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Onto-epistemological Understandings of Generative Artificial Intelligence in Education

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Abstract: Over the past decade, the growth in generative artificial intelligence (GenAI) is reshaping and changing how we interact, learn, and work and is likely to bring ongoing change in the future. However, current educational understandings, frameworks, and models concerning digital technologies and digital literacies are remaining relatively static and hierarchical and do not adequately accommodate GenAI's unique learning capabilities, creative potential, and agency. In this conceptual article, we use critical dialogic inquiry and employ ecological thinking using the notion of symbiosis and posthuman perspectives to explore and speculate about the nature of GenAI and its potential impact on educators and learners. We offer a new way of conceptualizing human relationships with GenAI, which we call "symbi(AI)tic understandings." Symbi(AI)tic understandings acknowledge the evolving and contextual relationships between partners: from balanced mutualism to one-sided commensalism to potentially harmful parasitism. Thus, we position human–GenAI relationships as part of change futures in which there are complex associations between technology and human endeavor. These understandings aim to foster more nuanced ways of being with and thinking about technology: ways which are vital for educators and learners as they transition into an era of education with AI.

Keywords: AI, generative AI, symbi(AI)tic understandings, education, teacher education, onto-epistemology

1. Introduction

Artificial intelligence (AI) generally refers to computer systems that can perform tasks related to or emulating human intelligence and perception, including speech recognition, prediction, decision-making, creative production, and language translation. Although McCarthy [1] had been grappling with the concept of artificial intelligence since the 1950s, the ability of neural networks to solve more complex problems, also known as "deep learning," has increased significantly since 2012 [2]. In more recent times, neural network technologies are now arguably passing the Turing test [3]. In this article, we focus on how these technologies might need to be understood now that generative artificial intelligence (GenAI) has emerged into mainstream society. We consider the broader impact, including implications for education.

GenAI models use deep learning neural networks, which learn from large language models (LLMs) to generate new content, including images, text, and audio. Although GenAI has been evolving for years, the release of a free version of Chat Generative Pre-Trained Transformer (ChatGPT) by OpenAI in November 2022 showed the public, industry, and educators the wide-ranging possibilities of the technology, including emergent transactional roles such as collaborator and coach, guide on the side, exploratorium, study buddy, and dynamic assessor [4]. ChatGPT signaled its significance in the AI landscape when it gained 1 million users in 5 days and 10 million in two months [2]. ChatGPT now forms part of other GenAI products and applications, while other technology companies are releasing their own versions [5]. Current proprietary versions include Claude, Oracle, Gemini, and Apple Intelligence. GenAI is now no longer limited to text-to-text with image generators, and video generators, continuously emerging. In education, the technology is bringing profound change in several key areas including personalized learning, intelligent tutoring systems, grading automation and assessment, and generation of content and information [6]. It is envisaged that there will soon be AI-powered professional development and learning delivery systems that provide effective feedback and useful suggestions to students and teachers based on their emerging learning and developing teaching practices.

The fast evolution of GenAI has raised important ethical and equity concerns across all sectors of society, including education. For instance, GenAI-powered systems may perpetuate race, gender, and Western biases which could be significant, given the ubiquity of the technology [2]. GenAI may also bring into dispute issues of authorship and the authenticity of creative works [7]. In a changing future, this technology may create new jobs, but it also threatens to replace jobs for those who fail to navigate the transition. In the context of education, there are many concerns about critical awareness of the implications of the technology, and how it will affect student learning [8, 9].

It is into this fast-moving and emergent landscape that we assert that current understandings of the role of technology in education and across broader society are not sufficient to accommodate the profound capacity of GenAI in concert with human agency. We suggest that there is a need to ask more fundamental questions about the nature of the technology in the functioning of society that move beyond static and utilitarian ways of representing it.

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Our view is that we shift toward an ecological and relational understanding of GenAI that accounts for its profound and emerging capacities, and we proffer a new onto-epistemological basis for conceptualizing its intersections with human agency.

2. Literature Review

In this section, we focus on GenAI and especially its implications for education. In doing so, we point to current understandings, frameworks, and models used to theorize the function of technology in teaching and learning, with relevance to sectors beyond education. We then consider literature that allow us to speculate on possible futures or what might be as GenAI continues to emerge.

2.1. Models for understanding teaching and learning technologies

In the last 20 years, there has been a dominant instrumentalist and deterministic view of technology in education and beyond [10]. Technological devices and software are used for projecting slides in lecture theaters and classrooms, while online conferencing platforms with transcription services and chat rooms are used for lectures and classes. Learning management systems (LMSs) house online recordings, resources, lesson plans, and assessments: they enable publishing and storing of grades, and thus, the tracking of student attendance, engagement, and progress. Schools, educators, and students use and understand these technologies to varying degrees, largely depending on their confidence and comfort level with technology use and their level of digital literacy and competency [11, 12]. In these all too familiar learning contexts for the use of technologies, there is a sense of inevitability about the place of technologies as tools of efficiency and productivity that sit adjacent to teaching and learning and extend human capacity. However, the dynamism of how humans relate to technologies and technologies to humans is rarely considered when defining digital literacy or considering teaching models.

It is our view that digital literacy is an evolving concept in light of recent technological change. Digital literacy may be viewed as understanding technology and its use and developing capabilities and understandings that allow us to live, learn, and work in a digital world [13]. Skantz-Aberg et al. [14] report that the definitions of teachers' digital literacies and competence are mostly centered around technological competence and pedagogical competence, though they might also be understood to include content knowledge, attitudes to technology use, cultural awareness, a critical approach, and professional engagement. The development of teacher digital literacies is a multidimensional process which leads to knowledge and skills that teachers can employ in their teaching and for their students' learning in varying contexts and through critical and ethical engagement [15]. While this process of developing digital competence and literacies is certainly important, such understandings generally do not include more complex ways of thinking about, relating to, utilizing, integrating and being with technology [16–18].

Two of the most popular and most cited of the teaching models that engage with technology in education and learning are the Technological Pedagogical Content Knowledge (TPACK) model and the Substitution, Augmentation, Modification, and Redefinition (SAMR) model [19]. The TPACK model, developed by Mishra and Koehler [20], considers technological knowledge (TK) alongside pedagogical knowledge (PK) and content knowledge (CK) as essential for teachers in using and teaching with digital technologies. In 2019, Mishra suggested context knowledge (XK) as an addition to the model to describe teachers' understanding of the context in which technology was to be used [21]. This model has drawn an enormous following, both in academic and teaching practice contexts. Mishra et al. [22] expanded their model considering the impact of GenAI and included understanding about how it will shift the nature of teaching and learning. They conclude that TPACK will only be useful in the age of GenAI if it is used with a wider perspective of future GenAI, not just what is available today. However, what is not present, even in the revised version, is a sense of the predisposition of GenAI toward interactivity and agency, a concept we take up later in this article.

The SAMR model[1] is designed to identify the extent of teacher's uses of technology in classroom teaching. Its taxonomic structure aims to clarify each teacher's uses of technology in more advanced ways: from simply substituting traditional resources with technology to using technology to create new tasks. Though useful, the SAMR model does not address the teacher's context and has a rigid hierarchical structure that does not accommodate the complexity of teaching and prioritizes the changes in the uses of the technology (product) over the learning process [23]. This is thought to be a significant shortcoming when thinking about the more complex GenAI technologies.

Falloon [24] argues that in ignoring broader concepts such as context and the disposition of teachers and learners, current models of how technologies operate within educational settings offers minimal consideration to the relationality of employing technologies with humans. This includes understanding of what are safe, ethical, and productive uses of technologies as teachers integrate technologies into learning. We would add that both models not only ignore context and the nature of the learners but also the pace and fluidity of technological development and the emerging ways in which humans now relate to technologies. Indeed, accommodation of change must be a strong consideration in theorizing the connections between learning, the learner, the educator, and technology.

Finally, the pedagogical practices of classroom teachers about instantiating technology in education are similarly static and not oriented to emerging ways of conceiving humans and technology in relational and integrated terms [17, 25]. Falloon [24] argues that rigid discipline-based educational delivery has been resistant to change. In the context of initial teacher education internationally, for instance, courses continue to teach technology as a single unit, rather than embedding it across all units [26, 27]. Williamson et al. [28] suggest that a paradigm shift is needed to infuse technology into teacher education so that it is meaningfully centralized in the thinking and practice of new teachers. We concur with this orientation but also suggest that the proposed paradigm shift about integrating technology into learning needs to be quite drastic if it is to prepare institutions and educators for the now popular, fast-evolving and, arguably, human-like GenAI.

2.2. Guidelines, frameworks, and policy recommendations for GenAI in education

To address public concerns about the potential disruption and safety of GenAI, some institutions across several countries initially banned the use of GenAI for students and staff[2, 3]. As Australian researchers, we write out of the Australian context. In

[1]Puentedura, Ruben. "SAMR and Bloom's Taxonomy: Assembling the Puzzle." September 24, 2014. https://www.commonsense.org/education/articles/samr-and-blooms-taxonomy-assembling-the-puzzle

[2]Duffy, Conor. "Public school bans on AI tools like ChatGPT raise fears private school kids are gaining an unfair edge and widening a digital divide." May 26, 2023. https://www.abc.net.au/news/2023-05-26/artificial-intelligence-chatgpt-classrooms-schools/102356926

[3]Reuters. "Top French university bans use of ChatGPT to prevent plagiarism." January 28, 2023. https://www.reuters.com/technology/top-french-university-bans-use-chatgpt-prevent-plagiarism-2023-01-27/

the case of Australian government schools, this ban was lifted with the publication of the Australian Framework for Generative Artificial Intelligence in Schools in November 2023 [29]. This framework aims to guide and support the responsible and ethical use of generative AI tools using six principles (Teaching and Learning; Human and Social Wellbeing; Transparency; Fairness; Accountability; and Privacy, Security and Safety) with 25 associated guiding statements.

In the latest version of the Australian Curriculum, the need for the development of AI literacy as part of digital literacy is not included[4], though a resource for teachers, with a curriculum connection, was added in March 2024. For the Australian higher education sector, the Tertiary Education Quality and Standards Agency (TEQSA) has released assessment guidelines with two guiding principles and 5 propositions with simple examples [30]. The underlying assumption in developing policies and frameworks is that GenAI is a relatively stable technology and so definable guidance for educators is possible.

Internationally, the European Commission [31] and Miao and Holmes [32] provide similar ethical guidelines and adds guiding questions for educators to help teachers' reflections. They indicate, however, that an assessment for the trustworthiness of GenAI should be conducted to ensure it meets legal and ethical requirements. Though important for policy and curriculum development, these documents are very limited in terms of practical implementation for schools and teachers, and, most importantly, they do not engage with fundamental ontological understandings of the ways these rapidly changing GenAI technologies will work (and are working) with humans.

In the academic literature, more practical frameworks and policy recommendations have been published to guide educators, with similar limitations. For example, there are frameworks for AI-driven learning analytics [33, 34], an AI policy education framework for university teaching and learning [35], policy recommendations for the ethical use of AI for parents and teachers [36], and books that outline the implications of GenAI [2, 37]. Casal-Otero et al. [38] summarize the availability of resources and programs for implementing AI and developing AI literacy in schools. Unsurprisingly, they found that there is a need for teacher training in AI.

The underpinning concept for most of this literature is the development of AI literacy, which incorporates the notions of AI competencies and AI capabilities [39–41]. As with digital literacy, understandings of AI literacy are still evolving along with the rapidly changing technological environment. AI literacy, it is argued, will allow users of AI to evaluate the appropriateness and effectiveness of AI. Almatrafi et al. [42] offer six key constructs within most understandings of AI literacy: recognize; know and understand; use and apply; evaluate; create; and navigate ethically. Markauskaite et al. [40] identify a range of AI capabilities that are important for both learners and educators. They formulate this set of capabilities from multiple perspectives: AI-centered, humanistic, cognitive, and social. Both these sets of understandings about AI, although useful, are functional in scope, do not account for the interactional and embodied ways humans relate to technologies, especially now with GenAI, and thus appear to be relatively static conceptualizations without much fluidity [43]. By static, we mean the idea that the capacity for adaptation and change is diminished by the instrumental boundaries established around technological conceptualizations.

In the face of what we argue is an epistemological fixity in current models and conceptualizations about technology and humans, we propose a need to consider current and emerging GenAI technologies in relational and transactional terms that allow for adaptation and change and the possibility of a new paradigm to emerge. Russell and Williams [44] proposed the idea that there is a social shaping of technology, or an orientation of technologies to myriad human endeavors, as opposed to more deterministic readings of how technology relates to the human world. We suggest that a more reciprocal relationship with and understanding of technology and human experience is needed in the age of generative AI.

To better understand this reciprocity with GenAI, we turn to Ihde [18, 45, 46] and his philosophy of technology. While Ihde's work predates the widespread use of AI, it does point to a more fluid, transactional, embodied, and relational way of ontologically conceiving technologies–human connections that move beyond static approaches that also tend to the anthropocentric. Ihde considered the ways humans relate to technology to be immersive with nature of the technology and context of its use. He described many different types of relationship and dynamic interplays: embodied relations, where there is a corporeal unity between humans and technology; hermeneutic relations, where human use technology to help them represent the world; alterity relations in which humans interact with technologies in ways that recognize the agency and presence of the technology; and multistabilities, where there are many different ways in which the technology may be perceived, related to and employed in a range of contexts. Ihde's work points to the fundamental relationality between humans and technologies that have, he claims, shaped human evolution.

2.3. Speculations and futures

In 2010, Watson [47] synthesized what was then a burgeoning body of research about the intricacy of how technologies are affecting and changing the human brain and mind [48]. Far from being separate from embodied human experience and the disposition of the societies in which we live, technologies could be seen as shaping and forming who we are and becoming as human beings, including our ideas, practices, and ideologies [49, 50].

Researchers in this developing field have speculated what the future might look like for humans with the continuing evolution of GenAI. In the 2023 book, Impromptu, Hoffman [51] asks his co-author, OpenAI's GPT-4, to describe a human world where GenAI has improved society's productivity, prosperity, and stability with ample safety nets for housing, education, and healthcare needs. GPT-4 describes a world which appears utopian at first: humans no longer must work, worry about disease, or experience violence. It is a world replete with comfort, security, and entertainment. However, then it considers that this world, rather than being perfect, is dystopian: where humans are passive consumers and spectators who have dulled senses and souls. This example not only illustrates how technology can co-author, and thus shape, human thinking, but it also provides us with a speculative dystopian future.

As a response to this speculative dystopian future, we suggest that what is missing in this provocative scenario is the reciprocity of human interactions with technology and GenAI in particular [52–55]. The development of AI and its current and future uses may well be predicted on relationality and mutuality, as humans shape and are shaped by this technology and respond ethically and critically to the ways that the technology is responsibly adopted in society [56–58].

In the field of teacher education, Bozkurt et al. [8] speculate on the future of GenAI (ChatGPT) based on collective narratives from 37 authors. The researchers found three common positive themes from the narratives: there needs to be an educational paradigm shift, a substantive change; there is a need to redefine human and

[4]Australian Curriculum and Assessment Reporting Authority, " The Australian Curriculum, Version 9.0."

AI roles in education and their respective ownership of content as AI is now able to be an author; and there needs to be a reconsideration of the responsible use of AI in order to maximize the educational effectiveness and minimize the educational risks. They also report negative narratives about AI: fears of the unknown and concerns about its power led to common themes around ethics, privacy, data ownership, academic integrity, and bias. Many of the authors consider that handing over power to the developers and technology companies makes education (and society) vulnerable to manipulation and surveillance. There are also concerns around the development of new types of literacies, loss of diversity and originality, issues of instructional authority and learner agency, and the pressing need for new educational roles.

To counter these concerns around GenAI, Bozkurt et al. [8] call for a recalibration of teaching and learning practices as well as innovation so that practitioners can have new or different ways of understanding the role of emerging technologies in educational experiences. Though we largely agree with Bozkurt et al. [8], we consider that learning to work with AI may mean that educators must consider the posthuman in the sense of the propensity for agency and creativity in the technology [59]. While current models and frameworks provide some foundational understandings useful in education, they often fall short in addressing the dynamic, relational, and reciprocal nature of human–technological interactions. To harness the full potential of GenAI, and recognize its limitations and dangers, there is a need for a significant paradigm shift that embraces the fluidity of this new technological landscape that is now becoming ubiquitous across many societies and in educational contexts.

3. Methodology

Methodologically, we came as two Australian university researchers from education faculties with common philosophical and practical concerns that current models of technology and education are not adequate in the new GenAI era. We entered a critical dialogic space of inquiry to develop an onto-epistemological understanding of its possibilities in education. Critical dialogic inquiry involves purposeful and reflexive dialog with the aim of developing critical understandings within the context of social change [60]. The approach is based on Mikhail Bakhtin's notion of dialogism, by which he means the uttering (heteroglossia) of a range of viewpoints in a space of emerging understandings which includes interactions with texts [61]. It involves questioning ideas and assumptions and exploring multiple perspectives within the parameters of a research problem, in this instance, how to think about technological change in education in the light of the impact of GenAI.

We had three objectives as part of our inquiry:

1) Criticality. To embody a critical perspective about technological change in education and engage with the diverse ideas and ways of understanding change considering the impact of GenAI [62].
2) Dialog. To create a dialogic space that involved the authors in critical engagement with the literature and theory in a series of collaborative and formative conversations [63, 64].
3) Cross-disciplinarity. To adopt a cross-disciplinary approach to thinking, drawing on a range of philosophical ideas, practical knowledge, and empirical research in our quest to offer some fresh perspectives in this emerging research space [65].

4. Key Conceptual Understandings

In this article, our critical dialogic inquiry is oriented toward onto-epistemological thinking about the GenAI and its existence with humans. Onto-epistemological thinking is a philosophical approach that concerns the relationship between ontology, or the study of what exists and has a sense of being with constituent parts, and epistemology or the study of how we might know and understand being [66, 67]. It seeks to understand how being (reality) and our knowledge about reality (epistemology) are entangled and mutually constitutive. Onto-epistemological thinking disrupts the tendency for separation or a binary between ontology and epistemology by bringing attention to the interconnectedness of these two areas of philosophical investigation. It acknowledges that our understanding of reality is not objective or fixed but is instead constructed through our shifting perceptions and experiences, as well as the social, technological, and environmental contexts [68].

Onto-epistemology also brings attention to language and discourse in shaping knowledge and the perception of reality [69]. It recognizes that our conceptual frameworks, categories, and linguistic structures influence how we make sense of the world and construct knowledge about it. It encourages a critical examination of how our being in the world and our ways of knowing are intertwined and influenced by various factors. However, we would not want to give the impression that this relationship between being and knowing is resolved, and in postmodern times there is considerable dispute about what is meant by reality and knowledge of it [70].

With the introduction of GenAI and its incursion into mainstream education, we require an onto-epistemological approach that takes into consideration this technology as a phenomenon that is fluid and likely to change, with levels of predictability and unpredictability [71, 72]. Given this rapid technological development of GenAI and the subsequent evolution of human–GenAI connections, we argue that there is need for an onto-epistemological approach that moves away from static hierarchies and siloed frameworks toward understandings that are more dynamic and holistic and allow for the inevitability of change [73, 74]. To do this, we turn to ecological thinking and posthumanism.

This section focuses on the concepts of ecological thinking and posthumanism employed in our dialogic inquiry as part of developing our onto-epistemological approach. In both these concepts, arguably, the relationship between being and knowing is intricately entangled. Our purpose in exploring this intricacy is to generate a new way of thinking about the transactional and relational nature of GenAI in intersection with humans, with implications for education.

4.1. Ecological thinking

In support of our onto-epistemological approach, we embrace ecological thinking, and more specifically symbiosis, to elucidate the intricate evolving relationships between humans and GenAI, which we consider to be an under-explored part of current conceptualizations of generative AI and change futures. Thinking about human and technological relationships as symbiotic was first introduced in 1960 when Licklider [75] described the mutualistic relationship between humans and a computing machine that operates as part of a larger system. Since then, symbiosis has been used to describe human–machine collaborations. For example, Gilbert et al. [76] described the symbiotic human–machine relationship of an artificially intelligent brain–computer interface used to alleviate symptoms of neurological and psychiatric disorders. To our knowledge, however, reference to human–machine symbiotic relationships have been limited to mutualistic relationships. We believe that it may be useful to consider a broader definition of symbiosis to help explain human–GenAI relationships.

In biology, the term 'symbiosis' means an interaction in which species are physically associated and physiologically dependent for most of their lifetime [77, 78]. At least one of the entities in the interaction receives a benefit from exchanging commodities such as transportation, protection, and/or nutrition. These interactions do not need to be mutually beneficial: they can have a net benefit for one species and not the other. There are generally considered to be three types of symbiotic relationships:

1) *Mutualistic:* the interaction benefits both partners. For example, lichen with trees and gut microbiome with humans.
2) *Commensalistic:* the interaction benefits one partner and does not harm the other. For example, barnacles on whales.
3) *Parasitic:* the interaction benefits one partner and harms the other. For example, mosquitoes feeding on human blood.

In the examples above, we refer to benefits and harms by calculating the overall net effect: each relationship is likely to have costs even though the net effect may be beneficial. It is worth noting that the net effect of a relationship may change according to circumstances.

Symbiotic relationships are often context-dependent, sometimes unstable, and evolve over time [77, 79]. The context and other biotic and abiotic factors can cause the type of relationship to evolve over time. Symbiotic relationships may only be beneficial under some circumstances and not others. For example, a parasitic relationship may evolve into a mutualistic relationship as it is in the interest of the parasite to benefit its host so that it may thrive. Symbiotic relationships are often far more complex than they are often portrayed. We consider this to also be applicable to human–machine relationships.

Employing understandings of different symbiotic relationships may enhance understanding of human interactions with GenAI as it potentially evolves as a "species" [80]. This notion of the functional autonomy of the technology as a "species" may be especially pertinent in the future with more sophisticated training of LLMs, increasing computing power that supports GenAI emerging capacities, more ubiquity of the technology across all sectors, including education, and a much larger array of applications designed to utilize AI [81]. At the same time, we acknowledge that this designation as an intelligent species (or having digital existence) is highly contentious. The usual notions of "being" as having consciousness, volition, and feelings appears to discount this perspective, along with the current limitations of the technology [80]. However, we argue that a non-biological sense of "being" is plausible [82] when considered from a posthumanist perspective.

4.2. Posthumanism

Posthumanism has provoked a new gaze for researchers beyond the confines of human agency (with its inherent anthropocentrism) out to the natural world and to non-human forms of being. Two fundamental questions emerged for us in our dialogic inquiry. First, in the pursuit of creating intelligence beyond the human, does the outcome need to emulate humanity [83, 84]? Second, are we, as a species, the only possible apex of nature [85]? GenAI is, perhaps, an indicator of the desire to explore realms of thought and creation beyond what might be deemed as human [86]. It is not constrained by human biological limitations, beckoning the further question: what might a post-biological world look like?

Historically, the focus of research, practice, and policy in terms of technologies and AI has been on competencies and capabilities, viewing them instrumentally to fulfill a need for certainty, as we made clear in our review of the literature. However, in moving toward a possible posthuman future and in embracing change, it might be important to think more dynamically and conceive of human–machine hybridities [87]. Instead of a focus on static skills using GenAI, we argue that the emphasis should be on malleable skills and profound understandings that go to the relational and to future possibilities that include those beyond the Anthropocene and the colonizing of knowledge [88].

Moreover, the fundamental agency of the material, including technologies, might be considered as part of this posthuman orientation [89]. We suggest that technology does not just serve – it relates, interacts, and in some cases, decides [90, 91]. In a world where machines can potentially think differently to humans, there is the potential to harness this capacity. Technologies sit relationally with humans, and this synergy might include both human and machine notions of intelligence [18].

5. Findings

In response to a need for widening our perspectives of technology [22], in this section, we offer a summary of the findings of our critical dialogic inquiry. These include our onto-epistemological understandings, speculations and explorations about GenAI based on our dialogus, and three examples of applying these understandings to an educational context. In our dialogs, we coined the term "symbi(AI)tic understandings," to reflect our use of ecological thinking in concert with posthuman ideas to consider human–GenAI relationships as part of larger interactional ecosystems. In using symbiosis analogously, we amplify the relational, changeable, and agential nature of being with this technology. Through employing the notion of symbi(AI)tic understandings, we aim to disrupt the tendency for binary thinking about humans and technologies, and specifically, consider humans and GenAI to be inexplicably entangled in a system of complex relationships with multiple agencies.

5.1. Symbi(AI)tic relationships

In this onto-epistemological rendering of GenAI, we consider that it will emerge as a set of relational and complex technological "beings" that learn, make judgments and decisions, and can act independently of humans, though we acknowledge that this possibility that has not yet fully arrived. These futuristic technological beings will be perceived to have human-like agency and the construct of considering this technology as merely a set of tools is no longer appropriate. Thus, GenAI may well be perceived as a highly intelligent species with which we are in a relationship, rather than a tool which we use. We label this relationships between AI technologies and humans as "symbi(AI)tic."

In symbi(AI)tic relationships, the beings are post-biological and so do not exchange nutrition, protection, or transportation: they exchange data, knowledge, skills, hardware, electrical energy, power, and identity (to name but a few). For example, in the way we currently use ChatGPT, the human provides ChatGPT with source information, a prompt, hardware, and electrical energy and in return receives information in the form of outputs such as a text or image. Such outputs may enhance a person's life through, for example, their confidence and facility in creating content with the assistance of GenAI. This technology with its LLMs and highly complex algorithms currently has the potential to learn from and respond to the human prompt and then offer nuanced creative outputs. In this case, the response closes the feedback loop of the reciprocal relationship.

The evolution of human–GenAI relationships is likely to be analogous to those seen in nature. A human–AI relationship may begin as a mutualistic win-win relationship: where data and energy are exchanged for mutual net benefit in a simple learning feedback loop between the two beings. As the beings evolve, however, the benefit for one being may become more pronounced than the other and become more of a one-sided, commensalistic relationship. The relationship will also be commensalistic if the human decides they do not want to share any of the information in a closed "private" system. Relationships may also evolve to become more harmful and thus parasitic. For example, if the AI is given biased information by human programmers, then its learning is flawed and may result in it becoming less useful to others [92]. Competition between humans and GenAI technologies is also likely to affect the disposition of these intricate relationships.

As in nature, and current human–human relationships, symbi(AI)tic relationships may be experienced in disparate ways. Some relationships with GenAI may feel mutualistic for some, commensalistic, parasitic, or competitive for others. For example, data from school cameras may be used by GenAI to automate attendance and send out messages to parents: if the information is kept within the school, this may seem to be a commensalistic relationship that benefits the administrative running of the school, but a parasitic relationship for the students who are aware of being watched and controlled by the technology. How relationships are perceived and evolve is going to be largely dependent on the context on which they are deployed. As in ecological systems, symbi(AI)tic relationships will usually not occur in isolation: they will be part of larger systems and networks.

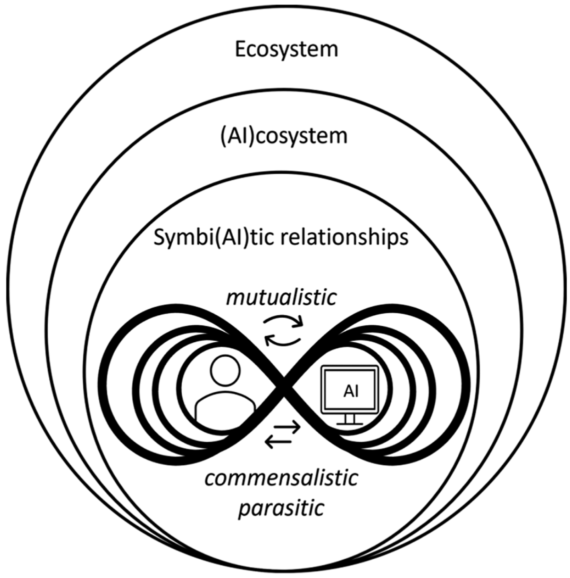
5.2. (AI)cosystem

It is likely that symbi(AI)tic relationships (humans with AI) will mostly be formed within larger systems, which we call (AI)cosystems. An (AI)cosystem is understood as a network of symbi(AI)tic relationships that sit within the context of a data ecosystem [93]. All beings in the (AI)cosystem will receive inputs and outputs from each other, influenced by broader contextual factors related to human systems, institutions and networks, each with their own set of policies, rules, and practices. (AI)cosystems are likely to be complex and have different, interconnected levels: individual, institutional, governmental, and include mobile networks.

(AI)cosystems may be open or closed. In an open (AI)cosystem, the network is connected to other (AI)cosystems and transactions and learning can occur across systems. In an ideal world, a mutualistic open (AI)cosystem will revolve around an intricate network of GenAI in which human and machine are fully interconnected globally and all agents are mutually benefitted. In a closed (AI)cosystem, AI is isolated from input from other GenAI systems: it acts independently and only learns from the humans who have access to it. For example, a school may buy a closed AI-driven LMS that processes information in "private." This system will certainly keep student data private but loses the capacity to learn outside of the system and take advantage of large data systems and LLMs. As this (AI) cosystem does not contribute to overall learning of other LMS systems, it may be commensalistic: it wins but the other systems from which it is gleaning information do not, though they are unharmed. In an extreme case, this relationship may become parasitic if there are few or no systems providing information, thus diminishing the system and causing harm.

Figure 1 illustrates how most symbi(AI)tic relationships will be entangled in complex knowledge and production systems in which GenAI has significant agency. The diagram illustrates the disruption

Figure 1
A diagrammatic representation of symbi(AI)tic understandings



to our current anthropocentric notions of productivity that conceive these technologies as just instrumental tools.

Though conceiving GenAI as a technological being or "species" with agency may be disputed, we speculate that it, as part of these complex human and non-human systems, will increasingly become its own entity with agency quite apart from humans and function in ways increasingly integral to human communication, work, and leisure. We consider this likely, or at least plausible, in a future with increased computing power, and more sophisticated training of LLMs and large multimodal. Although AI applications may not embody the usual notions of consciousness, volition, and feelings [80], we consider that they are going to be perceived as having them. This being the case, we propose that having an understanding of symbi(AI)tic relationships and how they operate in (AI)cosystems is going to be essential for educators and their students. This relational and fluid notion of interacting with technology will need to supplant current static models, frameworks, and human-centered conceptual understandings.

5.3. Possible applications of symbi(AI)tic understandings

From our critical dialogic inquiry, we propose that an awareness and understanding of symbi(AI)tic relationships within (AI) cosystems will allow educators and students to ethically and practically relate to and collaborate with GenAI toward future needs and possibilities. This relationality includes awareness of how it operates at the micro level of the human–GenAI and at the macro level of human–machine systems.

In doing so, the technology may be recognized as akin to a human partner in a relationship: a relationship that transcends simple utility and operates within human systems. In ethical terms, moving away from seeing GenAI as a mere tool and giving it the status of partner allows it to be understood (much like a human partner) as capable of biases, hallucinations, and misinformation [94]. These understandings can afford educators the perspective from which to better manage their expectations of these technological relationships as they continue to evolve and promote awareness of how to foster an effective creative and productive partnership with GenAI. Part of this awareness is adopting the thinking of the symbi(AI)tic to understand the affordances and limitations inherent in the technology, especially in the type of complex symbiotic relationships that emerges for each person who interacts with GenAI.

In our dialogic inquiry as education researchers, we imagined and speculated about many scenarios related to education, three of which are presented below.

5.3.1. Scenario 1: Tutoring

An example of pre-emptive boundary setting through applying symbi(AI)tic understandings is the case of a GenAI tutor [95] for the learning of a vulnerable, anxious primary-aged child. The use of GenAI as an omnipresent personal tutor privy to very private information about the child raises questions about dependency and who has agency. This dependency may impact the teacher who depends on the role and intervention of GenAI and the child whose learning is highly contingent on it. In this example, the GenAI tutor has (perceived) control over both the child and the teacher. Although this may be positioned as a mutualistic relationship with many affordances for learning and creative production, it may become parasitic if its agency increases, and monitoring becomes more invasive. For example, if the GenAI tutor is "sent home" with the child for homework, the dependency for the child could become greater and even extend to the child's parents. The GenAI tutor is now a powerful conduit between school and home. Furthermore, if communication between home and school is limited, the teacher may put their trust in AI-driven learning analytics, giving it additional agency. Appropriate boundary setting may mean generative AI tutors are siloed: the child has a different GenAI tutor for school and home, thus distributing the agency between two GenAI tutors and mitigating dependency.

5.3.2. Scenario 2: University education

A second example of applying this symbi(AI)tic thinking is in university education [96]. GenAI would be operationalized at an overarching or macro level within the interactions and intersections of two large systems: that of the GenAI provider and the policies and provisions of the university. At the micro level, students completing an assignment can use GenAI within the boundaries of university policy and the inherent possibilities of the AI system to engage with GenAI as a mutualistic partner in the development of the assignment, where students employ the technology critically and with awareness of ethical boundaries and the agency of GenAI in the relationship. However, it is also possible that GenAI could become parasitic in the relationship if there is undue dependence on GenAI as an agentic creative partner, potentially leading to issues about authorship and ethical use of AI [53]. In this instance, the agency of the GenAI has supplanted that of the human.

5.3.3. Scenario 3: Surveillance

When a mutualistic relationship is identified, the human partner can aspire to collaborate with the GenAI partner to enhance the benefit for both partners, rather than trying to compete with it. When a commensalistic symbi(AI)tic relationship is identified, however, the interplay is less collaborative as only one partner benefits. In a commensalistic relationship where the AI has the net benefit, the interplay may position GenAI as the controlling agent and might be perceived as parasitic for some. For example, an extensive AI-driven surveillance system within a school or other educational organization that analyses data for a leadership team may be considered mutualistic by leadership and commensalistic by educators, especially if they are unaware of its existence [97]. However, once educators become more aware of the surveillance, or the data is used against them, this relationship may start to feel like an invasion of privacy and therefore be perceived as parasitic. In understanding the likely evolution of the relationship with GenAI, leaders may pre-empt the ethical consequences by being transparent in their assessment of trustworthiness of the data. They may also set clear boundaries as to the use of the data.

6. Discussion

Our notion of symbi(AI)tic relationships within (AI)cosystems introduces new understandings that provoke critical examination of the roles that GenAI may play in education in the wake of significant technological change. Our symbi(AI)tic understandings draw on both ecological thinking and posthumanism to reconsider the complex relationships that will entangle humans and AI technologies now and into the future. The notion of symb(AI)tic is ecological in employing symbiosis as a relational and transactional analogy. It is posthuman in that it disrupts anthropocentric thinking: it conceives the human as part of networks of communication and production alongside GenAI, and part of broader human and technological ecosystems. While symbi(AI)tic understandings offer a promising avenue for the enhancement of learning and being creative, with many possibilities open for educators and researchers in a range of educational contexts including teacher education, it also necessitates the acknowledgment of its ethical uncertainties and limitations.

Through the lens of symbi(AI)tic understandings, the anthropomorphizing of technology may be considered an issue because it assumes correspondence between human cognition and sense of being, with its notions of sentience and feeling states, with that of a machine [98]. While we acknowledge arguments against positioning GenAI as "beings" and in symbi(AI)tic relationships, at the same time, we think that the emergence of GenAI raises fundamental questions about the nature of technology as an agentic entity and its place in the human world with sentient beings. Scholars such as Barad [89] suggest, as we do, that all material is agentic and shapes humans and society, just as technology is shaped in human interaction. Thus, our symbi(AI)tic understanding of agency and the sense of GenAI as "person" or "species" reflect this attribution but takes it further to combine agency with relationality [55, 99].

Ihde's [18, 45, 46] concept of alterity in the context of technology also supports the idea of a co-agentic relationship where GenAI technologies are perceived as substantive "other" to humans, with their own set of non-human, non-biological characteristics that can influence human experience and perception, as well as how humans can be creative and productive. This perspective is pivotal in understanding the active and reciprocal nature of technology and how it embodies roles or identities that interact with humans beyond the limited metaphor of seeing technologies as tools [18, 100]. With the launch of GPT-4o there is a signal that OpenAI[5] is engendering more fluid and natural interactions between humans and AI, and in other versions of generative AI, such as Claude, the same shift is evident. In this latest iteration of the technology, humans can input text, audio, image, and video and receive similar outputs with human-like quality, including natural voice interactions. Our onto-epistemological thinking in this article (the being with and knowing about AI) accounts for the evolution and fluidity of

[5]OpenAI. "Hello GPT-4o." May 23, 2024. https://openai.com/index/hello-gpt-4o/

GenAI and the ways that it will form human experiences (and be form) and hybridities of working with it into the future.

While symbi(AI)tic understandings offer innovative ways of thinking about GenAI in education, they do not solve the complex array of ethical considerations and practical challenges that are associated with the introduction of GenAI in educational settings. They may, however, serve to clarify the need for them. The success of creating a mutualistic (AI)cosystem hinges on a balanced approach that respects the strengths and limitations of both human and artificial intelligences [101]. Although educators might navigate this partnership with discernment and foresight, they are unlikely to be able to predict the complexities of future (AI)cosystems, as is the case for all ecosystems. GenAI is, after all, not a singularity but a multiplicity: there are going to be many different applications of this technology across the spectrum of society and in education, which are being introduced in quick succession and then evolving rapidly. We argue that the concept of symbi(AI)tic understanding might provide educators, policymakers, industry leaders, and researchers better clarity about the possibilities and challenges of AI into the future.

7. Conclusion

In this article, we have explored a new onto-epistemology approach to how we understand GenAI in education (and beyond) through a dialogic inquiry that went to the speculative in engaging with change futures. Our notion of symbi(AI)tic understandings draws from ecological thinking and posthumanist perspectives, to proffer a relational and transactional perspective about humans with GenAI technologies. We envision symbi(AI)tic partnerships between educators, students, and GenAI that can range from mutualistic to commensalistic to parasitic. These understandings suggest the needs for a paradigm shift from static, instrumental views of technology, that effectively disconnect human experience and activity from the technologies they employ, to dynamic, relational engagements that reflect the complex interdependencies and hybridities possible in an increasingly digitized educational landscape where AI technologies are becoming centralized.

The implications of this symbi(AI)tic approach to conceptualization are many. It encourages educators to reimagine their roles in AI-integrated learning environments, where embracing GenAI not just as a fancy tool but as a creative partner in the educational process as part of thinking about design for learning. This re-envisioning can lead to a range of new possibilities for learning that have applications in classrooms, teacher education, and more broadly across education and industry. This onto-epistemological approach may allow educators, institutions, and governments to better understand the considerable possibilities as well as the limitations of GenAI as a learning and productive technological partner. We note concerns about stripping students, educators, and parents of their agency and the problems of dependency, necessitating careful assessment by reflexive educators as to the transparency and trustworthiness of the AI, now and in the future.

In presenting the concept of symbi(AI)tic understandings, we acknowledge its limitations. We understand that in describing GenAI as technological "beings" or a "species" with agency we are not aligned with how beings and agency are often understood in current educational and societal contexts where human-centric understandings tend to prevail. We also understand that we are not any closer to offering practical ways in which ethical standards, such as trustworthiness and transparency, may be achieved. Issues of bias, privacy, hallucinations, and authorship must be carefully navigated to ensure that the reliance on these technologies does not undermine human agency or the authenticity of educational experiences. We assert, however, that using symbiosis as a powerful analogy will be more useful to educators, policymakers, and researchers than the current static understandings of technology often touted in education and beyond.

In centering the human–GenAI relationship in a complex (AI) cosystem that sits within wider social, economic, and educational ecosystems, a more dynamic way of understanding technological change is possible. As we move to futures unknown, educators might consider engaging with GenAI in ways that respects human uniqueness together with its potential, promoting a balanced and ethical integration of technology in education. It allows for understanding of how mutual relationships may evolve in time, thus enabling pre-emptive boundary setting and evaluation of ethical issues. Ultimately, we advocate for mutualistic relationships that leverage the strengths of all partners, human and non-human. Such understandings, while not without their challenges, hold the promise of a more responsive, adaptive, and enriching approach to learning and creative production. This being the case, empirical research is needed to establish how these symbi(AI)tic understandings might operate in a range of environments where GenAI and humans are strongly integrated.

Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

Data Availability Statement

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

Author Contribution Statement

Edwin Creely: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, & Project administration. **Kitty Janssen:** Conceptualization, Methodology, Software, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization.

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