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PAPER

An Evolutionary Study of the Impact of Artificial Intelligence Technology on Foreign Language Education

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ABSTRACT

This study investigates the evolutionary impact of applying artificial intelligence (AI) technology to foreign language education. By employing complex systems thinking, the relationship between foreign language education and AI technology is explored, and dynamic models are employed to analyze the evolutionary patterns of AI technology in foreign language education. Through model analysis and numerical simulations, the interactive effects between foreign language education and AI technology in different modes are revealed. The findings demonstrate that, under different coupling modes, foreign language education and AI technology can achieve self-organizing evolution. When the interaction coefficient between foreign language education and AI technology is appropriately set, AI technology exhibits emergent properties for foreign language education. Lastly, suggestions are presented to promote the sound development of foreign language education and AI technology.

KEYWORDS

artificial intelligence (AI) technology, foreign language education, complexity analysis, logistic equation

1 INTRODUCTION

The "Six Excellence, One Top" Plan and the "Declaration on the Construction of New Liberal Arts" propose the construction of new liberal arts, emphasizing the integration of disciplines, promoting the cross-fertilization of arts, science, engineering, agriculture, and medicine, guiding collaboration between liberal arts and various industries, and strengthening liberal arts education in Chinese higher education [1] [2]. Currently, there are a considerable number of foreign language teaching majors in Chinese universities, making it a significant battleground for the development of new liberal arts. Within this context, the integrated development of foreign language teaching majors is the fundamental starting point for enhancing their quality and effectiveness, a key breakthrough for promoting disciplinary transformation and upgrading, and a crucial prerequisite for achieving interdisciplinary

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and "super-disciplinary" cross-fertilization [3–5]. However, challenges frequently arise in the integration and development of foreign language teaching majors, such as a weak integration of comprehensive courses, prominent disciplinary barriers, insufficient collaborative momentum among majors, and excessive specialization and isolation [6]. One of the important reasons for such issues is that the integrated development of foreign language teaching majors is a complex system that does not merely manifest as a simple division of labor between majors, but as a non-linear and bidirectional competitive relationship characterized by mutual interaction [7] [8]. Therefore, it is essential to conduct in-depth research on the interactive and evolutionary relationship between foreign language teaching majors analyzing the evolutionary development patterns between majors. This research is crucial for promoting the collective high-quality development of foreign language teaching majors and expediting their transformation and upgrading towards the new liberal arts.

Currently, existing research on the relationship between foreign language teaching majors mainly focuses on the following three aspects: (1) In terms of curriculum systems, existing literature suggests establishing or deepening the relationship between foreign language teaching majors through the introduction of cross-major courses, integrated courses, comprehensive discipline courses, and common courses for major clusters. Such courses, including both theoretical and practical components, are offered after general courses, basic courses, and core courses of respective majors, indicating that the evolution and development of majors should be based on the development of each major [9] [10]. (2) In terms of teaching systems, research on the interaction of foreign language teaching majors mainly revolves around multi-teacher collaboration, teacher-student collaboration, and student collaboration during the course teaching process. Multi-party collaboration can facilitate the comprehensive integration of teaching resources from various majors, promote loosely coupled and integrated teaching links, and enhance the deep integration of major clusters [11–13]. (3) In terms of supporting platforms, existing operational modes and means are relatively limited, making it difficult to achieve cross-major interdisciplinary cultivation. Scholars advocate creating modern, comprehensive support platforms shared by multiple majors to promote collaboration and communication among various majors [14–16].

Previous literature has qualitatively and statistically analyzed the interactive relationship between foreign language teaching majors and studied the cooperative evolution of majors, which provides a valuable reference for this research on the evolution of foreign language teaching majors. In fact, the evolution and development of foreign language teaching majors possess characteristics of openness, non-linearity, emergence, evolution, and self-organization, belonging to the category of complex systems. Under the background of the new liberal arts, the complex system characteristics of the evolution and development of foreign language teaching majors will be further highlighted, and the complexity of evolution will continue to increase. This determines that comprehensive and systematic methods are needed to grasp the evolution and development of foreign language teaching majors. Unlike previous findings, this study takes on a complex systems perspective to examine the evolutionary connection among foreign language teaching majors within the framework of the new liberal arts. It establishes an evolutionary model for foreign language teaching majors, presenting a quantitative and dynamic exploration of the evolutionary process through model analysis. Additionally, the study investigates the evolutionary patterns of foreign language teaching majors under varying modes via numerical simulation. Ultimately, the study puts forth specific recommendations for the targeted development of foreign language teaching majors.

2 EVOLUTIONARY RELATIONSHIP BETWEEN FOREIGN LANGUAGE TEACHING MAJORS AND ARTIFICIAL INTELLIGENCE TECHNOLOGY IN THE CONTEXT OF NEW LIBERAL ARTS

The evolutionary relationship consists of three elements: evolutionary units, the evolutionary environment, and evolutionary patterns. Evolutionary units, under the influence of the evolutionary environment, form evolutionary bodies through certain evolutionary patterns. Evolutionary units serve as the foundation for the formation of the evolutionary relationship, while the evolutionary environment represents the external factors that influence the existence of evolutionary units. The evolutionary pattern, on the other hand, reflects the ways in which evolutionary units interact with each other and is the primary manifestation of the evolutionary relationship [17] [18]. In this study, we consider foreign language education majors and artificial intelligence (AI) technology as evolutionary units, and the evolutionary environment encompasses all external factors that influence the transformation of foreign language majors into new liberal arts, including political, technological, economic, and social environments. The evolutionary pattern between foreign language majors and AI technology refers to the organizational and behavioral modes in which they interact and co-evolve.

In this study, we categorize the behavioral patterns of AI technology and foreign language majors into four modes: independent evolution, antagonistic evolution, beneficial evolution, and mutualistic evolution. These different evolutionary behavioral patterns reflect the degree of acceptance and utilization of emerging technologies in foreign language education and consequently determine the stability of the evolution of foreign language majors. In the independent evolution mode, the development of foreign language education is not influenced by AI technology, and both evolve independently. The antagonistic evolution mode refers to the adverse effects that AI technology has on the evolution of foreign language education. On the other hand, the beneficial evolution mode signifies that the development and application of AI technology can promote the development of foreign language education. In mutualistic evolution mode, AI technology contributes to the advancement of foreign language education, while the development of foreign language education also fosters further advancements in AI technology.

In the context of the new liberal arts, the evolutionary development stages of foreign language education majors and their evolutionary patterns exhibit a certain inherent unity during the evolution process. In the formative stage of foreign language education majors' development, initial collaborative relationships are established, but with a lack of a collaboration foundation. Parties involved in collaboration are cautious in their choices, and collaborative resources are separate. The evolutionary patterns mainly manifest as independent evolution, antagonistic evolution, and beneficial evolution.

During the growth stage of the evolution of foreign language education majors, each major further clarifies its division of labor and collaborative resources, transitioning from a separate state to a superimposed state. The level of collaborative operation is enhanced, and the evolutionary pattern exhibits asymmetric mutualistic evolution.

In the mature stage of the evolution of foreign language education majors, each major moderately intervenes in the other's talent cultivation programs, practical teaching, employment guidance, and other processes. Collaborative resources are optimally integrated, generating superimposed emergent effects, and each major development has high quality. The evolutionary pattern shows symmetric mutualistic evolution.

In summary, the evolutionary stages of foreign language education majors, progressing from the formative stage through the growth stage, and culminating in the mature stage, transition from independent evolution, antagonistic evolution, or beneficial evolution to asymmetric mutualistic evolution. Ultimately, this progression culminates in symmetric mutualistic evolution, exhibiting complexity, as shown in Figure 1.

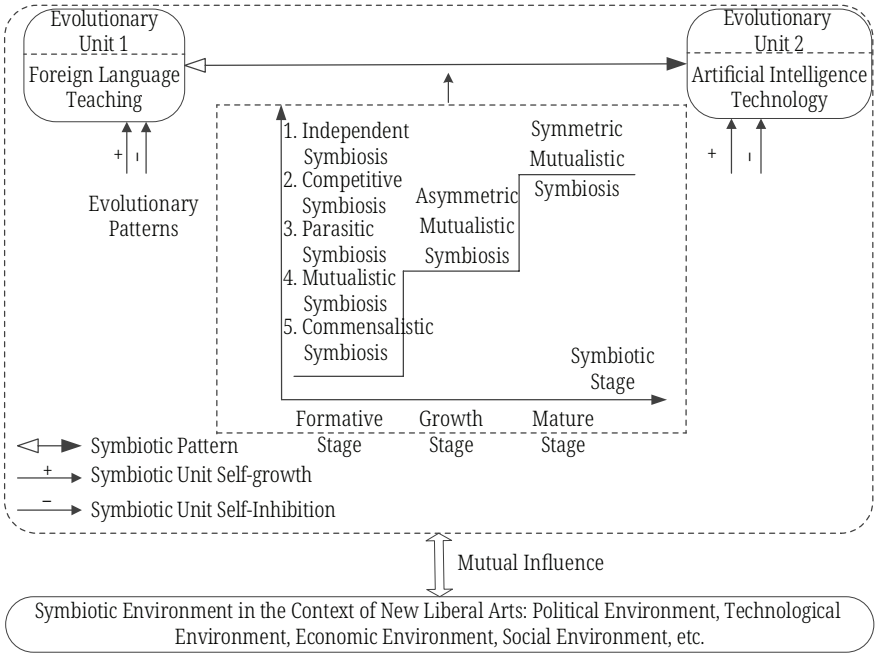


Fig. 1. Evolutionary framework of foreign language education majors

3 EVOLUTIONARY MODEL OF FOREIGN LANGUAGE EDUCATION MAJORS IN THE CONTEXT OF NEW LIBERAL ARTS

3.1 Model assumptions

Assumption 1: The development of foreign language education majors is a function of time, denoted as t, which abstracts the changes in all factors affecting the development of foreign language education majors. The status fluctuations of foreign language education majors under the influence of all factors are simplified as changes in the teaching level. At the same time, the impact of foreign language education on the development of AI technology mainly reflects the application level of AI speech recognition technology.

Assumption 2: The independent development process of foreign language education majors follows the logistic growth law.

Assumption 3: In the process of evolutionary development, there exist competitive or cooperative relationships among foreign language education majors. Such relationships can either inhibit or promote each other's growth.

3.2 Construction of the evolutionary model

When foreign language education majors develop independently, the variation of their foreign language teaching level over time can be represented by the logistic equation:

$$\begin{aligned}\frac{dx_1}{dt} &= \alpha_1 x_1 - \beta_1 x_1^2 \\ \frac{dx_2}{dt} &= \alpha_2 x_2 - \beta_2 x_2^2\end{aligned} \tag{1}$$

In (1), variable x_1 represents the teaching level of foreign language education majors, while variable x_2 represents the application level of AI technology in foreign language teaching. Parameters α_i represent the growth rates of the teaching level of foreign language education majors or the application level of AI technology when the input is constant. The larger the value of α_i, the more inputs are involved. Parameters β_i represent the self-inhibitory effects on the growth of the teaching level of foreign language education majors and the application level of AI technology. Generally, $\beta_i > 0$, because in the process of evolution, both foreign language education majors and the application of AI technology will gradually consume limited resources, leading to self-inhibitory effects when consumption reaches a certain level. Due to the existence of nonlinear interactions among foreign language education majors, (1) cannot fully represent the actual evolution of the teaching level of foreign language education majors. This paper considers the interaction between foreign language education majors and the application of AI technology, and the evolutionary model for both is as follows:

$$\begin{aligned}\frac{dx_1}{dt} &= \alpha_1 x_1 - \beta_1 x_1^2 + \gamma_1 x_1 x_2 \\ \frac{dx_2}{dt} &= \alpha_2 x_2 - \beta_2 x_2^2 + \gamma_2 x_1 x_2\end{aligned} \tag{2}$$

In (2), x_1 and x_2 represent the non-linear evolutionary interactions between foreign language teaching proficiency and the application level of AI. The parameters $\gamma_i\,(i = 1, 2)$ are evolutionary coefficients that measure the impact of the evolutionary interactions between AI technology and foreign language teaching on the growth of foreign language teaching proficiency. The range of values for $\gamma_i\,(i = 1, 2)$ defines different evolutionary patterns among foreign language education majors, as specified in Table 1.

Table 1. Relationship between evolutionary coefficients and evolutionary patterns

Evolutionary Coefficient	Evolutionary Patterns	Characteristics or Features
$\gamma_1 = 0, \gamma_2 = 0$	Independent Evolutionary Mode	No mutual influence, each develops independently
$\gamma_1 < 0, \gamma_2 = 0$; $\gamma_1 = 0, \gamma_2 < 0$	Antagonistic Evolutionary Pattern	One is damaged, the other remains unaffected
$\gamma_1 > 0, \gamma_2 = 0$; $\gamma_1 = 0, \gamma_2 > 0$	Biased Beneficial Evolutionary Mode	One benefits, one remains unaffected
$\gamma_1 > 0, \gamma_2 > 0$	Reciprocal Evolutionary Pattern	$\gamma_1 \neq \gamma_2$: Both parties benefit, but the benefits are unequal $\gamma_1 = \gamma_2$: Both parties benefit and benefit equally

3.3 Analysis of evolutionary equilibrium in evolution

In the context of new liberal arts, the evolutionary process of foreign language education majors is dynamic and ultimately converges towards certain equilibrium states. Possible equilibrium states correspond to the equilibrium points of the evolutionary model. For (2), setting $dx_1 / dt = 0$, $dx_2 / dt = 0$, we obtain four equilibrium points: $P_1(0, 0)$, $P_2(\alpha_1 / \beta_1, 0)$, $P_3(0, \alpha_2 / \beta_2)$, $P_4((\alpha_1\beta_2 + \alpha_2\gamma_1) / (\beta_1\beta_2 - \gamma_1\gamma_2), (\alpha_1\gamma_2 + \alpha_2\beta_1) /$

($\beta_1\beta_2 - \gamma_1\gamma_2$)). The equilibrium point P_1 indicates that after a period of evolution, both the level of foreign language teaching and the application level of AI technology remain unchanged. Equilibrium points P_2 and P_3 indicate that after a period of evolution, one of them has a level of 0. Equilibrium point P_4 represents a scenario where both the level of foreign language teaching and the application level of AI technology have improved after a certain period of evolution. Under different evolutionary patterns, foreign language education majors may stabilize at these four equilibrium points during the evolutionary process. To determine the stable points in the evolutionary process of foreign language education majors and identify the conditions for stable evolution, stability analysis of each equilibrium point is required. The Jacobian matrix J for (2) is as follows:

$$J = \begin{bmatrix} \alpha_1 - 2\beta_1 x_1 + \gamma_1 x_2 & \gamma_1 x_1 \\ \gamma_2 x_2 & \alpha_2 - 2\beta_2 x_2 + \gamma_2 x_1 \end{bmatrix} \tag{3}$$

The trace of the aforementioned Jacobian matrix is equal to $Tr\,J = \alpha_1 - 2\beta_1 x_1 + \gamma_1 x_2 + \alpha_2 - 2\beta_2 x_2 + \gamma_2 x_1$, Determinant is $Det\,J = (\alpha_1 - 2\beta_1 x_1 + \gamma_1 x_2)(\alpha_2 - 2\beta_2 x_2 + \gamma_2 x_1) - \gamma_1\gamma_2 x_1 x_2$. The traces and determinants of (2) at the equilibrium points are shown in Table 2.

Table 2. Traces and determinants of evolutionary model equilibrium points

Equilibrium Point	Trace and Determinant of a Matrix
P_1	$Tr\,J = \alpha_1 + \alpha_2, Det\,J = \alpha_1\alpha_2$
P_2	$Tr\,J = \alpha_2 - \alpha_1\left(1 - \frac{\gamma_2}{\beta_1}\right), Det\,J = -\alpha_1\left(\alpha_2 + \frac{\alpha_1\gamma_2}{\beta_1}\right)$
P_3	$Tr\,J = \alpha_1 - \alpha_2\left(1 - \frac{\gamma_1}{\beta_2}\right), Det\,J = -\alpha_2\left(\alpha_1 + \frac{\alpha_2\gamma_1}{\beta_2}\right)$
P_4	$Tr\,J = \frac{-\beta_1(\alpha_1\beta_2 + \alpha_2\gamma_1) - \beta_2(\alpha_1\gamma_2 + \alpha_2\beta_1)}{\beta_1\beta_2 - \gamma_1\gamma_2}, Det\,J = \frac{(\alpha_1\beta_2 + \alpha_2\gamma_1)(\alpha_1\gamma_2 + \alpha_2\beta_1)}{\beta_1\beta_2 - \gamma_1\gamma_2}$

According to the Lyapunov stability theory, a point is considered stable only if the trace of the equilibrium point is less than 0 and the determinant is greater than 0. The stability analysis of the equilibrium points of (2) is as follows:

1. When $\alpha_1 < 0$ and $\alpha_2 < 0$ (referred to as condition 1), the growth rates of foreign language teaching level and AI technology application level are both less than 0. Consequently, the foreign language teaching level and the AI technology application level will eventually stabilize at equilibrium point P_1. Under all evolutionary patterns, both teaching level and AI technology application level will converge to zero.
2. When $\alpha_1 > 0$ and $\gamma_2 < -(\alpha_2\beta_1)/\alpha_1$ (referred to as condition 2), the equilibrium point P_2 is stable. This implies that after a long period of evolutionary process, the teaching level stabilizes at α_1/β_1 while the AI technology application level tends to be 0. This evolutionary outcome is independent of the type of evolutionary pattern.

3. When $\alpha_2 > 0$ and $\gamma_1 < -(\alpha_1\beta_2)/\alpha_2$ (referred to as condition 3), the equilibrium point P_3 is stable. In this case, regardless of the type of evolutionary pattern, the evolutionary outcome of foreign language teaching class profession is that the teaching level becomes 0, and the AI technology application level becomes α_2/β_2. It is important to note that when the stable conditions of P_2 and P_3 are both satisfied, the final steady state of the foreign language teaching class profession can be represented by either P_2 or P_3, which depends on the initial state of the profession.
4. When $\gamma_1\gamma_2 < \beta_1\beta_2$, and if $\alpha_1 > 0$, $\alpha_2 < 0$, $\gamma_1 < -(\alpha_1\beta_2)/\alpha_2$ and $\gamma_1 < -(\alpha_1\beta_2)/\alpha_2$ (referred to as condition 4), or $1 < 0$, $\alpha_2 > 0$, $\gamma_1 < -(\alpha_1\beta_2)/\alpha_2$ and $\gamma_1 < -(\alpha_1\beta_2)/\alpha_2$ (referred to as condition 5), or $\alpha_1 > 0$, $\alpha_2 > 0$, $\gamma_1 < -(\alpha_1\beta_2)/\alpha_2$ and $\gamma_1 < -(\alpha_1\beta_2)/\alpha_2$ (referred to as condition 6) are satisfied, only the equilibrium point P_4 is stable, and the remaining equilibrium points are unstable. This indicates that after a long period of evolutionary process, the foreign language teaching level and the AI technology application level will stabilize at $(\alpha_1\beta_2 + \alpha_2\gamma_1)/(\beta_1\beta_2 - \gamma_1\gamma_2)$ and $(\alpha_1\gamma_2 + \alpha_2\beta_1)/(\beta_1\beta_2 - \gamma_1\gamma_2)$, respectively. Additionally, if either condition 4 or condition 5 is satisfied, the mode of evolution between foreign language teaching class profession and AI technology can only be mutualistic or beneficial. If condition 6 is satisfied, the foreign language teaching level and AI technology application level can converge to P_4 under any evolutionary pattern. The above analysis shows that the type of evolutionary pattern and the growth rates of teaching level and AI technology application level can influence the final steady state of the collaborative evolution of foreign language teaching profession and AI technology. The summarized results of the stability analysis are shown in Table 3.

Table 3. Stability analysis of evolutionary model equilibrium points

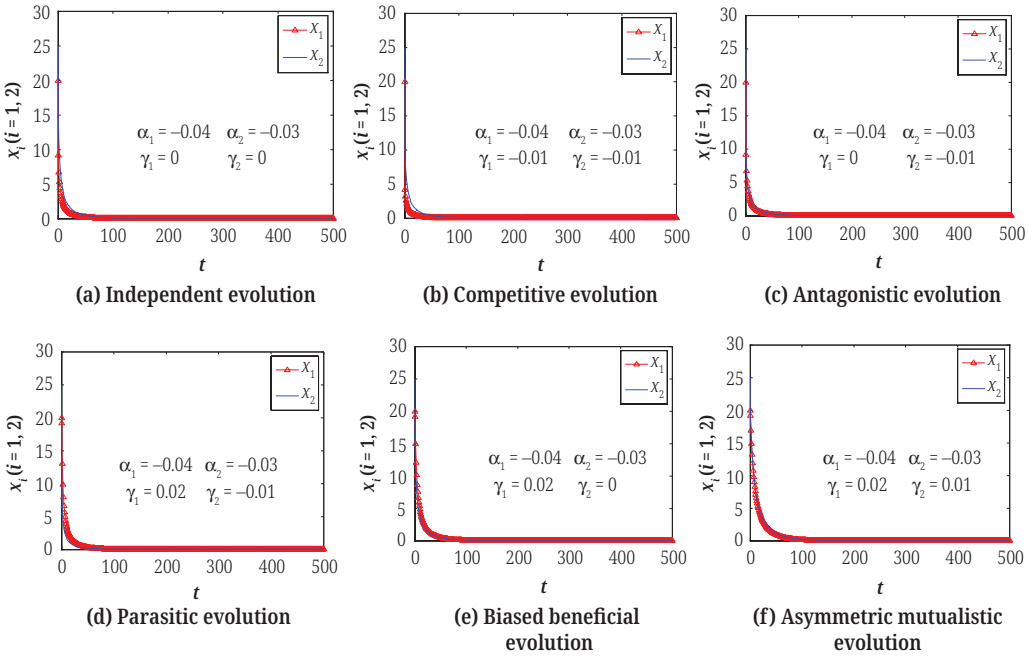
Equilibrium Point	Stability Conditions		Potential Evolutionary Patterns	Other Stable Equilibrium Points
P_1	$\alpha_1 < 0, \alpha_2 < 0$		All Evolutionary Patterns	Non
P_2	$\alpha_1 > 0, \gamma_2 < -\frac{\alpha_2\beta_1}{\alpha_1}$		All Evolutionary Patterns	P_3
P_3	$\alpha_2 > 0, \gamma_1 < -\frac{\alpha_1\beta_2}{\alpha_2}$		All Evolutionary Patterns	P_2
P_4	$\gamma_1\gamma_2 < \beta_1\beta_2$	$\alpha_1 > 0, \alpha_2 < 0, \gamma_1 < -\frac{\alpha_1\beta_2}{\alpha_2}, \gamma_2 > -\frac{\alpha_2\beta_1}{\alpha_1}$	Mutualistic Evolution, Beneficial Evolution	Non
		$\alpha_1 < 0, \alpha_2 > 0, \gamma_1 > -\frac{\alpha_1\beta_2}{\alpha_2}, \gamma_2 < -\frac{\alpha_2\beta_1}{\alpha_1}$		
		$\alpha_1 > 0, \alpha_2 > 0, \gamma_1 > -\frac{\alpha_1\beta_2}{\alpha_2}, \gamma_2 > -\frac{\alpha_2\beta_1}{\alpha_1}$	All Evolutionary Patterns	

In the context of the new liberal arts, foreign language teaching requires synergistic sharing and cross-fertilization with AI technology. Additionally, within a certain timeframe, especially in the short to medium term, each major also expects to maintain balanced development while inheriting its original characteristics and advantages. The equilibrium states represented by P_1, P_2, or P_3 indicate that either

the level of foreign language teaching or the level of AI technology application ultimately diminishes to zero. In contrast, the equilibrium state represented by P_4 indicates enhancement in both the level of foreign language teaching and technology application. Therefore, the states represented by P_1, P_2, and P_3 are not expected to occur during the evolution process of the major, and the steady state represented by P_4 is the ideal steady state of the evolution process.

4 NUMERICAL SIMULATION

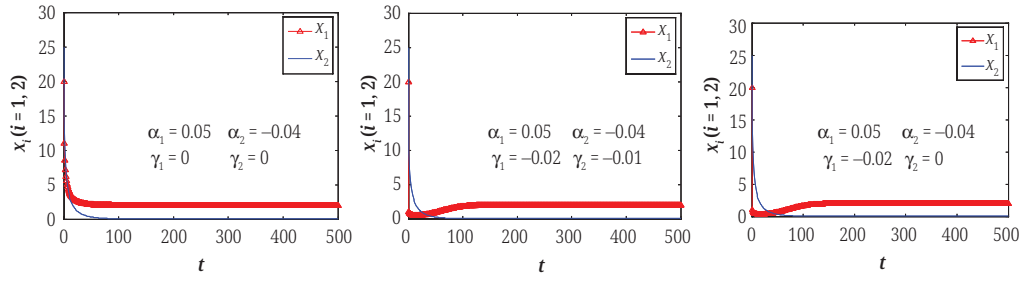
The aforementioned analysis indicates that different evolutionary patterns can have diverse effects on the co-evolution process of foreign language education levels and the application levels of AI technology. To verify and visually reveal the impact of different evolutionary patterns on the collaborative evolution of foreign language education and AI, this section conducts numerical simulations based on the evolutionary model of foreign language education majors using simulation software. The iteration period t is set to 500, and the simulation results are depicted in Figures 2–7.



(a) Independent evolution (b) Competitive evolution (c) Antagonistic evolution

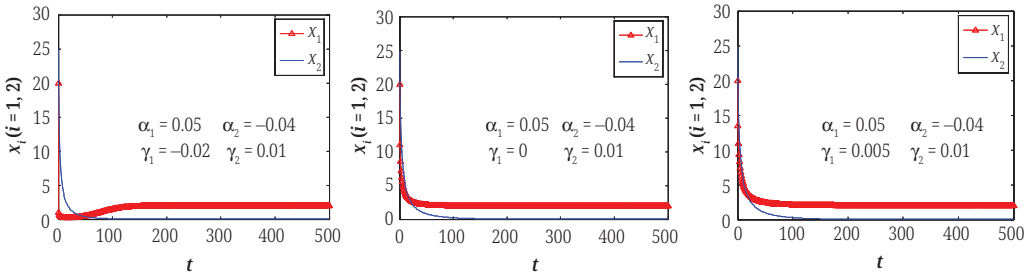
(d) Parasitic evolution (e) Biased beneficial evolution (f) Asymmetric mutualistic evolution

Fig. 2. Six evolutionary processes of foreign language teaching majors when condition 1 is met



(a) Independent evolution (b) Competitive evolution (c) Antagonistic evolution

Fig. 3. *(Continued)*

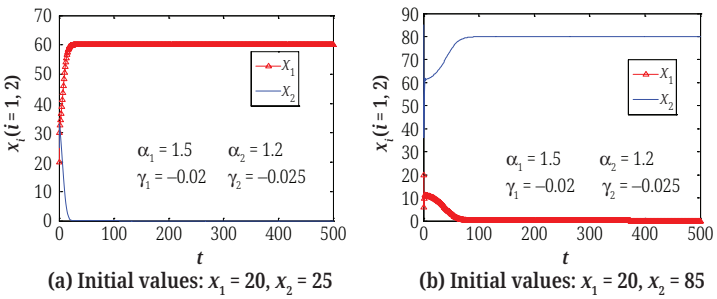


(d) Parasitic evolution **(e) Biased beneficial evolution** **(f) Asymmetric mutualistic evolution**

Fig. 3. Six evolutionary processes of foreign language education majors when condition 2 is met

When $\alpha_1 = -0.04$ and $\alpha_2 = -0.03$, condition 1 holds true. Regardless of the evolutionary pattern between majors, the teaching level and the level of AI application in foreign language education will eventually both reach 0, as shown in Figures 1 and 6(a). At this point, as the evolutionary stage and evolutionary pattern of foreign language education majors' progress, the teaching level and the level of AI application exhibit an increasing trend at an unstable simultaneous iteration moment. The longer the iteration cycle when both teaching level and AI application level decrease to 0, the more favorable it is for symmetric mutualistic evolution to counteract the inherent negative growth of teaching level. Asymmetric mutualistic evolution follows, and other evolutionary patterns are least favorable.

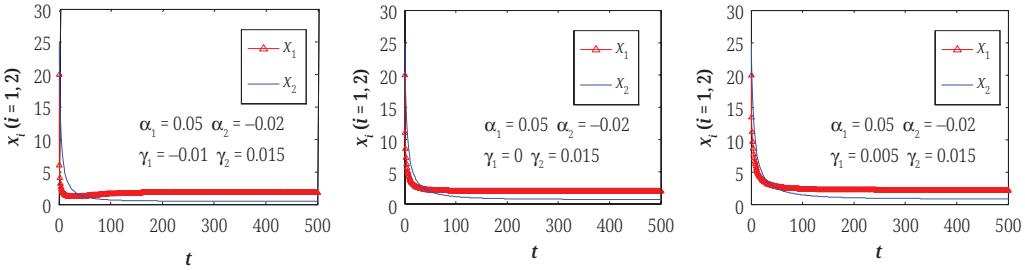
When $\alpha_1 = 0.05$, $\alpha_2 = -0.04$, $\beta_1 = 0.025$ and $\gamma_2 < 0.012$, condition 2 holds. Under the influence of any evolutionary pattern, both the foreign language teaching level and the level of AI application will eventually stabilize at the equilibrium point P_2 (2, 0), as shown in Figures 2 and 6(b). When this condition holds, with the evolution of the stages and patterns of foreign language education majors, at the same unstable iteration moment, the foreign language teaching level shows an upward trend, while the foreign language teaching level and the level of AI application fluctuate downward as a whole and stabilize respectively at the required iterations 2 and 0; This implies that, as the co-evolution period between AI and foreign language teaching is extended, symmetric mutualistic evolution is superior to asymmetric mutualistic evolution, and asymmetric mutualistic evolution is superior to other evolutionary patterns. When condition 3 holds, foreign language education majors will exhibit a similar evolutionary process. Therefore, this study omits the simulation of the evolutionary trend toward the equilibrium point P3 for foreign language education majors.



(a) Initial values: $x_1 = 20$, $x_2 = 25$ **(b) Initial values: $x_1 = 20$, $x_2 = 85$**

Fig. 4. The impact of initial values on the evolutionary pattern of foreign language education majors when conditions 2 and 3 are satisfied

When $\alpha_1 = 1.5$, $\alpha_2 = 1.2$, $\beta_1 = 0.025$, $\beta_2 = 0.015$, $\gamma_1 < -0.01875$ and $\gamma_2 < 0.02$, both condition 2 and condition 3 are met simultaneously. After a certain period of evolution, the foreign language education majors can stabilize at either equilibrium point P_2 (60, 0) or P_3 (0, 80), depending on the initial state of the majors. For example, if the initial teaching level and the level of AI technology application satisfy $x_1 = 20$ and $x_2 = 25$, the final stable point is P_2 (60, 0). On the other hand, if the initial teaching level and the level of AI technology application satisfy $x_1 = 20$ and $x_2 = 85$, the final stable point is P_3 (0, 80), as shown in Figure 3. It should be noted that once the initial states of the foreign language education majors and AI technology are determined, their final stable points will remain unchanged, and the evolutionary process towards the stable points will be similar to the case when a single condition is met.



(a) Parasitic evolution **(b) Beneficial evolution** **(c) Asymmetric mutualistic evolution**

Fig. 5. The three evolutionary processes of foreign language teaching majors when condition 4 is met

When $\alpha_1 = 0.05$, $\alpha_2 = -0.02$, $\beta_1 = 0.025$, $\beta_2 = 0.015$, $\gamma_1 < 0.0375$ and $\gamma_2 > 0.01$, condition 4 is satisfied. Under this condition, foreign language education majors can stabilize at equilibrium point P_4 $((0.75 - 20\gamma_1) / (0.375 - 1000\gamma_1\gamma_2), (50\gamma_2 - 0.5) / (0.375 - 1000\gamma_1\gamma_2))$ through the effects of three evolutionary modes: beneficial evolution, asymmetric mutualistic evolution, and symmetric mutualistic evolution. Furthermore, with the evolution of the developmental stage and evolutionary mode of foreign language education majors, the upper limit of language teaching proficiency increases, transitioning from the stable scale of the formative stage (1.81, 0.48) or (2, 0.67) to the stable scale of the growth stage (2.17, 0.83), and further to the stable scale of the mature stage (3, 1.67), as shown in Figures 4 and 6(c). The main reason for this phenomenon is the increasing positive impact of the evolutionary interaction between foreign language education majors and AI technology on the growth of both teaching proficiency and technology application levels. In other words, in achieving the maximum stable growth scale for foreign language education majors, beneficial evolution is weaker than asymmetric mutualistic evolution, and the latter is weaker than symmetric mutualistic evolution. When condition 5 is satisfied, a similar evolutionary process of foreign language education majors occurs; hence, this study omits the simulation of the evolutionary trend towards equilibrium point P4 under this condition.

When $\alpha_1 = 1.5$, $\alpha_2 = 1.2$, $\beta_1 = 0.025$, $\beta_2 = 0.015$, $\gamma_1 > -0.01875$ and $\gamma_2 > -0.02$, condition 6 holds. Under the influence of all evolutionary patterns, both the level of foreign language education and the level of AI technology application will eventually stabilize at the equilibrium point P_4 $((22.5 + 1200\gamma_1) / (0.375 - 1000\gamma_1\gamma_2), (30 + 1500\gamma_2) / (0.375 - 1000\gamma_1\gamma_2))$; as the evolutionary stages and patterns of foreign language education majors evolve, the development trajectory of foreign language education majors tends to converge, the upper limit of growth increases, and the gaps between the upper limits of growth decrease. As shown in Figures 5 and 6(d), from the formative stage to the

growth stage and then to the mature stage, the development trajectory of foreign language education majors and the level of AI technology application shift from reverse growth dominance to positive growth in the same direction. The stable scale increases from (60, 80), (18.75, 68.75), (12, 80), (11.11, 81.48), or (60, 88) to (63.54, 88.47), and then to (67.12, 88.95). This indicates that the evolutionary pattern that best facilitates foreign language education majors to achieve the largest stable growth scale in a benign development trend is the symmetric mutualistic symbiosis, followed by asymmetric mutualistic symbiosis, and finally other evolutionary patterns.

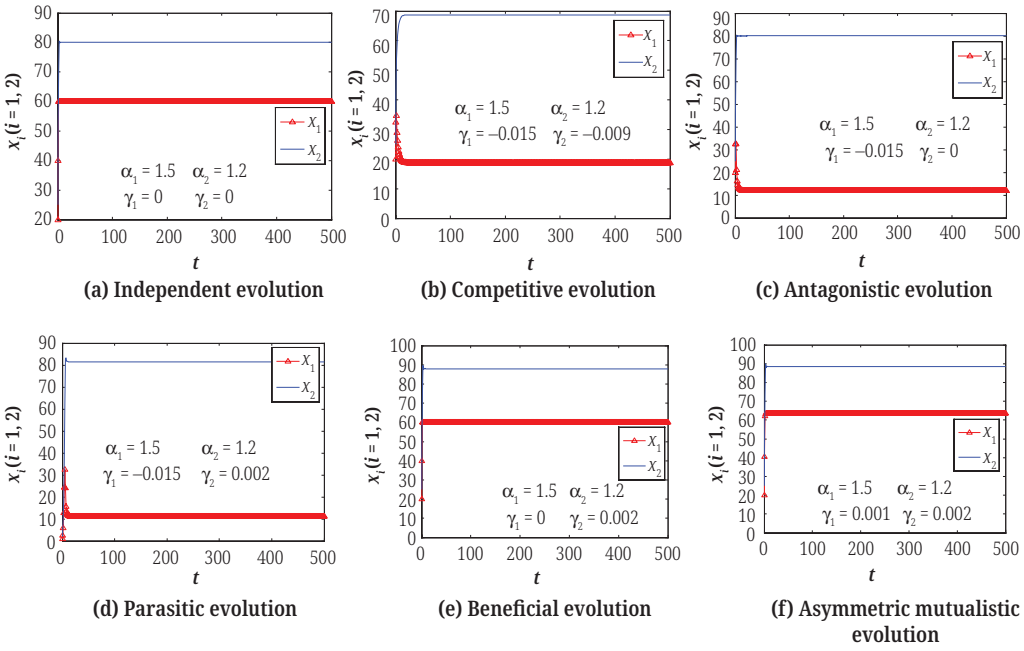


Fig. 6. Six evolutionary processes of foreign language teaching majors when condition 6 is met

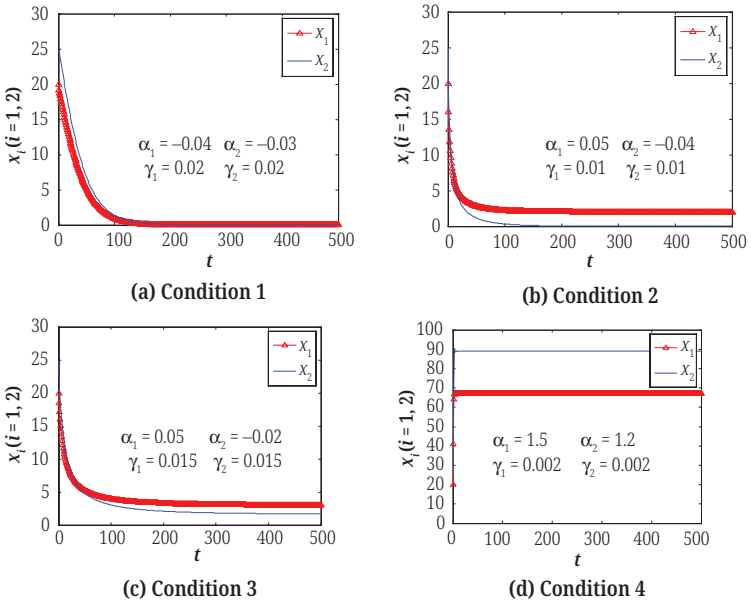


Fig. 7. Symmetric mutualistic evolution process of foreign language teaching majors under various conditions

Based on the above analysis, it can be concluded that foreign language education majors and AI technology co-evolve under the linkage of evolutionary relationships. The evolutionary coefficients between foreign language education majors and AI technology, as well as the growth rates of teaching level and technology application level, determine the evolutionary outcomes of foreign language education majors. When the growth rate of foreign language teaching is constant, foreign language education and AI technology exhibit different evolutionary trends under different evolutionary modes, leading to different emergent effects and eventually reaching evolutionary equilibrium.

Under the effect of symmetric mutualistic evolution, foreign language education majors and AI technology collaborate deeply and co-evolve, aiming to achieve the maximum growth amplitude in a satisfactory evolutionary direction. This represents one of the ideal states of collaborative development for foreign language education majors in the context of the new liberal arts.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Based on the framework of the symbiotic evolution between foreign language teaching programs and AI technologies in the context of the new liberal arts, this study developed a dynamic model to analyze the evolution of teaching levels in foreign language programs and the application levels of AI technologies. The following were the main conclusions drawn: 1) The symbiotic evolution between foreign language teaching programs and AI technologies can be divided into three stages and four evolutionary modes. The three stages are the formation stage, the growth stage, and the maturity stage. The four modes include independent coevolution, competitive coevolution, parasitic coevolution, and mutualistic coevolution. The dominant evolutionary mode in the coevolution of foreign language teaching and AI technologies varies across different evolutionary stages. 2) The evolutionary trajectories of foreign language teaching and AI technologies are complex and varied. The dynamic model based on the logistic equation effectively describes the evolutionary relationship between foreign language teaching and AI technologies. The final steady state of the coevolution of foreign language teaching programs mainly depends on the growth rate of teaching levels and the size of the coevolution coefficient. 3) The mode of symmetric mutualistic coevolution is stable and efficient, representing the most powerful evolutionary mode for foreign language teaching programs. Under this mode, foreign language teaching programs exhibit the highest consistency in evolution and can achieve the maximum student scale, facilitating the deep integration and development of various programs in the context of the new liberal arts.

5.2 Recommendations

Based on the above research conclusions and to promote the transition and maintenance of foreign language teaching programs towards the symmetric mutualistic coevolution mode, thereby achieving high-quality integration and interaction among programs, the following recommendations are proposed:

1. To foster a the coevolution of foreign language teaching programs and AI technologies at different evolutionary stages, it is recommended to institute a regulatory mechanism led by supervisory entities, alongside the formulation of pertinent policies and measures. In the formation stage of program evolution, administrative directives, resource allocation, and subsidy measures can be used to inject initial impetus into foreign language teaching programs, promoting top-down integration. At the growth stage, a reasonable mechanism for sharing benefits and bearing risks can be established, along with a leadership group and expert group for program integration to regulate the integration process, optimize resource allocation, and guide foreign language teaching programs towards the evolution mode of symmetric mutualistic coevolution. During the maturity stage, it is advisable to implement a comprehensive evaluation and governance system aimed at supervising the actual evolution status of foreign language teaching programs, rectify deviations in a timely manner, and maintain a high-quality interactive state among programs in the long term. In the regulatory process, special attention should be paid to monitoring the co-evolutionary effects of foreign language teaching programs. Specifically, if the teaching level of a foreign language program is consistently increasing, the co-evolutionary effect of AI technologies should be monitored to keep their impact below a threshold to avoid their extinction. If the teaching level of a foreign language program is consistently increasing while the application level of AI technologies is decreasing, the coevolutionary effect between them should be monitored to maintain their impact on each other within a threshold range, ultimately enabling the coordinated and ideal development of foreign language teaching and AI technologies. If the teaching level of a foreign language program is consistently increasing, the coevolutionary effect between them should be monitored to ensure their impact on each other remains above a threshold, stabilizing each program at an ideal state.
2. Establish a driving mechanism led by foreign language teaching programs to unleash the demand for program integration. On the one hand, foreign language teaching programs should break free from the mindset of "waiting, relying, and demanding," proactively align with the development plan of the new liberal arts, innovate boldly, break through self-imposed constraints, enhance their own development levels, and release the demand for cross-program integration to form an intrinsic driving force for program integration. On the other hand, foreign language teaching programs should follow the laws of program evolution, actively collaborate, and create evolutionary points in curriculum systems, teaching systems, support platforms, and interdisciplinary competition organizations to undertake the demand for evolutionary dynamics and value creation, thereby promoting the coevolution of foreign language teaching programs.
3. Establish a technical support mechanism led by modern information technology to promote the deep integration of foreign language teaching programs both online and offline. First, AI technologies should be used to create a blended teaching mode for foreign language teaching programs, enhancing their ability to exchange and share resources and ensuring the sustainability and smoothness of program evolution, especially in emergencies. Secondly, the remaining data within the technical system should be fully exploited to analyze the health status of the evolution of foreign language teaching programs, propose corresponding strategies, and enhance the new liberal arts transformation effect of foreign language teaching programs in the dimension of internal integration.

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