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Evolutionary Game Analysis of Artificial Intelligence Such as the Generative Pre-Trained Transformer in Future Education

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Abstract: As an emerging research area since generative artificial intelligence (represented by Chat Generative Pre-trained Transformer (ChatGPT)) has been accessible to the public, especially in education, appropriate AI application could bring numerous benefits to education; however, its abuse has the potential to be harmful. In this paper, we aimed to explore the potential of AI in the future of education with the analytical method of evolutionary game analysis (EGA). By studying the behavior of two agents, the school and the students, EGA can be used to identify strategies that can be used to improve the effectiveness of the education model in the context of the AI era. A stable evolutionary strategy for the school and students was devised under a variety of scenarios. Additionally, we conducted a numerical analysis to further explore the impact of several key factors on the stable strategy. The results indicated that schools should adopt positive supervision to standardize the use of AI in education, and students should be more active in becoming involved in AI technology. Based on this study, we believe that the school has the ability to provide effective suggestions and practical guidelines to help students succeed academically and embrace future trends in AI education.

Keywords: education; artificial intelligence; generative pre-trained transformer; evolutionary game; replicator dynamic equation



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1. Introduction

Since the advent of Chat Generative Pre-trained Transformer (ChatGPT), a chatbot, in the latter part of 2022, generative artificial intelligence (AI) has been shown to have a wide range of ramifications. The program was the latest model released by OpenAI, based in San Francisco, CA, USA. As to its mechanisms, large language models (LLMs) are sophisticated deep learning models adapted to comprehend and generate natural language [1]. As an LLM, ChatGPT is a machine-learning algorithm which is capable of autonomously assimilating information from data and is able to generate intelligent written content after being trained with a voluminous corpus of text [2,3]. ChatGPT is designed on the basis of GPT-3.5; that is, by receiving feedback from humans, it is trained through reinforcement learning such as via personnel who survey and classify noxious text. This approach enables ChatGPT to modify its conduct based on input from human assessors. Consequently, ChatGPT is much more proficient at grasping user objectives, producing text in a human-like manner, and sustaining consistency in dialogue.

Within the realm of education, these AI-based language models have extensive implications for community and technology. Scholars, researchers, and even students have already utilized the language models represented by ChatGPT to compose essays and orations, abridge literature, write original drafts, and refine papers, as well as determine study

deficiencies and conduct statistical analyses [4–6]. In the near future, it is predictable that this technology will progress to the extent that it will be capable of devising experiments, writing manuscripts, and finishing research.

However, research quality, transparency, and human autonomy would be compromised due to the inappropriate use of chatbot-based language models. Disinformation and misconceptions can result from the use of AIs such as ChatGPT because they produce convincing but sometimes incorrect text. Additionally, the risk of inaccuracies, bias, and plagiarism in specialized research by AI technology has become a pressing issue [7]. Thus, academic researchers and students should use it reasonably. With this in mind, it is clear that a ban on the use of LLMs is not a viable solution; instead, the research community must engage in an urgent and comprehensive discussion on the influence of this game-changer and path-breaking innovation.

In this context, we aimed to explore the application of AI (represented by ChatGPT) in the future of education using the evolutionary game model. Evolutionary game analysis is a method of studying populations' behavior in a variety of scenarios [8,9]. It combines elements of game theory and evolutionary biology to analyze the behavior of a population in a given environment. By studying the behavior of a population, evolutionary game analysis can be used to identify strategies that are most beneficial for a given population. Previous studies have used comments or short reviews to explore the influence of ChatGPT and other AIs on future education and academic development [10–12]; however, few studies have applied evolutionary game theory as a quantitative means of investigating such issues.

As artificial intelligence becomes increasingly important in future education, it is critical to explore how to develop and apply generative pre-trained transformers among schools and students. Different from the previous literature, this study undertook the following: (i) it aimed to establish an evolutionary game framework between the school and students and explore the potential difficulties of AI technology at the micro level; (ii) then, this paper analyzed the complex interaction between the school and students in the practice of the AI technology in order to develop the system dynamically by elaborating on the problems that both agents might encounter in the process of applying this technology; (iii) the theoretical results were verified by numerical simulation, and the influence of sensitivity parameters on the evolution trajectory was discussed.

2. Materials and Methods

By reviewing the existing research on AI technology and the emerging ChatGPT, a number of top international journals have paid close attention to the appropriate use of AI (represented by ChatGPT) in scientific and education issues [13–15]. Evolutionary game models can be applied to research on the key influencing factors on a specific topic, which has been maturely applied in sociology [16]. Specifically, evolutionary game theory is an analytical theory based on the combination of classical game theory and evolution theory in biology and designed to build a dynamic model. The equilibrium achieved by the evolutionary game was not the result of a single decision. Instead, it is a dynamic equilibrium state that is finally reached after repeated adjustment and correction of strategies in event learning. In this state, all game players' strategies are presented in a stable mode, and the strategy at this time is the evolving stable strategy. The replicator dynamic equation can accurately describe the dynamic convergence process to achieve this equilibrium equation.

Schools and students are two of the main agents in the replicator dynamic equation of the application of AI in education. The supervising process modification is embodied in the application of AI in the formulation of school's teaching contents, teaching resources, and teaching techniques so as to improve students' academic performance. For the dilemma of using AI in future education, the schools are lacking sufficient motivation to supervise AI during the whole study process and the initial input of new teaching methods and equipment, while students are facing the difficulty of learning and using AI, with extra effort allocated to understanding its language and text generation process. In the evolutionary

game framework, interactions between individuals are represented using payoff matrices. These matrices describe the costs and benefits associated with different strategies in a given interaction. Equilibrium states in the evolutionary game framework represent stable strategies for all individuals involved in an interaction. Through mathematical analysis and simulations, researchers can identify these equilibria and predict how they may evolve over time. Finally, the predictions of the evolutionary game framework can be tested through empirical studies. By comparing observed behavior to the predictions made by the framework, researchers can assess its accuracy and refine its parameters as necessary.

Several representative studies have recently used evolutionary game theory in the application of AI and other topics [17–19]. Wang et al. [17] used evolutionary game analysis to theoretically understand consumer privacy protection with the growth of AI-empowered online shopping. He et al. [18] and Yan et al. [19] also used similar methods to explore the provision of elderly care services among different participants and tourism recovery in the post-COVID-19 period, respectively. Referring to these previous settings, this study set the parameters as follows: for schools: supervising expenditure of rulemaking regarding AI academic use in school was set as C_s ; extra teacher resource allowances for experts in AI use were set as C_a ; the development of a checking system for detecting AI-generated texts was set as C_o ; the school performance evaluation from active guidance and supervision was set as R_e ; government support and incentives regarding active measures were set as R_s ; and student's academic decline caused by abused use of AI technology was set as P ; when it comes to students: basic academic achievements if AI technology is not adopted were set as R_b ; extra effort and attention allocated to learning and training language models to generate meaningful text were set as C_e ; deep understanding of language and the text generation process was set as C_p ; additional academic benefits from AI technology were set as R_a . Table 1 describes the detailed settings for the two agents.

Table 1. Parameter definitions of the evolutionary game model.

Symbols	Stakeholders	Descriptions
C_s	School	Supervising expenditure of rulemaking regarding AI academic use in school
C_a		Extra teacher resource allowances for experts in AI use
C_o		Development of checking system for detecting AI generating texts
R_e		School performance evaluation from active guidance and supervision
R_s		Government support and incentives regarding active measures
P		Student's academic decline caused by abused use of AI technology
R_b	Students	Basic academic achievements if AI technology is not adopted
C_e		Extra effort and attention allocated to learning and training language to generate meaningful text
C_p		Deep understanding of language and the text generation process
R_a		Additional academic benefits from AI technology

According to the parameter settings above, the two agents, the school and the students, had two choices: it is up to the school to decide whether to actively supervise or passively supervise the use of AI, and students can determine whether to actively participate or passively participate in the use of the new technology during their studies. The payoff value matrix is generated in Table 2.

Table 2. The payoff values matrix between the school and students.

Game Agents and Their Strategies		Students	
		Active Participation	Passive Participation
School	Active Supervision	$R_e + R_s - C_s - C_a - C_o$, $R_b + R_a - C_e - C_p$	$-C_s - C_a - C_o$, R_b
	Passive Supervision	0 , $R_b - C_e - C_p$	$-P$, R_b

3. Results of Evolutionary Game Analysis

3.1. Equilibrium Points of the Evolutionary Game

In the systematic evolution framework of the school and students, the main factors affecting the strategy selection of participants were expected return, input cost, and assessment system. Variable U_{1s} and U_{2s} represented the expected payoffs of schools for adopting “Active Supervision” and “Passive Supervision”, respectively, and variable U_s represented the school’s average expected payoff.

Subsequently, the replicator equation of the schools adopting the “Active Supervision” strategy was described as follows:

$$U_{1s} = y(R_e + R_s - C_s - C_a - C_o) + (1 - y)(-C_s - C_a - C_o) \quad (1)$$

$$U_{2s} = y \cdot 0 + (1 - y)(-P) \quad (2)$$

$$\bar{U}_s = xU_{1s} + (1 - x)U_{2s} \quad (3)$$

Similarly, we used U_{1g} and U_{2g} to signify the expected earnings when students chose “active participation” and “passive participation” strategies, respectively, and the average earnings for this group are designated by U_g . The description can be calculated as follows:

$$U_{1g} = x(R_b + R_a - C_e - C_p) + (1 - x)(R_b - C_e - C_p) \quad (4)$$

$$U_{2g} = xR_b + (1 - x)R_b \quad (5)$$

$$\bar{U}_g = yU_{1g} + (1 - y)U_{2g} \quad (6)$$

On the basis of the Malthusian dynamic equation, it was the case that once the income of a strategy in one group was higher than the average expected utility of other strategies, that strategy can have resistant access to prevent the invasion of the mutation strategy [20] and thus can promote the adaptation of the group evolutionary process. According to this theory, the replicator dynamics equations of the “Active Supervision” strategy by the school and of the “active participation” strategy by students were as follows:

$$F(x) = \frac{dx}{dt} = x(U_{1s} - \bar{U}_s) = x(1 - x)[y(R_e + R_s - P) - C_s - C_a - C_o + P] \quad (7)$$

$$F(y) = \frac{dy}{dt} = y(U_{1g} - \bar{U}_g) = y(1 - y)(xR_a - C_e - C_p) \quad (8)$$

By combining Equations (7) and (8), the replicated dynamic equation of the system can be constructed. Let $F(x) = 0$ and $F(y) = 0$, and the local equilibrium points (LEPs) of the evolutionary game were obtained by solving Equation (9):

$$\begin{cases} x(1 - x)[y(R_e + R_s - P) - C_s - C_a - C_o + P] = 0 \\ y(1 - y)(xR_a - C_e - C_p) = 0 \end{cases} \quad (9)$$

As a result, the LEPs were $E_1 = (0, 0)$, $E_2 = (0, 1)$, $E_3 = (1, 0)$, $E_4 = (1, 1)$, $E_5 = (x^*, y^*)$, $x^* \in [0, 1]$, $y^* \in [0, 1]$, where $x^* = \frac{C_e + C_p}{R_a}$, $y^* = \frac{C_s + C_a + C_o - P}{R_e + R_s - P}$.

3.2. Stability Analysis of the System

It was noteworthy that the equilibrium solution was not necessarily the evolutionary stability strategy (ESS); the ESS must also have to resist the error or deviation caused by bounded rationality. Referring to Friedman’s view [21], the local asymptotic stability method can be applied to ascertain whether the equilibrium point of the evolutionary

system was stable. Hence, this section would take the Jacobian matrix and its stability analysis means to estimate the stability of the above points. The Jacobian matrix was as follows:

$$J = \begin{bmatrix} \frac{\partial F(x)}{\partial x} & \frac{\partial F(x)}{\partial y} \\ \frac{\partial F(y)}{\partial x} & \frac{\partial F(y)}{\partial y} \end{bmatrix} = \begin{bmatrix} (1-2x)[y(R_e + R_s - P) - C_s - C_a - C_o + P] & x(1-x)(R_e + R_s - P) \\ y(1-y)R_a & (1-2y)(xR_a - C_e - C_p) \end{bmatrix} \quad (10)$$

Then, we can obtain the determinant (det) and trace (tr) of the matrix, respectively:

$$\det J = \frac{\partial F(x)}{\partial x} \frac{\partial F(y)}{\partial y} - \frac{\partial F(y)}{\partial x} \frac{\partial F(x)}{\partial y} \quad (11)$$

$$\text{tr } J = \frac{\partial F(x)}{\partial x} + \frac{\partial F(y)}{\partial y} \quad (12)$$

When $\det J > 0$ and $\text{tr } J < 0$ were satisfied, it was understood that the equilibrium point of the locally asymptotically stable method corresponds to the ESS. Additionally, an anti-disturbance ability must exist when the evolution strategy came to a steady condition. The results of $\det J$ and $\text{tr } J$ for the respective LEPs are represented in Table 3.

Table 3. Results of $\det J$ and $\text{tr } J$ for the LEPs.

LEP	$\det J$	$\text{tr } J$
A(0, 0)	$(C_s + C_a + C_o - P)(C_e + C_p)$	$P - (C_s + C_a + C_o + C_e + C_p)$
B(0, 1)	$(R_e + R_s - C_s - C_a - C_o)(C_e + C_p)$	$R_e + R_s - C_s - C_a - C_o + C_e + C_p$
C(1, 0)	$(C_s + C_a + C_o - P)(R_a - C_e - C_p)$	$C_s + C_a + C_o + R_a - C_e - C_p - P$
D(1, 1)	$(R_e + R_s - C_s - C_a - C_o)(R_a - C_e - C_p)$	$C_s + C_a + C_o + C_e + C_p - R_e - R_s - R_a$
E(x*, y*)	$\frac{(C_e + C_p)(R_a - C_e - C_p)(C_s + C_a + C_o - P)(R_e + R_s - C_s - C_a - C_o)}{R_a(R_e + R_s)}$	0

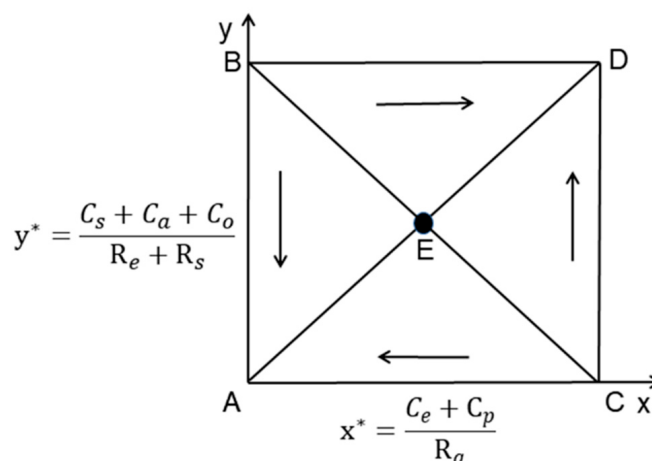
Note: LEP refers to local equilibrium point.

As seen in Table 3, to determine the symbols of $\det J$ and $\text{tr } J$ for different conditions, the symbols of “ $R_e + R_s - C_s - C_a - C_o$ ” and “ $R_a - C_e - C_p$ ” needed to be analyzed. Therefore, as described in Table 4, several cases of the evolutionary condition should be further discussed. One setting should be hypothesized initially for simplifying the analysis process: $C_s + C_a + C_o - P > 0$. Basically, under the guidance of the policies, the school had an obvious tendency to implement the active supervision reform to improve the education model for a better reputation. Instead of putting the economic expenses into the expenses caused by students’ academic decline, it was better to invest resources into education mode reform in the early stage. Therefore, the initial investment cost of the school was higher than the additional cost brought by the decline in students’ academic achievements. However, when the initial inputs of the school’s students were too high, the evolutionary strategy of both sides would continuously decrease to zero with time; that is, when one of the game agents adopted a “passive” strategy, both agents would select the same strategy (see Table 4, Scenarios 2–4) rather than cooperating with one another. Hence, it was of paramount importance to discuss on the stability of the model when $R_e + R_s > C_s + C_a + C_o$ and $R_a > C_e + C_p$.

Table 4. Evolutionary stability state under different conditions.

Conditions	Equilibrium Point (x, y)	det J	tr J	Stability
Condition 1: $R_e + R_s > C_s + C_a + C_o$ and $R_a > C_e + C_p$	A(0, 0)	+	−	ESS
	B(0, 1)	+	+	Unstable
	C(1, 0)	+	+	Unstable
	D(1, 1)	+	−	ESS
	E(x*, y*)	+	0	Saddle
Condition 2: $R_e + R_s > C_s + C_a + C_o$ and $R_a < C_e + C_p$	A(0, 0)	+	−	ESS
	B(0, 1)	+	+	Unstable
	C(1, 0)	−	Uncertain	Saddle
	D(1, 1)	−	Uncertain	Saddle
	E(x*, y*)	−	0	Saddle
Condition 3: $R_e + R_s < C_s + C_a + C_o$ and $R_a < C_e + C_p$	A(0, 0)	+	−	ESS
	B(0, 1)	−	Uncertain	Saddle
	C(1, 0)	−	Uncertain	Saddle
	D(1, 1)	+	+	Unstable
	E(x*, y*)	+	0	Saddle
Condition 4: $R_e + R_s < C_s + C_a + C_o$ and $R_a > C_e + C_p$	A(0, 0)	+	−	ESS
	B(0, 1)	−	Uncertain	Saddle
	C(1, 0)	+	+	Unstable
	D(1, 1)	−	Uncertain	Saddle
	E(x*, y*)	−	0	Saddle

In Condition 1 in Table 4, both A (0, 0) and D (1, 1) were the ESSs of the system, corresponding to passive supervision/passive participation and the perfect strategies (active supervision/active participation), respectively. Figure 1 represents the evolutionary game phase diagrams. It can be found that not only the saddle point E (x*, y*) but also the initial endowment would affect the ESS. On the one hand, when the initial endowment was located in the area of ABEC, the evolutionary game system would approach the equilibrium point A (0, 0), and the passive supervision or participation of both the school and the students seemed to be the evolutionary stable strategy; on the other hand, when the initial endowment was in the area of BECD, the evolutionary game system would tend towards the equilibrium point D (1, 1), and coordination between the school and students would inhabit the expected evolutionarily stable strategy. In this case, the school would provide substantive support and supervision, and students would also actively implement the rules of appropriate AI use. Eventually, with the evolution of time, students' academic performance would be comprehensively improved.

**Figure 1.** Replicated dynamic diagram of the system.

4. Results of Numerical Simulation Results and Analysis

Simulation analysis can further verify the effectiveness of the evolutionary game's results. Thus, to clearly describe the game process, this section uses MATLAB (MathWorks, Inc., vR2023a, Natick, MA, USA) to simulate the choices of the two agencies in different conditions. According to Sterman, simulations can reveal trends and evolutionary tendencies to some extent, which can assist audiences. In view of the short application time of the use of AIs such as ChatGPT, the relevant parameters of the model were neither supported by professional databases nor obtained from published literature. However, three principles were applied when setting parameters in numerical simulations of evolutionary game analysis: (i) the author should assess whether the parameter values align with the empirical data; (ii) the author should choose a modular approach and simulate simpler components (such as a value between 0 and 1) before implementing more complex models; and (iii) there should be no unreasonable or illegal values, such as negative values. In this study, on the basis of investigations of relevant schools and departments in different regions, the parameters were set based on model assumptions that were in line with reality. In consideration of the fact that at the beginning of the stage, the school had to input more manpower and material resources and other investment in carrying out and guiding the rules of AI use in academic work, while, in terms of their investment, the students only had to be responsible for themselves, as an initial input, schools had to undertake more responsibility and input more resources than the students. Combined with the characteristics of two game agents, the initial values of the parameters were set as follows: $C_s = 0.5$, $C_a = 0.5$; $C_o = 0.5$, $C_e = 0.3$; $C_p = 0.3$; $R_e = 1$; $R_s = 1$; $P = 1$; $R_a = 1$; $R_b = 0.5$. The initial value setting of the above parameters met condition 1.

4.1. Initial Evolutionary Trends of Two Game Agencies

In consideration of the project implementation and policy effective time in the actual situation, the initial and the end time were set as 0 and 50, respectively. The time step was 10, which can better describe the tendency of both game agencies. "x" and "y" represented the initial probability of the "school" and the "students". In order to intuitively observe the evolution trend of both sides under different initial probabilities, we set the initial probabilities of "x" and "y" as 10%, 30%, 50%, 70%, and 90%, respectively. The evolution results are shown in Figure 2.

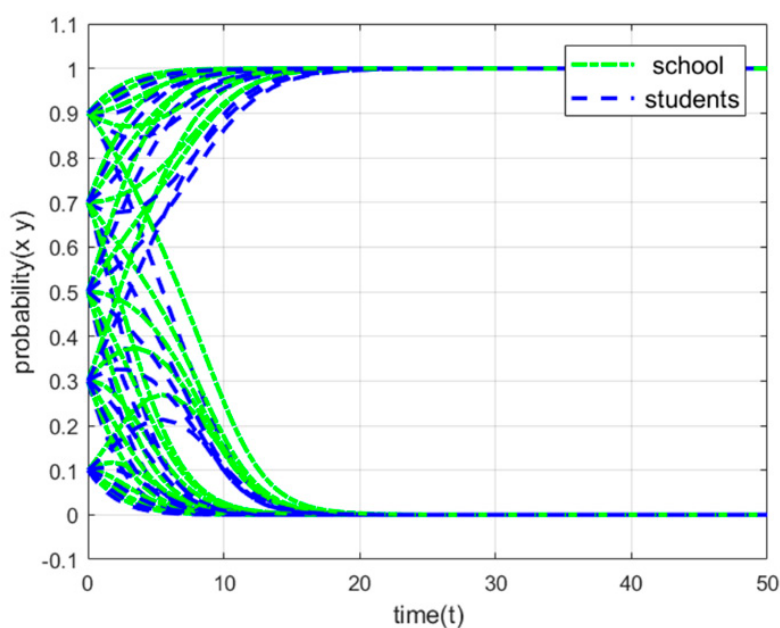


Figure 2. Influence of initial probabilities of two game agencies on the evolutionary process.

It can be seen that if the initial probability of x or y was fixed, the evolution trend of the active supervision plan of AI use between the school and the students was significantly affected by the initial willingness of the other side. When the school's initial willingness to participate was certain, and its initial value was dominant (such as $x = 0.9$), the strategy of students would converge to 1; that is, the two game agencies were very willing to actively cooperate with the exercise plan to improve the students' health status. When the initial value of x was small, the strategy of both sides would converge to 0 synchronously; that is, at this time, both game agencies were unwilling to invest more resources to carry out new the education mode using AI, and they tended to maintain the status quo. When the initial participation intention of students was certain, it also reflected a similar tendency. As a result of comparing the different values of x and y , the school showed a stronger motivation towards 1 than did the students. This can be understood as follows: under the influence of new education innovations induced by the application of AI, schools had more subjective initiative in paying attention to students' academic achievements. The simulation results also showed that, affected by the initial value of x , the greater the school's initial investment intention, the faster the tendency of both sides to converge on 1, and vice versa.

Overall, the school and the students' initial willingness to integrate AI use during study had a positive impact on game stability. If the initial values of x or y were small—that is, the two game agencies were not active—then the development plan of AI use in future education would be difficult. On the contrary, when the initial intention of both sides was strong, the realization of the goal of achieving better academic performances in students with the help of AI would constitute the target point of the day.

4.2. Influence of Input and Return on Evolutionary Trends

Given that the expected goal was the promotion of students' academic performance under the background of AI use in future education, schools had to standardize the use of AI to implement active supervision through basic financial investments. It was hoped that the system would possibly evolve toward the strategy of active supervision/active participation in the D (1, 1) (Figure 1). Therefore, schools and students were more likely to form a virtuous circle cooperatively. Based on the above assumptions, firstly, we increased the initial value of C_s , C_a , C_o , C_e , C_p to evaluate the initial input of both agents in the game stability strategy. Figure 3a shows the results of this condition, with more initial input leading to the ultimate possibility that both sides would converge on 0. Moreover, the situation wherein the initial input decreased was discussed (Figure 3b). Referring to the ref. line (red for school and green for students), we found that decreasing the initial input could significantly inverse the evolutionary trend, and both agents tended to achieve the goal in the game stability strategy. Subsequently, we assumed the higher return of both sides' behavior and discussed evolutionary trends. As shown in Figure 3c, it was detected that higher benefits held sufficient attraction for both sides' decisions and all agents tended to collaborate with each other. According to Figure 3d, when the return decreased, the opposite occurred, and both sides chose not to cooperate and not to achieve the objectives.

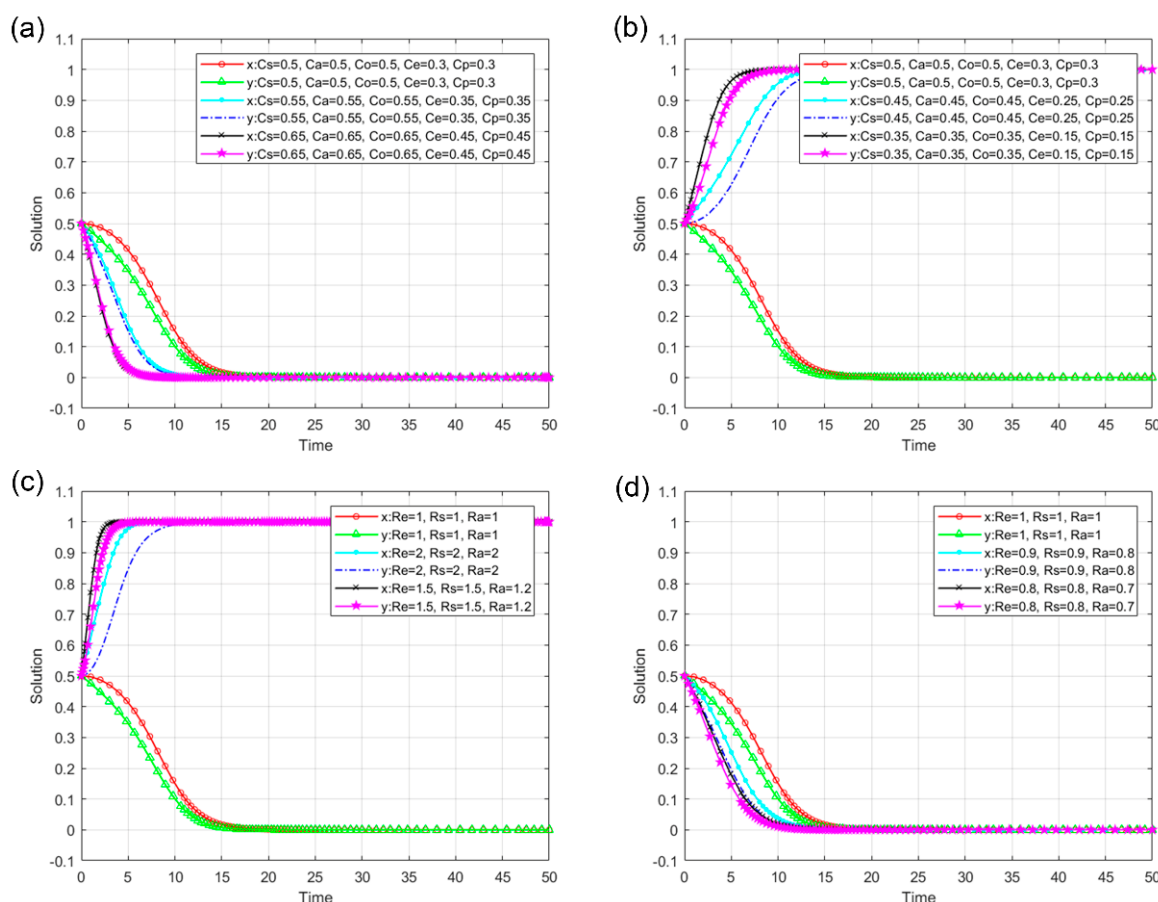


Figure 3. Influence of the increased input (a), decreased input (b), increased return (c), and decreased return (d) of the two game agencies on the evolutionary process.

5. Discussions

This current study employed evolutionary game theory, which abandoned the assumption of “perfect rationality” and held the point that both the school and students were “limited rational”, which was more in line with the realistic future of education against the background and the flourishing use of AIs such as ChatGPT. Additionally, in consideration of the long-term influences of AI technology development, it was possible that more advanced AIs such as ChatGPT would play more pivotal roles in promoting students’ academic performance. On the basis of the reality mentioned above, this study explored the interactive behavior of the two stakeholders (“Active Supervision” by school and “Active Participation” by students) and contributed novel insights into how to transform the two agents’ choice to promote students’ academic achievements.

Technology is evolving, and future education should follow suit. Text processing, editing, and search engines will certainly incorporate AI in the future. For students’ attitudes, it should be noted that AIs such as ChatGPT might not always be right. Thus, the extra effort and attention allocated to learning and training language to generate meaningful text would be a challenge for green-hand users. The absence of relevant information in AI’s practice setting, an inability to distinguish pertinent details, or a failure to differentiate dependable sources from questionable ones can result in AI errors. Hence, the accuracy and comprehensiveness of the models should be ensured by students. On the other hand, these AI chatbots can help students to complete homework faster, allowing them to focus on being creative and innovative [22]. After that, a significant increase in innovation could lead to breakthroughs in a wide range of fields, provided that the students are able to understand and use the technology appropriately.

The use of AI in education has several practical implications that can positively impact both teachers and students. Overall, the use of AI in education offers a range of opportunities for innovation, collaboration, and enhanced learning outcomes across communities and geographical locations, such as personalized learning, enhanced teaching and assessment, improved learning outcomes, greater accessibility, and better resource allocation. For example, AI algorithms can help teachers create personalized learning pathways tailored to different learners' unique abilities and learning styles. The use of AI can also improve the accessibility of language translation and knowledge dissemination, offering support to non-native speakers who find it difficult to understand classes delivered in other languages. Moreover, with AI analyses of multiple data sources, school administrators can make more informed decisions regarding resource allocation and optimize time and budget through the efficient placement of teachers, programs, and technology systems aimed at enhancing the teaching–learning process.

However, there should be caution in schools when students use AIs such as ChatGPT for their homework. AI's ability to generate accurate summaries, evaluations, and statistical results will not replace school-based fact checking. Moreover, considering the diversity of education, how to integrate education in sports, music, and art with artificial intelligence presents an interesting question [23]. Online education and artificial intelligence education may lead to more health problems, and how to handle the relationship between work and exercise, sedentary behavior, and sleep is an emerging issue that may have to be faced [24,25]. Maintaining moderate exercise and muscle quality is an effective way to promote physical and mental health, as well as to improve study and work efficiency [26].

As for the future, in summary, school administrators should always remain accountable for their students' learning status, even with the help of AI. In the current state, it seems there are already tools for predicting whether a text originated from a human or from a machine. As AI technology develops, methods such as these might be developed to detect students manufacturing content using AI [27]. However, clever prompts and evolving AI technology might circumvent these detection methods. In addition, the use of AI in education also raises potential ethical implications that demand attention and consideration. The use of AI-based tools in education often involves the collection, processing, and storage of sensitive personal data. With the sensitive data involved, privacy rights can be jeopardized if appropriate safeguards or protections are not put in place.

Informed consent should be reached to ensure that all learners and instructors understand what data are being collected, how they are being used, and whether they can be shared with third parties. Education institutions should adopt data security protocols such as encryption, access control mechanisms, password protection, antivirus programs, and firewalls to safeguard against vulnerabilities. Moreover, institutions utilizing AI should continuously monitor their systems, assessing possible risks that may arise and updating policies and procedures surrounding AI usage accordingly. Collectively, it is important that schools and students should treat AI in an ethical and transparent manner [28].

6. Strengths and Limitations

This study had notable strengths. It was the first study using evolutionary game theory to explore the application of AI in the future of education between two game agents: the school and students. Unlike traditional games, evolutionary games emphasize the research objects' limited rationality instead of their complete rationality. By incorporating the factors that affected the evolution results into the two-dimensional analysis framework with a time axis, this study can dynamically present and predict the changing trend of both parties' decision-making through learning and imitation during the game process at the micro level. Additionally, this research offered novel insights into AI technology application in the future and provided useful guidance for both schools and students to embrace the new era of AI.

However, this study had several limitations. Due to the short application period of such AI systems as ChatGPT, few professional databases supported the relevant parameters

of the model. Thus, we could only use simulation analysis to prove the dynamic process of AI applications. Further studies would be advised to use statistical data (via interviews or questionnaires) from authoritative institutions or to design longitudinal trials to verify the results of our model and accelerate its practical application. Furthermore, the development of AI is closely related to new technology in computer science. The popularization of science and the diffusion of innovation would significantly change the previous teaching module. Therefore, more influencing factors should be taken into account when an evolutionary game setting is applied. Finally, in future research, regional differences in openness to AI may also be considered (e.g., administrative abilities or economics), which can help promote students' academic performance.

7. Conclusions

Our analysis demonstrated that (i) the initial support of two agents significantly affected the evolutionary tendency; (ii) the decision making motivation is crucial to the innovation and breakthrough of future educational applications such as ChatGPT; (iii) higher achievements attracted both sides to their decisions. Moreover, with the development of AI and Internet courses, a variety of new teaching modes and e-learning modules are springing up nowadays. Schools should actively supervise and make rules for AI use, and students should make use of their ability to interact with language models to generate meaningful text and understand the text generation process. This will ultimately lead to an equilibrium point regarding the appropriate use of AI. Based on the results of this study, conducting more randomized controlled studies in order to develop, in greater depth, hybrid AI education modules is warranted.

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