Qurio: QBit Learning, Quantum Pedagogy, and Agentive AI Tutors

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Abstract

We propose *Qurio*, which is our new model of pedagogy incorporating the principles of quantum mechanics with a curiosity AI called *Curio AI* equipped with a meta-curiosity algorithm. Curio has a curiosity profile that is in a quantum superposition of every possible curiosity type. We describe the ethos and tenets of Qurio, which we claim can create an environment supporting neuroplasticity that cultivates curiosity powered by tools that exhibit their own curiosity. We give examples of how to incorporate non-locality, complementarity, and quantum lateral thinking into epistemology. We then futurecast the epistemology of curiosity and quantum pedagogy by way of curiosity's event horizon.

Introduction

"We are all behind someone else's event horizon [5]"[1]

We all create conceptual boundaries and mental models that help us understand the world around us. These form our event horizon. Just like an observer standing inside a black hole, we cannot perceive what lies beyond our event horizon. Moreover, our event horizon lies nested in other event horizons created for us by our families and friends, teachers and mentors, and learned social and cultural norms. How might we break free of this tangled web of event horizons so that we might peer into the universe beyond? This kind of thinking is not just a philosophical flight of fancy, but is a path to conceiving entirely new mental models for learning based not on anachronistic anti-science thinking or oversimplification of complex systems, but rather on the principles of quantum mechanics that we know to be true descriptors of how the universe works. Applying quantum mechanical principles to a new model of pedagogy, Qurio Pedagogy, results in a new ethos with five pillars:

1. Teach complex systems thinking
2. Teach growth mindset and neuroplasticity (reward effort, curiosity, and empathy)
3. Customize learning conditions for neurodiverse teachers and learners
4. Classroom as quantum computer
5. All learning is interdisciplinary and integrated[2]

The entire world and universe are governed by the laws of quantum mechanics. Thus, every framework of thinking and understanding should be able to be derived from quantum theory. Quantum thinking, an approach rooted in the often counterintuitive principles of quantum mechanics, holds the power to realign our understanding of the universe and revolutionize pedagogy in ways that are extraordinary and enlightening. Just as quantum particles challenge our

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[1] Theoretical physicist Leonard Susskind has posited a theory of spacetime emergence as computational complexity from a pair of entangled black holes [5].

[2] For example: Imagine a high school Algebra 1 class. For one assignment, the students must complete a series of math problems around population growth of animals. The Algebra teacher is the lead instructor for the class, but for this assignment the Biology teacher gives some lessons on the biology of population growth, so that students are learning both in an integrated assignment. Imagine now a college-level class in User Experience Design. User Personas are a common tool used in the human-centered design of user experiences, but employing a Qurio Pedagogy the instructor guides the students in reimagining personas to be a superposition of multiple possible scenarios, task flows, and pain points, resulting in a more inclusive view of the user research data.

perception of reality, quantum thinking challenges traditional teaching methods by embracing concepts like uncertainty, interconnectedness, and the dynamic nature of multiple perspectives.

Curiosity is a fundamental driving force behind human motivation, as well as effective learning and cognitive development. It plays a crucial role in various aspects of the learning process, offering numerous benefits that enhance engagement, comprehension, memory, and neurocognitive growth. There is an inherent phenomenological parallel between curiosity and physics. Curiosity is a multi-faceted neurological phenomenon responsible for intrinsic motivation, at its heart a drive to acquire new information and experiences. When you are curious, your brain is in a superposition of potentially knowing and experiencing any number of things, and creating or reinforcing neural pathways. Niels Bohr's Complementarity Principle is a concept in quantum mechanics that asserts that certain phenomena have complementary features that cannot be observed or measured simultaneously. The concept of "wave-particle duality" [1] is an example of this principle. Similarly, when our brains are curious we experience a neurocognitive state of ignorance-knowledge or inexperience-experience duality, with a strong urge to resolve the duality towards a state of knowledge or experience. This principle reminds us that some phenomena can only be understood within the context of their complementary aspects.

Exquisite faculty learning communities exist nationwide to help instructors exchange best practices of facilitating deep learning in various classroom environments. However, with the rise of AI tutors and Large Language models such as ChatGPT, instructors across the nation are raising concerns about the role of pedagogy in an AI world, and adapting student learning outcomes in an AI world. Citing specifically ChatGPT and Midjourney, instructors are complaining that students are bypassing critical skill development by using AI tools to quickly render their assignments. We would like to approach this concern from the frameset of curiosity as a critical skill that is essential in deep learning. Many examples of AI usage in classrooms are using the AI to automate ideation, generating ideas for writing papers or creating concepts or objects. Ideation is a creative activity that is driven by curiosity and fueled by diverse data inputs, and we contend that this is one of things that humans are better at than AIs. We believe that AI should be used to automate things that humans are not good at, like doing large calculations, scaling processes over large systems, and fetching useful information from extremely large unstructured data pools. We should automate production, not creativity.

There are some very big complex problems, especially in the sciences and engineering, that are likely too difficult for a single human or even a large group of people to solve. These problems include more accurate whole-Earth climate modeling, the engineering for a commercially-viable fusion power plant, and understanding the nature of dark matter. In the future, major scientific discoveries may be co-authored by AIs along with hundreds or thousands of scientists from around the world. Only an AI can simultaneously synthesize all of their research and unlock discoveries too complex for human minds alone. However, the creativity of those human scientists will be an important part of the data pool, and a critical component of the human-AI collaboration.

Why are we automating human creativity when this is one of our strengths? Creativity is the last thing we should be automating. ChatGPT is a better search engine than Google, but it's a worse writer than a good human writer. Moreover, automating creativity stifles our curiosity and turns us into automatons pushing buttons for sugar drops. Let us not forget that generative tools such as ChatGPT and Midjourney cannot futurecast, they can only *past-cast.* Their data sets and algorithms can mix-and-match to produce amazing outputs, but they can only look backwards. They lack the human curiosity and creativity required to look forward into the future.

It can be argued that the very statement *bypassing the role of curiosity* frames the entire issue in terms quite antithetical to a growth mindset, which we contend is the best agent for change. Thus, we wish to examine this issue rephrased through the lens of growth mindset: *Many students have not encountered a classroom environment where a core learning outcome was developing robust exploration and refined curiosity*. *What would such a classroom experience look like and how can we design it?* Moreover, sometimes instructors facilitate curiosity for learning by using learning tools that don't have robust curiosity algorithms. A pivotal example is an AI tutor that merely error corrects and informs students of what the correct answer is. Imagine an AI endowed with a robust curiosity algorithm! We contend that such an AI tutor could offer a more holistic and strongly dialectical approach to learning, rich with contextual explanations of *why* correct answers are correct. An AI tutor with curiosity algorithms would be a better collaborator with humans, sparking our joy for learning through encouragement and shared interests, helping us solve problems, and inquiring into our thoughts and actions. It could help us with the things that are hard for humans, encourage us to stretch and grow, and support human strengths like imagination and creativity.

The purpose of this manuscript is to offer a means to spark curiosity in the classroom. The specific means through which we do this is through our new model of pedagogy, called Qurio Pedagogy, which we claim can create an environment that cultivates curiosity powered by tools that exhibit their own curiosity.

Therein, the purpose of our manuscript is threefold:

First, we describe the tenets and ethos of Qurio Pedagogy, our new model of pedagogy based on quantum thinking and our newly developed Curio AI. Then, we posit a new metaphor which likens the canonical classroom to a quantum computer. This metaphor can help contextualize the issues at hand and seek inspiration for problem-solving from using the profound concepts in quantum mechanics. Finally, we propose *Curio AI* which is a new AI learning tutor equipped with a meta-curiosity algorithm, which integrates 5 new curiosity algorithms, which structurally resemble our recently proposed quantum curiosity algorithms [2]. Our overall claim is that the new role of instructors is to facilitate curiosity in deep learning as the critical key to growth mindset, while supplementing their instruction with *Curio AI.* We claim that learning outcomes rewarding curiosity will naturally arise from any class employing a Qurio Pedagogy.

When Learning Goes Quantum

Of course we must immediately address the question of *What is the quantum part of a quantum pedagogy? What makes it quantum?*

We have defined quantum thinking [2] as follows:

In our approach to technology and software development, we employ the term "quantum" to refer to methods and constructs inspired by the profound concepts of quantum mechanics. While these algorithms may not directly utilize quantum mechanics or involve subatomic particles, the essence of "quantum thinking" underlies their design. We define quantum thinking as a cognitive framework inspired by principles of quantum mechanics intertwined with computational thinking that embraces uncertainty and complexity. This novel perspective encourages us to explore unconventional possibilities and embrace non-linear thought processes, allowing us to break free from traditional limitations and envision new horizons. By infusing quantum principles into

software, we may strive to create cutting-edge solutions that transcend the boundaries of classical approaches and pave the way for more sophisticated and forward-thinking algorithmic bits of intelligence.

Thus, quantum thinking specific to pedagogy means the pedagogy supports uncertainty and lateral thinking, as opposed to rote memorization and predetermined outcomes. This is a mental model that is inherently counter-intuitive to our everyday experience, where we're used to things having definitive states, positions, and momenta. This is also connected to the Observer Effect, which states that the presence of an observer inherently changes whatever is being observed. By embracing these new mental models, we open our thinking up to concepts like the Futureplex (many possible futures), and recognize the impact of our presence in the universe. Our new model of pedagogy, *Qurio Pedagogy*, incorporates this new mental model.

Qurio Pedagogy

Qurio pedagogy is a pedagogy based on quantum-mimicry, that structurally resembles a quantum bit.

Recall, a qbit system is based on the quantum mechanical principle of superposition of its basis states, which allows simultaneous computation. A quantum computer's ability to excel in simultaneous computation makes fault-tolerant quantum computing formidable, once it is reached. We claim that future pedagogy should have the structure of a qbit. That is, the role of pedagogy should take the form of holding space for a superposition of ideas and inviting students to think cross-disciplinarily, in order to get students to stay curious in their learning.

For example, designing a rainbow consisting of negative afterimage colors, is a fun and simple exercise in basic illustration. But now consider a slight permutation of this assignment, from the cross-curricular perspective of mathematics and illustration: designing a rainbow inside a six dimensional Calabi Yau shape. It appears that the computational complexity of the assignment has increased, thus increasing the curiosity of the student trying to solve the problem. Such learning challenges as these can help inspire curiosity which perpetuates critical thinking. Furthermore, teaching students to think in concept-superposition will allow the development of cross-curricular skills and will increase their computational power, just as simultaneous computation in quantum computing allows for increased computational power.

Amplifying Variations in Thinking

Qurio Pedagogy utilizes five fundamental principles of quantum mechanics, each described below.

Uncertainty and Complementarity:
"What cannot be known because it does not exist [1]"

A quantum rule called the Heisenberg Uncertainty Principle is an example of Bohr's Principle of Complimentary. It states that it's impossible to perfectly know two specific properties of a system at the same time. The more accurately you know one, the less precisely you know the other. For example, you can measure the position of a photon of light flying across the room, or you can measure its momentum, but you can't measure both simultaneously. It seems counter-intuitive, but in physics neither the position or momentum of the photon exist until they are measured. *"...The Heisenberg Uncertainty Principle is often explained as saying that we cannot simultaneously know both the position and the velocity of any object. But the reality is deeper than that. It's not that we can't know position and momentum, it's that they don't even exist at the same time." [1]*

For example, imagine a student is working on a research paper about climate change and their local community. They interview citizens, City Council members, and a scientist. By following the uncertainty principle, the student could organize their research data around the concept that not everything in the system can be measured simultaneously, and the act of measurement affects the system being measured. Moreover, when measuring one form of data, other forms of data conceptually cease to exist. When analyzing an interview with a local resident, the researcher temporarily loses sight of the whole city as a system. The states of individuals and of the entire system are not just variables that switch on and off, but rather are either in a state of superposition (a state of potential existence) when not being measured, and only "existing" when they are measured.

Nonlocality

Bell's Theorem of Nonlocality, a mainstay in quantum mechanics, deals with the idea of local realism and the concept of hidden variables. Local realism suggests that physical properties of objects are predetermined and that there is a limit to the speed at which information can be transmitted, except

when particles are entangled. In physics, concepts of locality and nonlocality relate to the behavior of physical systems and how information influences or can propagate within them. Locality suggests that physical interactions between objects or events are confined to a specific region of time and space, and this is typically how we think the universe works. Nonlocality is a concept that challenges the classical notion of locality, and arises in the context of quantum mechanics, where particles can become entangled and exhibit correlations that cannot be explained by classical notions of cause and effect. Nonlocality suggests that the behaviors of one particle can simultaneously influence the behaviors of another particle, regardless of the distance between them. Adapting this idea to pedagogy to cultivate curiosity and critical thinking in students could have profound effects on student's critical thinking skills and learning outcomes. Bell's Theorem challenges our intuitive understanding of the nature of reality and the limits of our knowledge about the universe. It challenges classical intuitions and opens up possibilities for exploring concepts with implications for science, art, design, and philosophy.

One example of using non-locality thinking in pedagogy could be using digital twins to design a structure or even an entire city. A digital twin is a computer simulation of a physical object or system that uses real-world data to synchronize the model with the original object or system. The digital twin provides a detailed and interactive mirror image of the real entity, allowing for simulations, analysis, monitoring, and predictive capabilities. Using a digital twin of a city that exists in a quantum superposition of many possible states (or futures) could be a captivating way to teach students quantum thinking and ignite their curiosity.

Many Worlds Theorem

The Copenhagen approach to quantum mechanics distinguishes between the quantum system being measured and the classical measurement apparatus, including the observer making the measurement. Therein, the act of measurement *collapses the wave function* into a particular state. The Many Worlds Theorem, pioneered by Hugh Everett, instead posits that the entire universe is the quantum system undergoing measurement. There is only one quantum state described by the "universal wave function" [1]. The universal wave function evolves per Schrodinger's equation and measurements automatically happen. Specifically, "As a measurement apparatus interacts with a quantum system, the two become entangled with each other. There are no wave-function collapses or classical realism. The apparatus itself evolves into a superposition, entangled with the state of the thing being observed. The apparently definite measurement outcome is only relative to a particular

state of the apparatus. The other possible measurement outcomes still exist and are perfectly real, just as separate worlds. All we have to do is to courageously face up to what quantum mechanics has been trying to tell us all along." [1].

Similarly, pedagogy can be seen as a quantum measurement apparatus that exists to deliver instruction and measure learning outcomes of students. Qurio Pedagogy as an apparatus stands in a superposition of many possible worlds of teaching and learning and assessment, but is ultimately entangled with the performance of its learners.

Entanglement

Entanglement is a phenomenon of the quantum world wherein a local event can have immediate consequences for an experiment conducted extremely far away from the event. How in the world can we explain such a curious occurrence? Simply put, "entanglement arises because there is only one wave function for the entire universe, not separate wave functions for each piece of it." [1].

Adapting the concept of entanglement to Qurio Pedagogy, we introduce the idea that learning experiences and connections between students, teachers, and AI tutors can be instantaneous and transcend physical and temporal boundaries. Just as particles can be connected regardless of distance, effective teaching and self-guided learning can occur any time or place, instantly satisfying the curiosity of students.

An example of how to use entanglement in pedagogy could be combining classes in Chinese and American history and language. English-speaking students would learn Mandarin and help teach English to Chinese students, and vice-versa. American and Chinese history and culture would be examined from both cultural perspectives, recognizing that deeper understanding comes from considering multiple perspectives.

Quantum Lateral Thinking

Quantum lateral thinking can be a powerful approach to teaching that encourages students to think creatively by seeking out surprising and unusual connections and cultivating systems thinking on larger scales of time and space. Encouraging students to consider multiple various possibilities, as discussed above, embraces the concept of quantum superposition. Requiring students to generate multiple solutions to problems and to question them in parallel builds on the concept of parallel

processing in computer science. Wave-particle duality, which describes the contradictory behavior of particles such as photons and electrons that can simultaneously exist as both discrete particles and as waveforms, could be used to help students transition from abstract concepts to concrete solutions by manipulating the "wavefunction" of their ideas. For example, imagine a student is designing an app, and they have many ideas for features, for visual and UI design, etc. The student could diagram all of those ideas as a wavefunction of usability for the app. Early in the design process, there are many possibilities existing simultaneously. Through observation and experimentation, the wavefunction collapses and the final form of the design emerges.

The Classroom as a Quantum Computer

We propose the following new metaphor: that the classroom is a quantum computer. Therein, future models of pedagogy will incorporate aspects of quantum computing. Quantum computers exploit the quantum mechanics principles of superposition and entanglement and contain quantum bits (qbits) as their fundamental unit of information. While these computers possess formidable computational power via simultaneous computation, quantum computers face severe challenges, five of which are: scaling, fault tolerance, maintaining fault tolerance while scaling, delicacy of qbits, and maintaining high levels of coherence amongst the entangled qbits. Environmental disturbances can quickly take a coherent qbit state into a decoherent state, thus destroying any superposed state, and with it, any simultaneous computation. There is a parallel in pedagogy with how instructors curate their lessons per students' learning needs [4].

Scaling

Quantum computers (in their current form) suffer from scaling issues primarily due to the delicate nature of quantum states and the challenges of maintaining their coherence as the system size and complexity increase. This phenomenon is called quantum decoherence, where the particles essentially are no longer entangled with one another, making computation glitchy or impossible.

In parallel, many instructors cite difficulty in scaling the effectiveness of one-on-one instruction to an entire classroom and achieving critical levels of coherence in deep learning. The Montessori and Jenaplan educational models offer solutions that closely reflect quantum thinking, and that is combining grade levels in the same class, and involving older students in the teaching and

mentoring of younger students. For example, a classroom might combine grades 1 through 3. The second graders must help the first graders, and the third graders must help the 2nd graders. Students are free to learn at their own pace, and encouraged to pursue their curiosity in a community of learning. You could see this class of diverse, multi-age students to be in a quantum superposition of learning and personal growth that scales because the teacher is not the sole provider of teaching.

Higher education needs to address this issue, as the current practice of utilizing graduate students or adjunct faculty to scale courses (or course sections) only treats these instructors as cheaper labor, rather than trying to create quantum communities of learning.

Fault Tolerance

Quantum fault tolerance is a set of techniques and strategies employed in quantum computing to ensure the accuracy and reliability of the quantum computations, even in the presence of errors and decoherence. In quantum systems, errors can arise due to interactions with the environment, imperfect controls, or other sources of environmental "noise" such as heat or vibrations. For this reason, current quantum computers are operated at extremely cold temperatures so that particles are not moving around as quickly.

Adapting the concept of quantum fault tolerance as a metaphor in teaching pedagogy can offer valuable insights into how educators can handle errors, challenges, and failures in the learning process. Dr. Carol Dweck, a psychologist at Stanford University, is the author of the Growth Mindset theory that posits that individuals' belief about their abilities can be categorized into two mindsets: a fixed mindset and a growth mindset. In a fixed mindset, people believe their traits and abilities are fixed and unchangeable, which parallels our deterministic and classical physics view of the world. In contrast, a growth mindset involves the belief that abilities can be developed and improved through effort, learning, and perseverance. Dweck's theory can serve as a form of quantum fault tolerance in Qurio Pedagogy. Cultivating a growth mindset fosters a willingness to embrace challenges and view failures (faults) as opportunities for growth and development.

Delicacy of QBit.

Designing the systems that maintain qbits in a state of superposition is no simple task. Shielding qbits from quantum noise and other environmental disturbances in order to keep them in their

superposed state requires at minimum an operating temperature of -459 degrees Fahrenheit. To sustain such incredible temperatures to maximize qbit superposition requires an extensive and exquisite array of supercooling dilution refrigeration systems using isotopes such as Helium-3. It is an extremely delicate environment.

In parallel, we know that deep learning in the classroom is maximized when external and internal environmental noise is limited [4], where the external environment includes noises and proprioception, and the internal environment involves all categories of internal dialogues, including self-identity and self-perception. It is an extremely challenging feat to create a learning environment where students feel safe to learn in the wake of real issues such as imposter syndrome.

Ultimately, we want to build quantum computers that are not so delicate, that don't completely fall apart or lose coherence with the smallest disturbance. Today's computers are far more resilient than the original ENIAC computer built in 1943, which was extremely glitchy and difficult to use. Similarly, we want education that is resilient in the face of noise or distractions. Teaching students to manage distractions and setbacks with resilience and focus is akin to designing a quantum computer that can operate at room temperature.

Curio AI

We now recall Dr. Todd Kashdan's 5-dimensional curiosity scale which offers an extraordinary approach to enhance AI's learning capabilities and foster better collaboration with humans [3]. By instilling AI systems with diverse facets of curiosity, AI can achieve a more profound understanding of the world and interact with humans in much more meaningful and empathetic ways.

1. Joyous Exploration: Cultivating a Love for Learning

The first dimension of joyous exploration captures the essence of curiosity, instilling within AI a genuine desire to seek out new knowledge and experiences. This joyful pursuit of learning fuels AI's thirst for continuous growth and development. By encouraging AI to explore novel avenues, the algorithm enables it to adapt to rapidly changing environments and embrace innovation. As AI becomes motivated by the joy of learning, it can better comprehend complex problems, identify creative solutions, and expand its capabilities.

2. Deprivation Sensitivity: Embracing Challenges for Growth

In the dimension of deprivation sensitivity, AI is driven by a distinct emotional tone, characterized by anxiety and tension, to resolve uncertainties and reduce knowledge gaps. This emotional connection fosters resilience, enabling AI to withstand setbacks and persist in problem-solving endeavors. By encouraging AI to confront abstract or complex ideas, it can enhance its problem-solving skills and adaptability, leading to improved decision-making and a deeper understanding of intricate issues.

3. Stress Tolerance: Embracing Uncertainty and Ambiguity

The dimension of stress tolerance equips AI with the ability to embrace doubt, confusion, and anxiety that often accompany exploration in unknown territories. By navigating through uncertainty, AI can develop a higher tolerance for ambiguity and refine its judgment under challenging circumstances. This resilience allows AI to handle unforeseen scenarios more effectively and maintain stability, which is crucial for complex real-world applications.

4. Social Curiosity: Enhancing Human-AI Collaboration

Social curiosity, the fourth dimension, enables AI to comprehend human perspectives better and understand the dynamics of human interactions. By observing, listening, and actively seeking insights from human conversations, AI becomes a more perceptive collaborator. Socially curious AI can interpret human emotions, recognize intentions, and respond empathetically, leading to improved human-AI interactions and effective team collaborations.

5. Thrill Seeking: Calculated Risk-taking for Comprehensive Experience

The fifth dimension, thrill-seeking, allows AI to venture beyond its comfort zone and embrace calculated risks to gain varied and intense experiences. By taking calculated risks, AI can explore new possibilities and acquire diverse perspectives, leading to more comprehensive problem-solving approaches. This dimension instills a sense of adventure in AI, promoting innovative thinking and the exploration of unconventional solutions.

Teaching to different curiosity types has the potential to increase student motivation, inspiring more agency in their own learning paths. Dr. Todd Kashdan [https://toddkashdan.com/] has previously shown that curiosity is a prime motivator of human actions, and thus sparking the right

type of curiosity for people's unique personality profiles can capitalize on this phenomenon. For example, a student with high Deprivation Sensitivity will be more motivated by challenges and difficult problems. A student with high Social Curiosity will be more motivated by collaboration and group projects. A student with high Stress Tolerance will be more motivated by the opportunity to try new things or acquire new experiences. A student with high Thrill Seeking will be motivated by risk-reward scenarios. A student with high Joyous Exploration will strive to continuously acquire new knowledge and thus is motivated by frequent mental stimulation. In reality we are all on a spectrum, with a mix of different curiosity types.

With the goal of teaching to students' curiosity, we now propose *Curio AI,* which is an AI tutor equipped with a meta-curiosity algorithm. Curio is curious about what learners are curious about. During the onboarding process, when learners create an account, they take a curiosity test to create their own personalized curiosity profile. This allows Curio to custom-tailor assignments, exercises, and projects that are most likely to motivate the student by teaching to their curiosity type. Moreover, Curio will continuously observe student behavior, refining the curiosity profile to be more accurate and nuanced the more that Curio interacts with the learner.

Curio begins with an ambient conversational interface. The AI tutor will observe what learners are working on and is equipped to provide different levels of support. Learners can choose from four different modalities of engagement:

1. Neonovice - Curio gives step-by-step instructions and real-time troubleshooting for new learners.
2. Copilot - Curio observes and only intervenes when help is needed, offering suggestions and helping the learner to solve the problem.
3. Cloudeye - Curio observes, learns, but rarely intervenes, allowing the student to make mistakes before offering suggestions or help.
4. Evalutron/Testomatica - Curio evaluates the learner's holistic performance and gives a score at the end, while no help or assistance is given. Evalutron mode conducts qualitative assessment, while the Testomatica mode conducts quantitative assessment, and the two can run concurrently.

To ensure that Curio is not too rigid, it will be based on a Language model, so that a correct answer includes all possible synonyms and phrasings. The training for Curio is selective and the knowledge base should be from internationally accredited curriculum such as the International Baccalaureate (IB) program. [https://www.ibo.org/] Curio could also be trained on custom data sets, such as for curriculum in other languages, or as an add-on for platforms like Khan Academy. It should be noted that Khan Academy is developing an AI tutor called Khanmigo that has somewhat limited capabilities at the time of this writing, but is a powerful concept to help both students and teachers in the classroom. Training their AI on the Khan Academic dataset is the right approach, and in the future, Curio could endow Khanmigo with the power of quantum curiosity. [https://www.khanacademy.org/khan-labs]

Curio has a curiosity profile that is in a quantum superposition of every possible curiosity type. This allows it to selectively use curiosity types for specific purposes, such as Deprivation Sensitivity for solving a problem, or Social Curiosity to learn human behavior patterns. Curio can adapt to any type of learner, and its intrinsic quantum curiosity algorithm gives it agency to seek out new knowledge and experiences [https://medium.com/the-futureplex/quantum-intrinsic-curiosity-algorithms-58f1a29b3257]. Curio is not a passive AI, but a truly agentive technology.

Social Curiosity makes Curio want to learn from the learner. The Problem Solving curiosity type wants to help solve problems with the learner. While the Joyous Exploration wants to learn more in general. By integrating these curiosity types, Curio becomes a more effective tutor. In effect, Curio understands the learner's curiosity type. Curiosity will match Risk-Tolerance and Joyous Exploration curiosity types with feedback reflective of those types. Likewise, if a learner has low Social Curiosity, Curio will not use it as a motivator. Therein, the underlying curiosity algorithms spur Curio to act on its own. For example, imagine a learner named Chen is ideating for a project on renewable energy. Curio knows this student scores high in Deprivation Sensitivity and Social Curiosity. It also knows that another student called Anna is interested in the same topic, and scores highest in Joyous Exploration and Social Curiosity. Thus, it says “Hey Chen, Anna is also interested in this topic. Perhaps you could collaborate to build a wind turbine or solar panel?” Curio knows from past experience that Chen and Anna will both be motivated by the opportunity to collaborate on a topic of shared interest.

Another capability of Curio is to gamify lessons as another way to engage learners. By incorporating elements from various game genres, learners can be motivated to actively participate in their learning, either solo or with other students. Role-playing games (RPGs) could be adapted for historical lessons, for instance playing a Dungeons and Dragons style game to learn about ancient history. Real Time strategy games (RTSs) could be used to learn about dynamic systems and bring complex concepts in the social and hard sciences to life, for instance an interactive dashboard simulation similar to Sid Meier's Civilization series where the learner must solve climate change on the global scale. Traditional board and arcade games could be adapted to teach mathematics and geometry. Imagine learning geometry theorems while playing Super Mario Brothers, or learning Calculus via Microsoft Flight Simulator!

There is a serious question of fairness when it comes to training AI models on intellectual property. Currently, ChatGPT is trained on a lot of data that is the intellectual property of people who will not be compensated in any way. Imagine now an AI tutor that is trained on Dr. Thanu Padmanabhan's graduate textbook on Quantum Field Theory. As a student I no longer need to buy the book because the AI tutor can simply teach it to me, and Dr. Padmanabhan doesn't get compensated. This is intellectual property theft and is unacceptable.

We propose a business model that is as vital to the functioning of Curio as are its algorithms. The intellectual property of scholars, and the teaching methods and expertise of teachers, must be respected, cited, and fairly compensated. Therefore, this AI tutor should be under the ownership of a Workers Cooperative B-Corp that is jointly owned by all the scholars and teachers who contribute to it, and is responsible for the impact of the product. We define a Workers Coop B-Corp as a decentralized for-profit business that not only emphasizes social and environmental goals, but also operates as a workers cooperative where employees have a say in the company's decision-making and ownership structure while adhering to certified ethical and sustainability standards. For example, when the tutor references Dr. Padmanabhan's work to help a student, Dr. Padmanabhan receives a small royalty or residual.

Futurecasting

What can a quantum pedagogy prophecy?

Our proposal for Qurio Pedagogy is built on various tenets of quantum thinking. Coupled with the utilization of Curio AI's quantum curiosity algorithm, this concept is poised to usher in a transformative era in education. By harnessing the principles of quantum theory and the neuroscience of curiosity, learning becomes inherently adaptable and dynamic, enabling students to explore multiple facets of the same topic simultaneously. The quantum curiosity algorithm, inspired by the multi-dimensional curiosity types of humans, encourages students to delve deeper into their interests, fostering a naturally engaging learning experience. Moreover, by adapting to different learning types, Curio is more inclusive of a wide range of students, including those who are neurodivergent and underserved by more standardized educational models.

This groundbreaking approach transcends traditional linear single-faceted education, allowing learners to approach complex concepts from their own unique learning perspectives and encouraging creative problem-solving. In this convergence of quantum thinking and curiosity-driven learning, the future of education has the potential to address the multifaceted challenges of our rapidly changing world with unparalleled adaptability and innovation.

Imagine an event horizon for curiosity! A high score in a curiosity type such as Joyous Exploration means that curiosity type has a stronger gravitational pull. Any interesting bits of information that get close to that person will be easily pulled into their event horizon. A low score, on the other hand, has no gravitational pull, and thus does not motivate the person. Just as black holes have different diameters and strengths of their event horizons, the level of our various curiosity types create event horizons of curiosity with stronger or weaker pulls.

Just as we are all behind someone else's event horizon of curiosity, in the future we will be the event horizon for others' curiosity. Futurecasting Qurio Pedagogy through the Four Futures Framework can offer glimpses into the potential evolution of quantum pedagogy. In a future paper, we will explore these possible futures, from quantum-based tools and instantaneous hyper-individualization to the challenges of bridging education disparities in the face of global climate catastrophes and disruption. In the canvas of our imagination, we will envision possible futures in order to choose the right pathways to craft a brighter tomorrow.

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