other software today. This approach could aid in developing comprehensive plans that integrate diverse knowledge areas, such as hydrology, plant ecology, and community planning. By engaging in iterative and adaptive learning conversations GPT-4 engineers can effortlessly develop empathy and technical knowledge.

Section 3.2 1st Paragraph
GPT-4 has the ability to view and describe the content of images that you upload. The application to ecological engineering design is particularly relevant for ecosystem-level assessment, monitoring, and adaptive management. GPT-4's ability to analyze and describe images can be used for identifying ecosystem stressors, such as invasive species, pests, or diseases. For example, detecting the sudden presence of an invasive species can spur more immediate management actions. This capability supports near real-time, adaptive management by enabling continuous ecosystem monitoring and timely interventions, thereby enhancing the resilience and sustainability of restoration projects and ecological management practices.

Sect 3.5 Last Paragraph
Use cases for transcribing handwritten drafts, notes and especially fieldnotes to a digital-based text abound, such as 1) reinterpreting an old set of fieldnotes or drafts of handwritten papers from a deceased naturalist or ecologist that are difficult to read with gen-AI transcription, 2) working collaboratively in the field with citizen scientists to collect observations on plant or bird species and having their hand-written data translated and analyzed quickly and rigorously

because currently tools like this are rare or non-existent, 3) improving the accuracy and speed with which fieldnotes are entered into a database because manual data entry is error prone and labor intensive, and 4) assessing, summarizing and providing insight on the notes you take during a learning session of a class which would be a giant leap forward from what is available now.

Section 3.6 1st Paragraph
GPT4's Code Interpreter has the ability to write python code, which can be combined with its ability to read and interpret data files, word documents and images to statistically analyze data, create and run numerical simulations from text, and translate the symbols of Odum's energy systems language into to their set of differential equations. The potential applications of these features are extensive in the field. A key advantage of GPT-4 is its ability to lower the barrier for scientists across disciplines to advance their modeling and analytical capabilities, which will improve the gaps in accessibility to advanced modeling techniques and computational tool. For instance, undergraduate and graduate students can more efficiently learn to develop and refine ecological models because it is important that the next generation of ecologists and engineers be equipped with intuitive and accessible tools to engage with complex ecological data and simulations without being overwhelmed by technical programming requirements. The experienced data analyst who is familiar with general linear models, for example, can interact with GPT-4 to deepen their understanding of more sophisticated multivariate techniques, which will improve their ability to handle more nuanced and multi-dimensional ecological data, thereby enhancing the rigor and scope of their analyses. Through generative AI's support, they can explore these advanced methods and seamlessly integrate them into their research repertoire, ultimately enhancing their capabilities and productivity, which will bridge theoretical knowledge with practical application, fostering a more adaptive and innovative approach to ecological engineering challenges.

Section 3.7 Last 2 Paragraphs
The CustomGPT feature is a major step forward in how users interact with gen-AI. It allows for customized and highly effective AI interfaces tailored to specific needs and preferences. Like other features of GPT-4, the possibilities for creating CustomGPTs seem endless. Some examples of existing GPTs include math tutors, chemistry tutors, physics tutors, coding experts in R, financial planning advisors, scholarly article finders, science article writers, marketing copywriters, travel guides, statistical analysis tools, ecology assistants, and botany experts, among many others.

The growing collection of CustomGPTs can accelerate the impact, efficacy and speed of ecological engineering because it allows practitioners to develop a broader and deeper understanding of complex issues more quickly than current research techniques. It enhances the engineer's ability to communicate more effectively with precise and eloquent prose. It gives them an easier path toward creating ecosystem models that are more representative of reality. It widens the engineer's capabilities for gathering and synthesizing large datasets across a range of

ecosystems and platforms. The improved accuracy, coverage and timeliness provided can enhance the rudimentary adaptive management strategies that exist today.

Details
Section 3.1
- Lines 219-221: this has already been addressed in lines 187-188. Considder eliminating one of these duplicate instances.
AUTHOR RESPONSE: I removed the redundancy from sect 2.3.

- Line 222 (we have gone from plural geinuses to singular genius…revise for consistency).
Section 3.2
AUTHOR RESPONSE: done

- Line 267-270 – this reads as a bit anecdotal. Can you provide some quantitative basis for this? How often in a set of 100 images that contain a small insect does it correctly detect the insect? How often in a set of 100 images without a small insect does it inaccurately conclude that an insect is present? Details like this would really be helpful for someone considering using this approach in practice.
AUTHOR RESPONSE: For brevity I removed the paragraph.

- Lines 274-275. How would you propose quality controlling such measures? Are there particular validation approaches that you feel would be appropriate? It would be helpful to discuss the current state of the art for image analysis and how AI algorithms might advance best practices.
AUTHOR RESPONSE: For brevity (the article was already over JEED's word limit), I'll pass on diving into image analysis. My task was to highlight a capability, not to prove its accuracy. That would be nice to see in a future paper.

Section 3.3
- You have an extra a in line 28 AUTHOR RESPONSE: Done

- Line 297 – If you still have the iterative process that you went through to generate the final panels, it would be fantastic to include it as a supplemental document. Sometimes the journey is even more interesting than the polished result, especially for someone who might be interested in trying this out themselves and is not particularly familiar with GPT.
AUTHOR RESPONSE: For brevity (the article was already over JEED's word limit), I'll need to pass on diving deeper into the process. Interest readers can always reach out to me.

- Line 310 – change the young to youth AUTHOR RESPONSE: Done

- Paragraph starting on line 323 – it might be helpful to provide a counter to what Epic Tales provides (what does a google search suggest if you run a query on a similar topic)? I was also left wondering whether Epic Tales would have worked as well if it had been fed a scientific

article as it did when fed a story based on research. Are there best practices for getting content ready for GPT that can be discussed here?
AUTHOR RESPONSE: For brevity (the article was already over JEED's word limit), I'll need to pass on diving deeper into what Epic Tales can and can't do. Hopefully interested readers will follow up.

Section 3.4
- Line 353 – you are missing a citation here (just says cite research) AUTHOR RESPONSE: Citation added.

- Section 3.4. This section is a bit light on content that pertains directly to ecological engineering. Is there an ecological engineering problem that you could provide as an example instead? Is there any research that speaks to how the logic capabilities of GPT has already been used by ecological engineers that you could speak about in more detail?
AUTHOR RESPONSE: For brevity I will leave the Section as-is.

Section 3.5
- line 363 – Beginning a sentence with "one of which" is not grammatically correct. Please revise this sentence. AUTHOR RESPONSE: Corrected.

- Line 368 – I'm not sure that breeds is the word you are looking for. This sentence should also be supported with references from the literature.
AUTHOR RESPONSE: According to my Apple Dictionary: "breed: [with object] rear and train (someone) to behave in a particular way or have certain qualities: eg I was raised in an artistic household and bred to be a musician." So I think it is used appropriately.

- I recommend deleting the sentence beginning on line 370 and skip to the last sentence. "The goal was to have students participate in a multi-part conversation with GPT4 that gave them agency to dive deeper into the topic and further their own personal understanding and level of curiosity" AUTHOR RESPONSE: Done.

Section 3.6.1
- Typo on line 444 – change hat to that. AUTHOR RESPONSE: Completed.

- I'm sure that you confirmed this with a statistical package (i.e., the differences that CPT4 identified are real). If so, please indicate this in the text. This makes me curious whether GPT would also check to see if the data meets the assumptions necessary to perform a t-test in the first place (continuous data, statistical independence, homoscedastic variance, normality, etc.). Basically, do you view it as a substitute for coding/data analysis or does it confer added value beyond what a traditional stats package would do? It might be worth elaborating on this point.
AUTHOR RESPONSE: Yes. I added: "I confirmed that the analysis was correct using MS Excel's t-test function. If prompted to do so, GPT-4 will also conduct tests to determine if the data meets the criteria for using a t-test." To the end of Section 3.6.1

Section 3.6.2
- The is repeated twice in line 451 AUTHOR RESPONSE: Completed.
- Again, I presume that the outputs were checked against a standard statistical package and shown to be correct?
AUTHOR RESPONSE: yes. For brevity I added one line: "Accuracy of model output was confirmed using the PREYPRED.xls minimodel."

Section 3.6.3
- Please provide the equation in line 468 in mathematical notation (i.e., using subscripts instead of lowercase letters) AUTHOR RESPONSE: Completed.
- Line 486 – change combine to combined. AUTHOR RESPONSE: Completed

Section 3.7
- Suggest deleting "to enhance a user's interaction with GPT-4" from the end of the sentence beginning on line 503.
AUTHOR RESPONSE: Rather than delete I clarified because personalization of the response is a key feature: "The CustomGPT feature, introduced by OpenAI in November 2023 as a new feature within the GPT-4 suite, allows users to tailor GPT4 to focus on a unique aspect of its global knowledge and to enhance personalize the style of the response"

Section 3.8
- This section seems like it should be called out somewhere else (its less a current tool and more a future one). Honestly, I'd probably combine this section with the summary and conclusions to create a composite Conclusions and Future Implications section.
AUTHOR RESPONSE: I must respectfully disagree with this suggestion. I wish I had more to add on AI Agents. Programmers and AI industry folks talk about this one of the most important features. I wanted to mention it, but I don't have a good case study to share or the space to include it. I'll leave Section 3.8 intact.

- It would be helpful to clarify why AI agents would be useful. What do we, as ecological engineers, get out of creating multi-agent simulations like the ones you describe? Do you see this as principally an educational tool? Can it help us learn how to plan and manage systems better? Anticipate crises before they happen? Please explain further
AUTHOR RESPONSE: For brevity, I will leave Section 3.8 intact. However, here, for the Reviewer's benefit, I'll say that one idea is you could create a very comprehensive "design team" of AI Agents that represent specific skill sets and community interests to help with designing any type of green infrastructure. I leave it to the readers to dream up some great applications.

Summary
I typically view a summary less as a list of everything you reviewed and more a recap of your main findings. What tools did you identify as most promising? What outcomes were especially exciting. If it were me, I'd write a single sentence that reminds the reader that this was about the

applicability of AI for ecological engineering, a second that lists out all the evaluated tools, and then use the rest of the space to remind us about the most extraordinary tools you encountered (the comic strip, the coding and the customGPTs seem the most notable to me, but pick your favorites and remind us why they are so exciting for the field).
AUTHOR RESPONSE: I combined Summary and Conclusions by re-writing for brevity and in response to your suggestions.

Conclusion
I recommend combining with the summary (either as a summary and conclusions or as a Conclusions and Future implications as described under Section 3.8.)
AUTHOR RESPONSE: Combined with Summary.

Reviewer D (David Blersch, Auburn University):

This manuscript provides an overview and review of the advancing technology of generative AI, specifically GPT-4 and its associated tools, and the potential role in advancing ecological engineering teaching, pedagogy, and practice. After providing a brief overview of the mathematical and programming foundations of generative AI, the review moves into providing examples of applications of ChatGPT-4 in the development of classroom exercises, engagement strategies, and review and feedback of material. The review then gives examples of the potential application of agents in design scenarios for ecological engineering designed systems, posing this application as possible futures for the use of generative AI in the ecological engineering field.

Overall, this review paper addresses a significant need at a timely occurrence, as the field of AI is advancing rapidly and the reporting on apparent applications in the ecological engineering field are limited so far. The value of the topic to the field at this time cannot be overstated. The author has developed a fine review of the state of AI, the application of AI in specific scenarios in the classroom and in the design field, and provided excellent examples from personal experience that are illustrative, educational, and relevant to the overall topic. The trajectory of the manuscript is somewhat unexpected, however, with some sections underdeveloped in unexpected ways. For example, the discussion of the mathematical basis for AI is rather short, of only 3 paragraphs, and leaves many questions of the reader as to how the technology is all integrated and how it in fact functions. This may be the intention of the author, to remain as a cursory description of the technology merely for introduction, but some additional descriptions that synthesize the state and application of AI would be helpful and appreciated. Also, the title and abstract of the paper seemed to suggest more discussion of applications of AI in design of ecological engineered systems, and in furthering application of ecological engineering through technical analysis of ecosystems and ecological principles; the paper rather focuses much on utilization of AI in ecological engineering teaching and pedagogy, again providing examples sufficient for replication but not making adequate connection between classroom exercises and

principles of practice for ecological engineering. Some additional development and examples of AI use in ecological engineering practice would help to improve the overall discussion and wrap-up of the topic. In general, however, the manuscript is well written, overall well organized, and logically structured. There is some variation in tone of writing, perhaps due to the writing method described by the author that included sections partially written or composed initially by AI itself; to that defect, an additional round of review by the author to ensure continuity of voice is recommended.

AUTHOR RESPONSE: I added more examples, scenarios and reasons as to why these AI tools will help advance EcoE. Please see the lengthy set of responses to Reviewer C's comments and suggestions for details.

Detailed reviewer notes to be shared with the author and editors:

The following detailed critiques and edits are offered by this reviewer, in the hopes of improvement of the manuscript for future consideration:
• Line 54: Citation needed. AUTHOR RESPONSE: I added.
• Line 71: "…magnitude from 1939 to 2023." Citation for this fact? AUTHOR RESPONSE: I added.
• Line 77-78: " What does the future hold for ecological engineering?" It seems strange and mis-worded to turn to this question immediately. You can make slightly better connections to the potential impact of AI on biology in general, and then extend that to ecological engineering considerations, through rewording and rewriting the prior sentence.
AUTHOR RESPONSE: Agreed. I expanded Line 104-123: "Kurzweil's lavish optimism may lead an ecological engineer to ponder: "What does the future of gen-AI hold for us as a profession and field of investigation? Hopefully, readers will be able to seriously consider this question after learning about GPT4's multimodal capabilities. Here are few specific questions to prime their thinking:
1. Can generative AI enhance decision-making in ecological engineering by processing extensive datasets to optimize ecosystem management?
2. Might its code-writing abilities allow us to quickly and efficiently develop models to test hypotheses and revolutionize our understanding of system dynamics?
3. Could its ability for real-time data analysis offer more actionable and cost-effective monitoring programs?
4. Will gen-AI become the quintessential virtual teaching assistant that revolutionizes how we educate the next generation?
5. How might its image recognition improve restoration and conservation efforts?
6. Will gen-AI's rapid and realistic visualizations foster multidisciplinary collaboration and diverse stakeholder engagement?
7. Can specialized AI agents be developed that become proficient at ecological design and planning?
8. How could gen-AI optimize resource use for sustainability?

9. Does our knowledge of the innerworkings of complex natural systems inform the ethics of creating and using gen-AI?ecological engineering?"

• Line 104: Insert "the" before "vast". AUTHOR RESPONSE: Completed.

• Line 168: I feel like there should be one more paragraph here in this section describing integration of these components just described to make it all work together as GPT$ or similar. Otherwise, the discussion seems truncated here, and I am left wanting to know more. AUTHOR RESPONSE: Completed.

• Line 251 and continuing: The shift to first-person experiences here is distracting, as it seems to represent a shift in style. While the first-person experiences described are relevant and valuable to the intention of this paper, the tonal shift is off-putting. Perhaps rewrite some of the earlier sections with first person in strategic places to unify the approach? AUTHOR RESPONSE: Completed.

• Line 270-271: "…like small insects or flowers in the background." Can you provide a figure or example of this? AUTHOR RESPONSE: Completed.

• Line 292: Replace "dept" with "department". AUTHOR RESPONSE: Completed.

• Line 293: Ibid. AUTHOR RESPONSE: Completed.

• Line 356: Citation needed. AUTHOR RESPONSE: This is clearly the author's speculation and the point of the article so there is nothing to cite.

• Line 425 and future (line 430, 431, 442, 457, 679): "Python" is capitalized. AUTHOR RESPONSE: Completed

• Line 426: "Word" is capitalized. AUTHOR RESPONSE: Disagree. I'm referring to all types of word processed documents, not just MS Word.

• Line 430: You used first-person singular up until now, and now you use first-person plural. Somewhat confusing and distracting. Unify your pronouns throughout. AUTHOR RESPONSE: I honestly didn't see this on line 430.

• Line 438: "affect" should be "effect", but this entire phrase is in quotes. Is the correct quote with the incorrect word? If so, insert "[sic]" to indicate it is intentional as "affect". If not, correct to "effect". AUTHOR RESPONSE: sic inserted.

• Line 460: The double "the" is an error, but this is in quotes. Is the correct quote with the double "the"? If so, insert "[sic]" to indicate as such. If not, correct as necessary. AUTHOR RESPONSE: sic inserted.

• Line 480: Replace “100’s” with “hundreds”. AUTHOR RESPONSE: Completed

• Line 662: Insert comma after “In addition”. AUTHOR RESPONSE: Those sections were re-written per RevC’s suggestion.

• Line 668: Delete second “only”. AUTHOR RESPONSE: Those sections were re-written per RevC’s suggestion.

• Line 681: Insert comma after “In addition”. AUTHOR RESPONSE: Those sections were re-written per RevC’s suggestion.

• Line 683: “suggests” rather than “suggest”. AUTHOR RESPONSE: Completed

• Line 710: Replace “LLm’s” with “LLMs”. AUTHOR RESPONSE: Completed

• Line 703-704: “like being about to pre-test assignment types…” Awkward phrasing that is near-fragmentary. I cannot resolve the meaning of this phrase here. Rephrase for clarity. AUTHOR RESPONSE: Those sections were re-written per Rev C’s suggestion.

• Lines 729-734: Is there any supplemental material? These lines appear to be left in the manuscript from the original template. Please update to indicate the presence or absence of supplemental material. AUTHOR RESPONSE: No supplemental material. Deleted from template.

• Line 749: Replace period with a comma to make this a complete sentence. AUTHOR RESPONSE: Completed.

Associate Editor’s Round 2 Review Summary:

Thank you for comprehensively addressing the reveiwers' concerns. Please address the following two remaining comments when resubmitting the paper: 1. Please note the meaning of the "grounding" symbol in Figure 1.2. Please include the prompts/converstion used to generate Figure 4 as Supplementary Material. As noted by the reviewer, this would be a helpful resource for interested readers. However, if you no longer have these prompts available, this paper can still be accepted for publication.

Round 2 Reviewer Comments:

Reviewer A (Anonymous):

The revised version of this manuscript carefully incorporates many reviewer suggestions to good effect. I particularly like the additions to the introduction that address what the future of gen-AI

might hold for engineering (priming the reader with open ended questions). The additions to section 3 (and the subsections it contains) are also very beneficial, clearly tying each example back to its potential benefit for ecological engineering. My remaining comments are mostly minor and I strongly recommend acceptance of this manuscript. I would, however, still like to see the inclusion of a supplemental appendix that provides additional details about how certain outputs were generated (e.g., Fig. 4) (see comments below)
Detail level comments/questions with RESPONSES in RED

- Line 136: Extra period
- Period erased.
- Line 152: extra space
- Space removed.
- In figure 1, what is the little arrow at the bottom that points down to the three lines supposed to indicate? Perhaps provide a label that describes it (or remove if it's not important)
- That is the 2nd Law of Thermodynamics Heat Sink. I added a label.
- Line 184: missing a space between the citation and "and"
- Space added.
- Line 248: there is a period instead of a comma in et al.,
- I removed the comma.
- Line 359: extra space between "is" and "also"
- Space removed.
- Line 783: The word Python appears on its own line at the end
- I removed the stray "python".
- Given the importance of communicating with youth and laypeople in a time when ecological engineering principals (and science in general) is increasingly questioned, I would like to repeat my request for a supplemental appendix that details the conversation that led to the educational panels in Figure 4. When I use ChatGPT with students one of their biggest struggles is learning how to communicate with the platform. I really think that the inclusion of an appendix that lays out the dialogue with ChatGPT that resulted in such a nice outreach outcome would be beneficial to readers.
- I created an Appendix as Supplementary Material that shows the entire conversation that I had with the OpenAI based CustomGPT "Epic Tale Sketcher" to create the comic strip shown in Figure 4. I hope the Editors can publish this as Supplementary Material.

Reviewer B (Chris Streb, Biohabitats):

The revised version of the paper reads more readily, is well written, and addresses a primary concern this reviewer expressed in the previous draft. That being the ethical and environmental impacts associated with the technology. The author provides various examples that begin to show the reader how AI may contribute to advancing ecological engineering. The question remains whether the environmental impacts associated with a field of discipline deploying this technology will generate solutions that more than offset these impacts. Can AI save us before the climate and biodiversity collapse? Small nuclear reactors at data centers

are the dream of tech bros. Despite this lingering concern, I found the paper to be useful, even arousing curiosity of how I might apply it to my work as an ecological engineer.

- Line 136 - remove extra period after "real systems"
- Period removed.
  Line 783 - the word "python" seems like a left over
  I removed the stray “python” word.
- No additional comments.