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Paideia Education for learners' Competencies in the Age of Artificial Intelligence - The Google DeepMind Challenge Match

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Abstract

Baduk was produced by Emperors Yao and Shun in ancient China to instruct their sons, and it is the most intricate game that has ever invented and demands a high level of both intuition and insight in order for the players of the game to check their overall strategic position and consider their moves accordingly. Baduk has a symbolic significance as it represents the highest limit of human intellectual ability, and has remained so until this day. The game is also the holy grail of artificial intelligence (AI). For this research study, we analyzed Baduk matches that took place between AlphaGo, a supercomputer, and Lee Sedol, one of the top Baduk players in the world, as well as examining archival research in order to discuss learning capabilities and the appropriate learning techniques for students in the age of AI. In March 2016, AlphaGo played against Lee and beat him, and he was arguably the world's best Baduk player (professional nine-dan level) in Google's DeepMind Challenge Match. During the match, AlphaGo introduced a new model in Baduk as its play deviated significantly from the common plays of professional Baduk players. The age in which AI surpasses human intelligence is considered to be a point of "singularity" in the history of human civilization. A singularity is a term denoting an unknown territory in which we cannot make easy predictions. In order to prepare for the new age of AI, we may have to go back to the beginning of human civilization to learn from the wisdom of the educational system of the ancients. To be specific, to prepare for this new age, we can learn from Baduk education of ancient China and the Paideia education of ancient Greece, from which we can deduce the strengths kept within human nature.

Keywords*: Baduk, AlphaGo, Lee Sedol, artificial intelligence (AI), Paideia*

1. Introduction

The modern world, after going through the knowledge and information revolution commonly referred to as The Third Wave, is now entering a period wherein humans and machines co-exist as the two paradigms of the human and computer worlds undertake clash and reconstruction repeatedly [1-2]. There is a widely extended expectation that the age when artificial intelligence (AI) exceeds human intelligence will arrive soon [3]. An AI is with an intelligence created by a machine system, but possesses humanity as well as intellectual capacity. In other words, AI is an artificial system or machine that possesses the intelligence to perform particular tasks [4]. It was Turing who suggested an intelligent system comprising a machine that contained a human brain, which became an early notion of AI [5]. The term "artificial intelligence" was first used by McCarthy [4]. AI technology has been progressing rapidly in recent years. To be specific, artificial neural networks (ANNs), computer games, fudge systems, pattern recognition systems and robotics are all part of AIs that are being frequently used today.

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Baduk, according to legend, was created 4,500 years ago by Emperors Yao and Shun of ancient China to provide education to their sons [6]. Baduk is written as “Weiqi (圍棋)” in Chinese characters and “Go (ご)” in the Japanese alphabet. The English term is borrowed from the Japanese [6]. The rules of Baduk are very simple. Two players are provided with sets of black and white stones, in which the players take turns placing on a board consisting of 361 cross-sections in a 19 by 19 grid. The winner is the one who gains more territory (houses). The total number of places in which the stones can be placed is 361!, which gives rise to 10^{360} possibilities. This makes it the most complex game ever invented. Consequently, simulating a game of Baduk as the symbol of the highest limit can be achieved by human intellect and remained the holy grail of AI technology [7]. In order to use AI to play a game of Baduk, intelligent game simulations are needed for evaluating strategic positions and calculating the probability of success for each move. Professional Baduk players decide their next move based on an intuitive assessment of the strategic position of the game and the chance of winning in the next move. AlphaGo is an AI Baduk algorithm that uses deep neural network (DNN) technology to perform deep learning (DL), by which it learns by itself on how to win a Baduk game [8].

Google’s DeepMind Challenge Match between AlphaGo and Lee Sedol was held in Seoul between March 9th and 15th, 2016. In this tournament, AlphaGo beat Lee by a score of 4:1. The success of an AI in this event proved that an AI could dominate human intelligence at the highest level. However, Lee’s winning of the 4th match succeeded in demonstrating the infinite potential possessed by humans, and showed us a world of new possibilities in the future. AlphaGo showed us that a new paradigm of Baduk when the supercomputer computed creative moves that no humans had yet conceived. This was the moment when an AI surpassed a human in a game that required the highest level of human intellect and intuition. Despite a series of defeats, Lee never gave up. Instead, he kept saying, "It’s fun,” “I am full of high expectations” and “I’m learning from AlphaGo” [9-10]. His words reflected the excitement and curiosity experienced in the new, unknown world of AI. They also reflected his passion for learning new things, which is the one of the most important parts of education and what Emperors Yao and Shun had wanted to teach their sons through Baduk. Lee adapted amazingly quickly against the powerful and unpredictable AlphaGo. Even after three consecutive defeats, he never gave up and eventually went on to win the fourth match.

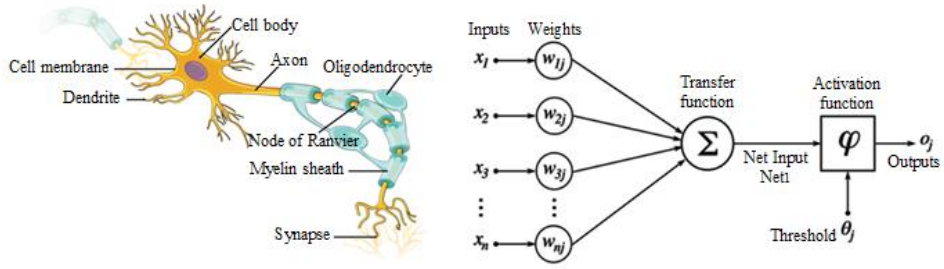
Today, we are facing a future where humans may have to compete with AIs that surpasses humans in ability in all areas. The time will come when our own survival will be jeopardized if we cannot develop the ability to control AIs. Therefore, the students of today, for the first time in human history, must compete with intelligent machines to get jobs in the future. It is claimed that in an age when AIs possess human abilities, 47% of existing jobs will be eliminated [3]. In order for the youth of today to avoid becoming the “lost generation” in the coming age of AI, there must be changes in education to prepare them for this brave new world. The aim of this research is to investigate learning capabilities in an age of AIs by analyzing the Google DeepMind Challenge Match between AlphaGo and Lee. The paper also discusses the future of education in preparation for the new age of AI.

2. Background Work

2.1. Artificial Neural Networks and AlphaGo’s Machine Learning

Artificial Neural Networks (ANNs) imitate the way biological systems utilize neurons to process information. Inside the human brain is a complex network consisting of 100 billion neurons that exchange information with one another, which, in fact, forms the foundation of the brain’s activities. When a stimulus is detected by human sensory organs, such as the eyes or the ears, electronic signals are communicated to the neurons through

dendrites, which in turn move to the synapses through the cell body, axon and myelin sheath (Figure 1a).



(a) (b)

Figure 1. Structure of Biological Neuron (a) and Artificial Neuron (B)

Countless artificial neurons (ANs) are linked in complex ways to form ANNs, which is similar to the way human brains function. Each neuron has a connector that receives inputs x1, x2, … xn. Each input element is multiplied by the weighted value of Wnj applied to each connector (Figure 1b). When the sum of these weighted values reach the critical threshold value θj, its results becomes activated and outputted [7]. ANNs comprise a countless number of ANs and can perform experience-based learning, formulate generalizations and make inferences similarly to how human brains do. These things become the foundation of machine learning (ML) that is similar to the process of human learning [7]. ML is an algorithm by which a computer carries out autonomous learning. The core of ML consists of "representations", which evaluate big data (training data) and makes "generalizations", which process unknown data [11]. The learning process that is based on "representations" is known as "supervised learning (SL)," which derives functional relationships from a very large amount of training data the pattern not displayed from the training data. SL is similar to the concept of learning in education. Another method of ML is reinforcement learning (RL), in which a machine learns through reinforcement using additional outputs (praising correct behavior and punishing mistakes).

2.2. AlphaGo's Deep Learning

Go players are determined for the next movement to make games advantageous through "the movement reading and the intuitive state interpretation." However, AlphaGo predicts optimal moves through the tree search analysis and the big data. The tree search algorithm of AlphaGo employees Monte Carlo Tree Search (MCTS) that is generally used in Go. MCTS is used for efficiency if search on every path becomes impossible and plays the role to restrict the search range to enable efficient analysis on the range and depth of search that are close to infinite. AlphaGo determines the best point for the next move by MCTS algorithm through 4 phases as in Figure 2 [8].

Step 1. Each simulation traverses the tree by selecting the edge with maximum action value Q, plus a bonus u(P) that depends on a stored prior probability P for that edge.

Step 2. The leaf node may be expanded; the new node is processed once by the policy network pσ and the output probabilities are stored as prior probabilities P for each action.

Step 3. At the end of a simulation, the leaf node is evaluated in two ways: using the value network vθ; and by running a rollout to the end of the game with the fast rollout policy pπ, then computing the winner with function r.

Step 4. Action values Q are updated to track the mean value of all evaluations r(·) and vθ(·) in the subtree below that action.

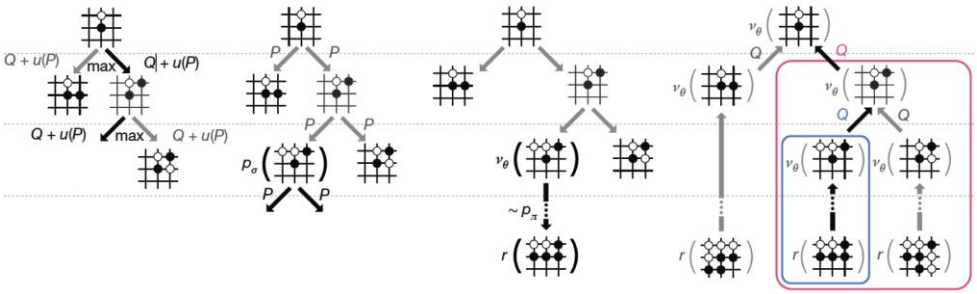


Figure 2. The Process of AlphaGo's Monte Calro Tree Search(MCTS) [8]

Deep Learning (DL) is a branch of ML based on a set of algorithms that attempt to model high-level data abstractions by utilizing multiple processing layers with complex structures, or otherwise, composed of multiple non-linear transformations [12]. DL, which is an expanded concept of an ANN, performs in a similar way that humans do when learning and is widely used in newly emerging industries, such as big data analysis, face recognition and image classification [13]. AlphaGo is a supercomputer consisting of 1,202 CPUs and 176 GPUs. Through SL in an amazingly short period of five weeks, AlphaGo studied 160,000 Baduk games played by professional players in only five weeks, absorbing at lightning speed the cumulative wisdom accumulated over the centuries. Furthermore, AlphaGo underwent RL by playing games against itself. This developed and enhanced its skills even further. RL made adjustments to AlphaGo's connecting links via trial-and-error processors to progress and formulate its own Baduk strategies autonomously [8].

2.3. Paideia and Humanitas

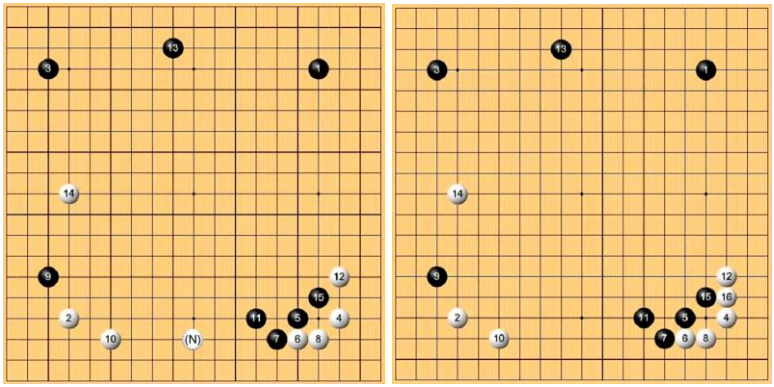
The ancient Greeks practiced Paideia, an education system that trained and cultivated free citizens for the first time in a human civilization [14]. Paideia derives from the Greek word pais/paidos, meaning raising children, and indicates humanitas, *i.e.*, liberal education that all mankind must have [15]. The Greeks developed Paideia in a desperate attempt to fight against the powerful Persians and was what led to the germination Greece of the first democracy in human civilization. The significance of Paideia goes beyond general education (liberal education) [16]. Paideia offers students the wisdom that permits them to make expert judgments, which we can call "super-expert education (Humanitas)". The free citizens of ancient Greece explored the unknown world and established democracy through Paideia [16]. A campaign for spreading Paideia started in 1982 in the United States by The Paideia Group, which consisted of twenty-two renowned education experts who drafted the Paideia Proposal [14]. Adler (1982), who led the Proposal, declared that Paideia is the window to the soul of humanity and a repository of the wisdom of human civilization that has accumulated over thousands of years. The essence of this wisdom must be taught via modern interpretation to create a better future for humanity [11]. However, Paideia was not well received on account of being too idealistic and difficult to implement in schools [17].

3. Data Analysis and Discussion

3.1. AlphaGo's Creative Ideas and Lee's Persistence and Challenge

AlphaGo opened in the second match with the black stones. In Figure 3a, when Lee moved to white 12, AlphaGo responded with black 13, which deviated widely from conventional wisdom and the standard procedure in Baduk that humans had developed over the history of the game. According to standard procedure, AlphaGo should have

moved its stone to position (N) in (a), because if Lee were to move one of his white stones to position (N), it would become very difficult for AlphaGo to maneuver its three black stones (5,7,11) in the lower right corner. At the same time, White (Lee) would be able to expand its influence over the range of territory that encompasses the lower left corner and most of the bottom area (2,10,N). Therefore, the taking of position (N) is crucial to winning the game because the player who takes it can take over the entire bottom area or else see all of their stones in the bottom area put into jeopardy [18]. However, AlphaGo moved to 13 instead and won the game.



(a) (b)

Figure 3. Black No. 13, 15 of the Second Game from the Match Between Alphago (Black) and Lee Sedol (White), a Professional 9 Dan

AlphaGo broke the conventional wisdom of Baduk, and suggested a new paradigm for playing Baduk. The move to 13-(a) was a very creative move that could not have been conceived by professional Baduk players. AlphaGo's black 15-(b) move was also very crucial. Moving to the black 15 position in between white 4 and white 12 would have been thought of as a disastrous move that simply went against common sense. Not even amateur players would have chosen such a move. The reason for this is that once the white 16-(b) move was made, White would be able to consolidate its territory in the lower right corner, while Black would have gained nothing. To make things worse, not making the black 15 move would have allowed Black to retain a chance to advance to the lower right corner. The black 15 move would have gained nothing and would have eliminated the "possibility" and the "first right to move" while allowing White to consolidate its own territory. Unless you are forced into an exceptional circumstance, the black 15 position was to be avoided as a taboo [18]. However, AlphaGo moved to black 15, and still won the game. In the second match, AlphaGo's black 13 and 15 were also moves that should not have been made based on conventional human wisdom. AlphaGo demonstrated creativity and broke away from convention to open up new possibilities that had not been conceived by most professional players. Lee had been only at the skill level of a professional two-dan when he defeated Fan Hui, the European Go Champion, and one year earlier [8]. Amazingly, AlphaGo took only about a year to improve enough to surpass even a professional nine-dan player. This illustrates how AIs can advance at a rate that humans cannot imagine.

It is believed that in the age of AI when machines possess the level of human abilities, about half the jobs that exist today will be eliminated [3]. In order to prepare for such an age, it is necessary to give young students the kind of education that they could use to successfully compete against AIs. In other words, we need education that can improve abilities in human nature that AIs do not yet possess, such as insight, intuition and inner drive. In order to help humans to avoid being the "lost generation" in the age of AI, we need to form their abilities to control AIs and even to create new jobs. Lee's dramatic

strike back in the fourth game against AlphaGo was a scenario that even the most seasoned professional Baduk players did not anticipate. Lee was able to win the fourth match by transforming the frustration of the prior three consecutive defeats into a passion for exploring the unknown world of AlphaGo. Lee said the following about his "divine idea," the white 78 move that led him to his victory in the fourth match: "At that moment, I wasn't able to see any more moves that I could make. Then, the white 78 move came to my mind as the inevitable move." [9]. This was the moment when the mind and spirit that Emperors Yao and Shun had wanted to teach their sons when they created Baduk was inspired inside Lee. This moment was also the revival of the spirit of Paideia that the ancient Greeks had taught to their children in order to defeat their powerful Persian enemies.

3.2. Paideia as Competence Education for Students in the Age of AI

Park *et al.* (2015) foretold that the future would be the age of AI and Cyber Now, with all parts of society connected together in real time at every moment [3]. In cyberspace, the division between work, study and leisure would disappear, and learning would take place in terms of playing games with AIs. Such games would not simply be entertainment, but would simultaneously become part of work, life and learning. Anyone who sought education according to their vocation, interests and appropriate level of learning would be able to acquire such education [3]. According to the 2045 United Nations State of the Future Report, futurists are seeing the year 2045 as the moment of a singularity in human civilization when scientific progress will arrive at a critical turning point [19]. The interesting thing is, the moment AIs surpass human intelligence, it is difficult to predict the direction of scientific progress from that time on [3]. What would be the most valuable thing students could learn at schools then? Spencer (1861), Bellack (1965) and Muller (2000) said that students must gain the "essence", the soul of humankind and the product of human wisdom accumulated over humanity's long history [20-22].

Humans, through education, evolved from animals in a state of nature into socially and culturally mature human beings by acquiring the window to the soul through which they can clearly see the objects, events and human relations that surround them, and by inheriting common values, wisdom and behavioral codes [23]. Moreover, in preparation for the age of AI, we may consider Paideia, the educational system developed by ancient Greeks for free men to explore and pioneer the unknown world and future as they fought against the mighty Persians. Paideia contains not only the spirit of challenge and learning, but also a paradigm of harmony and tolerance. It covers the idea of "Humanitas," education based on human nature that allows us to cooperate with one another to preserve democracy, as well as acknowledge and embrace the diversities among people [14]. It is possible that in the age of AI, people will realize that Paideia is a great philosophy of education that greatly enriches the abilities of learners. Paideia seeks learning through reading great books about history and cultivates the soul and the essence of the soul of humankind. In doing so, Paideia helps us make preparations for a future that is nearly impossible to predict [24-25].

Schools in the present teach only on safe knowledge that is already confirmed and not how to survive in an unknown world. Well-educated students in such school education only play their roles as gear wheels running well adapting in the existing society, yet, do not try to explore any new world or creatively resolve issues [24]. Ancient Greeks practiced 'Paideia' to educate their children. Paideia is composed of 'Pais' referring children and 'euo', the postfix referring the state of 'Paideuo' and has the meaning of 'being with children' [14]. Therefore, the term includes the meaning that 'the state of children being with adults' is the education. Paideia formed the education system making the Greek society with the meaning of discipline, training or education via academic training and free education methods in the children's education as well as almost all academic areas already in BC 6C [25].

Plato straightly faced the collapse of Athens where lawlessness and terror were rampant and established the educational philosophy by finding that not the politics, but the education were the answer to rebuild the righteous nation. He saw the educational activity of sophists, the educators in that era was only money making, not a true teaching and the true quality of education was on the discipline of personality. Paideia education in Plato's idea appear as the force accompanying pains, the directional change, the forced guide to goodness, the progression to escape from the world of ignorant tunnel, the guide to truth, the deep consideration, the road of wisdom, the understanding of true quality of human behavior and others [25]. Plato saw the most ideal teachers in Paideia education are the ones throwing questions opened without any answers. Paideia education in Greece was implemented in 5 phases presenting the theory of opened education that breaks the closed world and dogma. Phase 1 (7-10 year olds) is the preliminary education teaching the physical exercise, the music and the reading and writing. Phase 2 (11-16 year olds) is the basic education on practical knowledge beneficial in the day-to-day life. The phase included the music, the physical education, the poetry, the geometry, the arithmetic and the astronomy. Also, students not requiring further education were sent to the society having occupations. Phase 3 (17-20 year olds) is the 1st practice education performing the military training. Phase 4 (21-30 year olds) is a professional education focused to the grammar, the rhetoric, the geometry, the astronomy and dialectic theory. Phase 5 (31-50 year olds) is the 2nd practice education teaching including the philosophical dialogue method, the practice of governing and the course to train philosophers [25]. Paideia education is for the life-time training to become free persons and to build necessary qualifications to govern a nation.

Paideia is not only for getting knowledge already set as studying textbooks in today's schools, but it is a form of education pursuing the wisdom to think and make decisions on various issues. It is an education of desperation to think, learn and survive against an unknown word as in case of Greeks acutely fighting and thinking to win and survive against Persians in the wide field of Marathon. In the future society, the prediction will become more complicated and the change will be faster so that efforts to adapt and continuously learn such circumstances will be required. In the Go game between the artificial intelligence AlphaGo and the human intelligence Lee, the one who adapted and learned in surprisingly fast speed was rather Lee, not AlphaGo. Even after 3 straight loses, Lee did not give up, yet rather enjoyed the game, challenged and finally achieved the winning in the 4th game. Lee showed the process of wining Greeks achieved in the war without any principle or guide based on new knowledge acquired by sacrificing themselves to test under Paideia spirit [24]. In the era of artificial intelligence, the creative education that is not to acquire knowledge already existing, yet, to making own ideas on what to learn autonomously is required. Such creative education is Paideia and would be the one desired by the king of Liao dynasty when he picked the go stone for the first time in history for his son to learn.

Lee was full of free spirit when he said, "I see the moves. What else can I do?", "I did not play hard, but I won" [9-10]. Lee's Baduk playing has never conformed to conventional wisdom, and has always been free, creative and aggressive. The habits he had acquired from playing on the seashore when he was young and the positive emotions he had absorbed from nature must have played a great role in forming his free-spirited Baduk style. Lee was born on the small island of Bigeum-do off the southern coast of the Korean Peninsula. The youngest son in his family, he spent his childhood steeped in the beauty of nature, roaming freely in the meadows and hills, and playing by the sea [9-10]. The mind and spirit of young children are always widely opened. They do not pay attention to other people and have no established aesthetic standards. Therefore, the intuition and senses that are unique to one's own are developed in full force [24]. Despite not having received a normal school education, Lee naturally formed Paideia through free-spirited intuition and insights that he had acquired from nature, as well as through the

spirit of optimism and the joy of exploration he had learned from playing Baduk, a game that was created by Emperors Yao and Shun thousands of years ago.

4. Conclusion and Suggestions

The paradigms of human civilization have changed with the development of science and technology, and humans have survived by adapting successfully to such changes. After living in agricultural societies for a long time, humanity underwent the Industrial Revolution, which was sparked by the invention of the steam engine in the 18th century and led to the creation of modern industrialized society. Now, we have gone beyond the age of knowledge and information called The Third Wave and is currently facing the age of AI, a singularity that is a great turning point in human history [19]. Using Paideia and the strong inner drive embedded within its nature, and humankind has always overcome a crisis whenever there was a great turning point in history. As a result, we have progressed to a better world.

Although people have worried about the loss of jobs when faced with mechanization and automation after the Industrial Revolution, these have actually released humans from physical labor and created a knowledge-based industry that produces new jobs, making the world richer and more prosperous. Google's DeepMind Challenge Match announced the beginning of the age of AI as AlphaGo defeated Lee, who represented the best of human intellect. We were shocked that AlphaGo not only possessed human intellect, but also intuition. At the same time, we cheered for Lee who never gave up, but showed passion and grit, and eventually went on to beat the supercomputer using a creative and brilliant move to which not even the AI could respond. It is believed that from now on, AI machines, such as AlphaGo, will replace human intellectual labor and use deep learning technology or the like to upgrade itself constantly and eventually surpass humans in ability [3].

Paideia education can come under attention as a form of education that enhances a learner's abilities for students that are preparing for the age of AI. The purpose of Paideia is to provide education that is humanistic and universal, but not job-oriented. Its goal is to accomplish Humanitas, the ideal upheld by the ancient Greeks, and to preserve human dignity. In particular, in the coming age of AI and Cyber Now, the youth will gradually lose respect for humanity and their concept of self as they lose their sense of location and love of places (topophilia) in a cultural environment where the sense of location has been weakened [24-26]. We can reconsider Paideia as a form of education that enhances a learner's ability to prepare them for the coming age of AI. For the youth of the future, who will live the life of neo-nomads in cyberspace, Paideia will offer opportunities to acquire human intuition and insights from nature, hometowns or similar places, thus readying youths for the age of AI. Under Paideia education, we can help students to acquire the habits and the spirit of optimism from nature, and develop the spirit of challenge, curiosity and fun in exploring unknown worlds, such as playing Baduk, as it was in the case of Lee. In doing so, we must cultivate in the students the essence of the soul of humanity, so that they can compete successfully against AIs in the future. By offering Paideia in which our youth can develop intuition, insight and inner drive from nature, we can help them develop abilities to control and manage AIs, and even create new jobs.

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