Jie SUN, PhD (corresponding author)
jie.sun@buu.edu.cn
Beijing Union University, Beijing, China

Yiliu HE, Master's Candidate
heyiliu2023@126.com
Beijing Union University, Beijing, China

Mincong TANG, PhD
mincong@bjtu.edu.cn
Beijing Jiaotong University, Beijing, China

Taihui WU, Master's Candidate
Wutaihui2025@126.com
Beijing Union University, Beijing, China

The Dynamics of Education Public Opinion Governance: An Evolutionary Game Theory Approach

Abstract. *The governance of education public opinion has become a pressing issue in the digital age, where information dissemination is rapid, and public sentiment evolves dynamically. This study applies evolutionary game theory to model the strategic interactions among four key stakeholders: the media, government, netizens, and schools. Using bounded rationality assumptions, a quadripartite game model is developed to analyse the decision-making behaviours and stability conditions of these actors. MATLAB-based simulations reveal that government regulations, media reporting accuracy, school responsiveness, and netizen participation significantly influence public opinion evolution. Key findings indicate that proactive governance measures, such as transparent media policies, responsive educational institutions, and strategic government interventions, contribute to a more stable public opinion environment. The study provides a quantitative foundation for optimising policy decisions and improving the effectiveness of education public opinion management. Future research should explore real-world case validations and AI-driven predictive modelling to enhance the adaptability and efficiency of public opinion governance systems.*

Keywords: *game theory, education public opinion, collaborative governance.*

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1. Introduction

The rapid advancement of digital media technologies has dramatically transformed the dissemination and formation of public opinion (Lu et al., 2025), particularly in the domain of education governance. With the proliferation of social

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media platforms, individuals now have unprecedented access to information sharing and public discourse, reshaping the way educational issues are debated and perceived. This shift has led to a complex and dynamic public opinion ecosystem (Gao et al., 2023), where stakeholders – including the media, government agencies, educational institutions, and netizens – interact in unpredictable ways, often influencing policy decisions, institutional credibility, and public trust in the education system.

As the public discourse around education becomes increasingly fragmented and polarised, its governance poses significant challenges. Misinformation, exaggerated narratives, and the rapid viral spread of unverified content can trigger widespread controversy, erode institutional credibility, and escalate conflicts between stakeholders (Matteo et al., 2024). In this context, effective governance of education-related public opinion requires a strategic and systematic approach that accounts for the complex interactions among different actors.

Game theory, particularly evolutionary game theory, provides a powerful analytical tool to model these interactions. Unlike traditional static decision models, evolutionary game theory accounts for the bounded rationality of decision-makers, recognising that stakeholders continuously adjust their strategies based on real-time feedback and changing incentives. This study constructs a quadripartite evolutionary game model incorporating four key stakeholders:

(1) The Media, which acts as the primary channel for disseminating and framing information. The media can choose between truthful reporting and distorted reporting, impacting public perception and institutional trust.

(2) The Government, responsible for policy intervention and regulatory oversight. It must decide between active regulation to curb misinformation or a passive approach, which may lead to unchecked speculation.

(3) Netizens (the public), who engage in online discourse, either actively participating in shaping opinions or remaining passive observers.

(4) Schools and Educational Institutions, which can either proactively respond to public scrutiny through transparency and crisis management or adopt a passive stance, risking reputational damage.

Using MATLAB simulations, this study explores how different stakeholder strategies evolve over time, identifying equilibrium conditions and the impact of regulatory policies, media behaviour, and public engagement on the stability of education-related public opinion. The findings reveal that government intervention, media integrity, and institutional responsiveness play a crucial role in maintaining public trust and mitigating misinformation. This research contributes to the theoretical and practical understanding of education public opinion governance by offering quantitative insights into the strategic interactions between stakeholders. It provides policy recommendations for enhancing media accountability, optimising regulatory interventions, and fostering public engagement to create a more stable and transparent public discourse environment. Future research directions include real-world case validation, AI-driven predictive modeling, and cross-disciplinary applications to refine public opinion management strategies in education governance.

2. Literature review

Contributions to game theory span various economic disciplines, with scholars increasingly integrating game-theoretic frameworks with interdisciplinary approaches (Samuelson, 2016). Ramírez and Romo(2025) developed an evolutionary game model to analyse how trade liberalisation exacerbates poverty traps in high-wage economies by disrupting labour market dynamics and human capital accumulation (Ramírez & Romo, 2025). In the field of urban development research, Han et al.(2024) constructed an evolutionary game model to examine the phased characteristics of urban inefficient land redevelopment, demonstrating how stakeholder interactions influence spatial governance outcomes (Han et al., 2024). In consumer behaviour studies, Bó et al. (2024) employed experimental game theory to investigate strategic privacy-protection behaviours under personalised pricing schemes, revealing a paradox between market efficiency and data ethics (Bó et al., 2024). Meanwhile, Wu et al. (2025) proposed a cooperative game-theoretic mechanism for vehicle-to-grid (V2G) systems, achieving Pareto-optimal improvements that balance grid profitability and sustainability goals (Wu et al., 2025). Cao and Xing (2018) advanced tripartite game modelling to examine strategic interactions among governments, enterprises, and financial institutions under information asymmetry, offering insights into green policy implementation (Cao & Xing, 2018). Game theory applications also extend to economic benefit assessment through Shapley value allocations in virtual power plants (Wang et al., 2021), green innovation incentivisation via financial regulation games (Bai & Lin, 2024), and optimal delegation mechanisms in organisational decision-making (Hu & Lei, 2024).

The evolution of educational public opinion constitutes a dynamic gaming system in which multiple stakeholders compete for discursive dominance. Chen et al. (2016) employed signalling games to analyse information asymmetry during the incubation phase of online educational controversies (Chen, Liu, & Guan, 2016). Yin et al. (2019) integrated attitude change theory with evolutionary game principles to develop an agent-based opinion formation model, capturing the nonlinear propagation patterns of educational sentiments (Yin et al., 2019). Educational public opinion can be defined as the collective expression of emotions, attitudes, and perspectives held by a community centered around students, in response to public events related to education (Tian, 2022). The evolutionary system of educational public opinion involves four key stakeholders: the government, schools, media, and netizens. Within this system, the propagation of public sentiment triggers multifaceted interactions among these entities, characterised by varied qualities and directions, ultimately leading to specific configurations in their relationships. In this framework, the media plays a dominant role in shaping the trajectory of educational discourse and influencing societal opinion. The government is responsible for maintaining social order and fostering an environment conducive to positive public discourse (Gao et al., 2018)

Netizens serve as both key participants and collaborative forces in steering educational public opinion (Busemeyer et al., 2018; Shen et al., 2020). Schools act as the central force in addressing educational sentiment, guiding students toward appropriate value systems.

Based on the dynamics of educational public opinion, this paper constructs a four-party evolutionary game model involving the government, schools, media, and netizens. It analyses the dynamic strategic choices of these stakeholders and examines the mechanisms influencing game outcomes according to evolutionary stability strategy principles.

3. Research Methodology

3.1 Model Description and Hypothesis

The following assumptions are made:

1. The "Limited Rationality" Assumption: In reality, due to various influencing factors, decision-makers operate under conditions of limited rationality (Ma et al., 2021; Škare & Kostelić, 2015; Xu et al., 2024). This implies that in practical game scenarios, some participants do not strictly adhere to fully rational equilibrium strategies (Luo et al., 2023; Jin et al., 2024). Within the realm of educational public opinion, factors such as information asymmetry, varying cognitive abilities, and the complexity of information processing hinder stakeholders from making optimal decisions purely based on revenue maximisation. As a result, they must continuously adjust and refine their behavioural strategies (Cetin et al., 2023). Therefore, assuming limited rationality for these four stakeholders provides a more accurate and realistic representation of their decision-making processes.

2. This study assumes that the four key stakeholders: media, government, netizens, and schools, each of them has two strategic options in the evolutionary game model.

(1) Media Strategies

True Reporting: This involves rigorous content verification, high-quality information dissemination, and active public engagement to mitigate emotional reactions and promote rational discourse. The proportion of media adopting this strategy is x ($0 \leq x \leq 1$).

Distorted Reporting: This strategy involves blending facts with rumours, providing incomplete or misleading information, creating confusion and controversy. The proportion of media choosing this strategy is 1 - x.

(2) Government Strategies

Effective Supervision: This involves proactively managing education-related public opinion, utilising both automated and manual monitoring, facilitating transparent information flow, and actively addressing public concerns. The proportion of the government implementing this strategy is y ($0 \leq y \leq 1$).

Supervision Absence: In this scenario, the government fails to conduct pre-emptive analysis of educational public opinion, often due to complex social environments, leading to weakened regulatory effectiveness. The proportion choosing this strategy is 1 - y.

(3) Netizen Strategies

Participation: Engaging in discussions by expressing emotions such as outrage, ridicule, or skepticism, often driven by empathy or shared experiences following an education-related public opinion event. The proportion of netizens adopting this strategy is z ($0 \leq z \leq 1$).

Non-Participation: Remaining indifferent to the event, choosing not to engage in discussions or express opinions. The proportion selecting this strategy is 1 - z.

(4) School Strategies

Active Response: This entails strengthening ideological and political education, enhancing public opinion management, improving leadership structures, optimising internal workflows, and increasing institutional efficiency. The proportion of schools following this strategy is w ($0 \leq w \leq 1$).

Passive Response: Schools in this category fail to analyse public opinion trends, media concerns, and key public discourse points, which can lead to greater negative impacts due to inadequate handling. The proportion choosing this strategy is 1 - w.

This strategic framework provides a structured foundation for analysing the dynamic interactions between these four entities in the evolution of educational public opinion.

3. The value of the benefit (payment) under the four-way game:

(1) Schools actively respond to the need to invest in manpower, materials and other resources, constituting a cost of $\mathrm{C_{sh}}$, to obtain the benefits of maintaining campus stability as $\mathrm{B_{sh}}$. The media truthfully report on the school's initiatives to actively respond to the initiative, etc., the need to carry out information verification and other work to pay a cost of $\mathrm{C_{mh}}$, to obtain the benefits of $\mathrm{B_m}$. Netizens participate in the discussion of public opinion topics, obtaining the sense of social acceptance, emotional fulfilment and other potential benefits of $\mathrm{B_n}$, the need to invest in time, search and other resources, forming a cost $\mathrm{C_n}$. If the government regulates public opinion at the initial stage and during the diffusion process, it will have to pay the cost $\mathrm{C_g}$, but it can get the benefit $\mathrm{B_{gh}}$. On the contrary, If the government adopts the negative regulation strategy, its cost will be $\mathrm{C_{gl}}(\mathrm{C_{gl}} < \mathrm{C_g})$, but because of the positive role of the school and the media, the benefit will still be $\mathrm{B_{gh}}$.

(2) When the media disseminate information that is either exaggerated or distorted in order to attract attention and misrepresent the school's positive response, the consequence is a reduction in the value of the school's reputation, which can be

expressed as $C_{ml}(C_{ml} < C_{mh})$. In the absence of government regulation, the likelihood of inaccurate reports arousing heated debates among netizens increases. These result in additional benefits for the media, B_{ma}, in addition to the normal benefits B_m. However, the media also faces the possibility of fines from the government, with the cost of fines being P_m. The cost of damage to the school's image as a result of the inaccurate reports is N_{sa}, and the loss of the value of netizens' information is N_{na}. In the absence of government regulation, the cost is $C_{gl}(C_{gl} < C_g)$. The school still gains governance benefits B_{gh}because it responds positively, but the misrepresentation of the media has a negative impact on the government, resulting in a loss of N_{ga}. If government regulation is in place to effectively control the negative effects of inaccurate reporting, a higher cost $C_{gh}(C_{gh} < C_g)$ is incurred than if the media is regulated to report truthfully. The media pay a cost C_{ml} because of government regulation.

(3) Negative responses by educational institutions will result in negative consequences, including a loss of credibility, with a cost of $C_{sl}(C_{sl} < C_{sh})$ and a gain of $B_{sl}(B_{sl} < B_{sh})$. The value of the gain to netizens of enjoying a good social environment is reduced to $B_{nl}(B_{nl} < B_n)$, and the government's governance gain is reduced to $B_{gl}(B_{gl} < B_{gh})$. If the media report truthfully, the cost is C_{mh}. In addition to the normal benefit B_m, it also attracts more public attention and gains an additional benefit B_{mb} by reporting negative public opinion. The school is subject to disciplinary action by the government as a consequence of the media coverage. In the absence of netizens engaging in public opinion discourse, the potential value is lost, resulting in a cost of P_{sa}. When netizens engage in public opinion discussion, the cost of facing government punishment for making inappropriate remarks, etc. is P_{sb}. The government is under public pressure because of the participation of netizens, so $P_{sb} > P_{sa}$.

(4) The media's tendency to disseminate exaggerated and inaccurate information has the effect of increasing the benefit gained by the school (B_{mc}) while simultaneously reducing the cost to the government (C_{ml}).This is because the inaccurate reporting attracts greater public attention, thereby creating a greater negative impact value of N_{sb} for the school, a greater loss of information value of N_{nb} for the netizens, and an adjustment cost of N_{gb} for the government regulation.

The gain (payment) matrix of the four subjects is shown in Table 1.

Table 1. Gain (payment) matrix for the four-way game

		Government regulation in place: y		**Lack of government regulation : 1-y**	
		Netizen Participation: z	**Non-participation of netizens: 1-z**	**Netizen Participation : z**	**Non-participation of netizens: 1-z**
	Real Media Coverage: x	$a_{11}=B_{sh}-C_{sh}$ $b_{11}=B_m-C_{mh}$ $c_{11}=B_{gh}-C_g$ $d_{11}=B_{nh}-C_n$	$a_{12}=B_{sh}-C_{sh}$ $b_{12}=B_m-C_{mh}$ $c_{12}=B_{gh}-C_g$ $d_{12}=B_{nh}$	$a_{13}=B_{sh}-C_{sh}$ $b_{13}=B_m-C_{mh}$ $c_{13}=B_{gh}-C_{gl}$ $d_{13}=B_{nh}-C_n$	$a_{14}=B_{sh}-C_{sh}$ $b_{14}=B_m-C_{mh}$ $c_{14}=B_{gh}-C_{gl}$ $d_{14}=B_{nh}$

		Government regulation in place: y		Lack of government regulation: 1-y	
		Netizen Participation: z	**Non-participation of netizens: 1-z**	**Netizen Participation: z**	**Non-participation of netizens: 1-z**
Schools respond positively: w	**Media misrepresentation: 1-x**	$a_{21}=B_{sh}-C_{sh}$ $b_{21}=-C_{ml}$ $c_{21}=B_{gh}-C_{gh}$ $d_{21}=B_{nh}-C_n$	$a_{22}=B_{sh}-C_{sh}$ $b_{22}=-C_{ml}$ $c_{22}=B_{gh}-C_{gh}$ $d_{22}=B_{nh}$	$a_{23}=B_{sh}-C_{sh}-N_{sa}$ $b_{23}=B_m+B_{ma}-C_{ml}-P_m$ $c_{23}=B_{gh}-C_{gl}-N_{ga}+Pm$ $d_{23}=B_{nh}-N_{na}-C_n$	$a_{24}=B_{sh}-C_{sh}$ $b_{24}=B_m+B_{ma}-C_{ml}-P_m$ $c_{24}=B_{gh}-C_{g}l-N_{ga}+P_m$ $d_{24}=B_{nh}-N_{na}$
Schools responding negatively: 1-w	**Real Media Coverage: x**	$a_{31}=B_{sl}-C_{sl}-P_{sb}$ $b_{31}=B_m-C_{mh}+B_{mb}$ $c_{31}=B_{gl}-C_g+P_{sb}$ $d_{31}=B_{nl}-C_n$	$a_{32}=B_{sl}-C_{sl}-P_{sa}$ $b_{32}=B_m-C_{mh}+B_{mb}$ $c_{32}=B_{gl}-C_g+P_{sa}$ $d_{32}=B_{nl}$	$a_{33}=B_{sl}-C_{sl}-P_{sb}$ $b_{33}=B_m-C_{mh}+B_{mb}$ $c_{33}=B_{gl}-C_{gl}+P_{sb}$ $d_{33}=B_{nl}-C_n$	$a_{34}=B_{sl}-C_{sl}-P_{sa}$ $b_{34}=B_m-C_{mh}+B_{mb}$ $c_{34}=B_{gl}-C_{gl}+P_{sa}$ $d_{34}=B_n$
	Media misrepresentation: 1-x	$a_{41}=B_{sl}-C_{sl}-P_{sb}$ $b_{41}=-C_{ml}$ $c_{41}=B_{gl}-C_{gh}+P_{sb}$ $d_{41}=B_{nl}-C_n$	$a_{42}=B_{ol}-C_{sl}-P_{sa}$ $b_{42}=-C_{ml}$ $c_{42}=B_{gl}-Cgh+P_{sa}$ $d_{42}=B_{nl}$	$a_{43}=B_{ol}-C_{sl}-N_{sb}-P_{sb}$ $b_{43}=B_m-C_{ml}+B_{mc}-P_{mc}$ $c_{43}=B_{gl}-C_{gl}-N_{gb}+P_m+P_{sb}$ $d_{43}=B_{nl}-N_{nb}-C_n$	$a_{44}=B_{sl}-C_{sl}-P_{sa}$ $b_{44}=B_m-C_{ml}+B_{mc}-P_m$ $c_{44}=B_{gl}-C_{gl}-N_{gb}+P_m+P_{sa}$ $d_{44}=B_{nl}-N_{nb}$

Source: Authors` own work.

3.2 The analysis

3.2.1 Construction of the Expected Return Equation

The expected return equations of government, school, media, and netizens are presented in Table 2.

Table 2. Expected Returns of the Four-Party Game

Subject		Expected return	Serial number
Media		$A = xA_1 + (1-x)A_2$	(1)
	Real reporting	$A_1 = w\{y[zb_{11} + (1-z)b_{12}] + (1-y)[zb_{13} + (1-z)b_{14}]\} + (1-w)\{y[zb_{31} + (1-z)b_{32}] + (1-y)[zb_{33} + (1-z)b_{34}]\}$	(2)
	Distortion reporting	$A_2 = w\{y[zb_{21} + (1-z)b_{22}] + (1-y)[zb_{23} + (1-z)b_{24}]\} + (1-w)\{y[zb_{41} + (1-z)b_{42}] + (1-y)[zb_{43} + (1-z)b_{44}]\}$	(3)
Government		$B = yB_1 + (1-y)B_2$	(4)
	Supervision is in place	$B_1 = z\{w[xc_{11} + (1-x)c_{21}] + (1-w)[xc_{31} + (1-x)c_{41}]\} + (1-z)\{w[xc_{12} + (1-x)c_{22}] + (1-w)[xc_{32} + (1-x)c_{42}]\}$	(5)
	Lack of supervision	$B_2 = z\{w[xc_{13} + (1-x)c_{23}] + (1-w)[xc_{33} + (1-x)c_{43}]\} + (1-z)\{w[xc_{14} + (1-x)c_{24}] + (1-w)[xc_{34} + (1-x)c_{44}]\}$	(6)
Netizens		$C = zC_1 + (1-w)C_2$	(7)
	Participation	$C_1 = y\{w[xd_{11} + (1-x)d_{21}] + (1-w)[xd_{31} + (1-x)d_{41}]\} + (1-y)\{w[xd_{13} + (1-x)d_{23}] + (1-w)[xd_{33} + (1-x)d_{43}]\}$	(8)

Subject		Expected return	Serial number
	Non-participation	$C_2 = y\{w[xd_{12} + (1-x)d_{22}] + (1-w)[xd_{32} + (1-x)d_{42}]\} + (1-y)\{w[xd_{14} + (1-x)d_{24}] + (1-w)[xd_{34} + (1-x)d_{44}]\}$	(9)
		$D = wD_1 + (1-w)D_2$	(10)
Schools	Energetic response	$D_1 = x\{y[za_{11} + (1-z)a_{12}] + (1-y)[za_{13} + (1-z)a_{14}]\} + (1-x)\{y[za_{21} + (1-z)a_{22}] + (1-y)[za_{23} + (1-z)a_{24}]\}$	(11)
	Passive response	$D_2 = x\{y[za_{31} + (1-z)a_{32}] + (1-y)[za_{33} + (1-z)a_{34}]\} + (1-x)\{y[za_{41} + (1-z)a_{42}] + (1-y)[za_{43} + (1-z)a_{44}]\}$	(12)

Source: Authors` own work.

3.2.2 Construction of replicated dynamic equation

The equations (1), (4), (7), and (10) are subsequently integrated into the computation process as detailed in Table 3.

Table 3. Replicated dynamic equations of the four-party game

Subject	Replicating dynamic equations	Serial number
Media	$S(x) = \frac{dx}{dt} = x(A_1 - A) = x(1-x)(A_1 - A_2)$	(13)
Government	$T(y) = \frac{dy}{dt} = y(B_1 - B) = y(1-y)(B_1 - B_2)$	(14)
Netizens	$U(z) = \frac{dz}{dt} = z(C_1 - C) = z(1-z)(C_1 - C_2)$	(15)
Schools	$V(w) = \frac{dw}{dt} = w(D_1 - D) = w(1-w)(D_1 - D_2)$	(16)

Source: Authors` own work.

Substituting Eqs. (2) and (3) into Eq. (13), Eqs. (5) and (6) into Eq. (14), Eqs. (8) and (9) into Eq. (15), and Eqs. (11) and (12) into Eq. (16), and using the simplify function, we obtain the replicated dynamic equation system (17) as follows:

$$\begin{cases} S(X) = \sum_{i=1}^{4} \sum_{j=1}^{4} \left(b_{ij} \cdot (-1)^{i+j}\right) \cdot y^{i-1} z^{j-1} w^{\frac{5-i-j}{2}} \\ T(y) = \sum_{i=1}^{4} \sum_{j=1}^{4} \left(c_{ij} \cdot (-1)^{i+j}\right) \cdot x^{i-1} z^{j-1} w^{\frac{5-i-j}{2}} \\ U(z) = \sum_{i=1}^{4} \sum_{j=1}^{4} \left(d_{ij} \cdot (-1)^{i+j}\right) \cdot x^{i-1} y^{j-1} w^{\frac{5-i-j}{2}} \\ V(w) = \sum_{i=1}^{4} \sum_{j=1}^{4} \left(a_{ij} \cdot (-1)^{i+j}\right) \cdot x^{i-1} y^{j-1} z^{\frac{5-i-j}{2}} \end{cases} \tag{17}$$

3.3 Model solving

3.3.1 Constructing the Jacobian matrix

The Jacobian matrix that replicates the dynamic system of equations Eq. (17) is J:

$$\mathrm{J}(x,y,z,w)=\begin{bmatrix}\frac{\partial S(x,y,z,w)}{\partial x} & \frac{\partial S(x,y,z,w)}{\partial y} & \frac{\partial S(x,y,z,w)}{\partial z} & \frac{\partial S(x,y,z,w)}{\partial w}\\ \frac{\partial T(x,y,z,w)}{\partial x} & \frac{\partial T(x,y,z,w)}{\partial y} & \frac{\partial T(x,y,z,w)}{\partial z} & \frac{\partial T(x,y,z,w)}{\partial w}\\ \frac{\partial U(x,y,z,w)}{\partial x} & \frac{\partial U(x,y,z,w)}{\partial y} & \frac{\partial U(x,y,z,w)}{\partial z} & \frac{\partial U(x,y,z,w)}{\partial w}\\ \frac{\partial V(x,y,z,w)}{\partial x} & \frac{\partial V(x,y,z,w)}{\partial y} & \frac{\partial V(x,y,z,w)}{\partial z} & \frac{\partial V(x,y,z,w)}{\partial w}\end{bmatrix} \quad (18)$$

3.3.2 Equilibrium point solution

According to the equilibrium theory, let the system of equations (17) = 0. The solution of the system of equations (18) yields 17 equilibrium points, including 16 pure-strategy equilibrium points and 1 mixed-strategy equilibrium point. As the asymptotically stable solution of the replicated dynamical system of the multi-group game must be a strict Nash equilibrium (Ritzberger & Jörgen, 1995), the possible stable equilibrium points of the four-party evolution game are the aforementioned 16 pure-strategy equilibrium points, which constitute the boundaries of the domain of the evolution game$\{(\mathrm{x},\mathrm{y},\mathrm{z},\mathrm{w})|\mathrm{x}=0,1;\mathrm{y}=0,1;\mathrm{z}=0,1;\mathrm{w}=0,1\}$. The enclosed region M is the equilibrium solution domain of the four-party game. That is to say, O is defined as the set of all points (x, y, z, w) satisfying the following constraints: $O=\{(\mathrm{x},\mathrm{y},\mathrm{z},\mathrm{w})|0\le \mathrm{x}\le 1,0\le \mathrm{y}\le 1,0\le \mathrm{z}\le 1,0\le \mathrm{w}\le 1\}$.

3.4 Stability analysis of equilibrium point

The equilibrium points of the replicated dynamical system are incorporated into the Jacobi matrix equation (18), and the eigenvalues of the Jacobi matrix corresponding to the equilibrium points are derived as shown in Table 4.

Table 4. Stability analysis of local equilibrium point

Equilibrium point	eigenvalue (math.) λ_1	eigenvalue (math.) λ_2	eigenvalue (math.) λ_3	eigenvalue (math.) λ_4	plus or minus sign	Stability
E_1(0，0，0，0)	$b_{34}-b_{44}$	$c_{42}-c_{44}$	$d_{43}-d_{44}$	$a_{24}-a_{44}$	U Ritz Berger - U	Instability
E_2(1，0，0，0)	$b_{44}-b_{34}$	$c_{32}-c_{34}$	$d_{33}-d_{34}$	$a_{14}-a_{34}$	U - - U	Instability
E_3(0，1，0，0)	$b_{32}-b_{42}$	$c_{44}-c_{42}$	$d_{41}-d_{42}$	$a_{22}-a_{42}$	+ U - U	Instability
E_4(0，0，1，0)	$b_{33}-b_{43}$	$c_{41}-c_{43}$	$d_{44}-d_{43}$	$a_{23}-a_{43}$	U U + U	Instability
E_5(1，0，0，1)	$b_{24}-b_{14}$	$c_{12}-c_{14}$	$d_{13}-d_{14}$	$a_{34}-a_{14}$	U - - U	Instability
E_6(1，1，0，0)	$b_{42}-b_{32}$	$c_{34}-c_{32}$	$d_{31}-d_{32}$	$a_{12}-a_{32}$	- + - U	Instability
E_7(0，0，1，1)	$b_{13}-b_{23}$	$c_{21}-c_{23}$	$d_{24}-d_{23}$	$a_{43}-a_{23}$	U U + U	Instability
E_8(0，1，0，1)	$b_{12}-b_{22}$	$c_{24}-c_{22}$	$d_{21}-d_{22}$	$a_{42}-a_{22}$	+ U - U	Instability
E_9(1，0，1，0)	$b_{43}-b_{33}$	$c_{31}-c_{33}$	$d_{34}-d_{33}$	$a_{13}-a_{33}$	U - + U	Instability
E_{10}(0，1，1，0)	$b_{31}-b_{41}$	$c_{43}-c_{41}$	$d_{42}-d_{41}$	$a_{21}-a_{41}$	+ U + U	Instability
E_{11}(1，1，0，1)	$b_{22}-b_{12}$	$c_{14}-c_{12}$	$d_{11}-d_{12}$	$a_{32}-a_{12}$	- + - U	Instability
E_{12}(1，0，1，1)	$b_{23}-b_{13}$	$c_{11}-c_{13}$	$d_{14}-d_{13}$	$a_{33}-a_{13}$	U - + U	Instability
E_{13}(1，1，1，0)	$b_{41}-b_{31}$	$c_{33}-c_{31}$	$d_{32}-d_{31}$	$a_{11}-a_{31}$	- + + U	Instability
E_{14}(0，1，1，1)	$b_{11}-b_{21}$	$c_{23}-c_{21}$	$d_{22}-d_{21}$	$a_{41}-a_{21}$	+ U + U	Instability
E_{15}(0，0，0，1)	$b_{14}-b_{24}$	$c_{22}-c_{24}$	$d_{23}-d_{24}$	$a_{44}-a_{24}$	U U - U	Instability
E_{16}(1，1，1，1)	$b_{21}-b_{11}$	$c_{13}-c_{11}$	$d_{12}-d_{11}$	$a_{31}-a_{11}$	- + + U	Instability

Note: U means that the sign of positive and negative is uncertain, - means that the value is negative, and + means that the value is positive.

Source: Authors` own work.

When all four eigenvalues of a point are negative, the surface of the point is stable. A review of the above table reveals that 12 points lack stability. Conversely, the stability of four points, including $E_1(0,0,0,0)$, $E_2(1,0,0,0)$, $E_5(1,0,0,1)$ and $E_{15}(0,0,0,1)$, is uncertain and contingent upon the positivity or negativity of the following five expressions.

$$b_{34} - b_{44} = -(b_{44} - b_{34}) = B_{mb} - B_{mc} - C_{mh} + C_{ml} + P_m \tag{19}$$

$$b_{24} - b_{14} = -(b_{14} - b_{24}) = B_{ma} + C_{mh} - C_{ml} - P_m \tag{20}$$

$$c_{42} - c_{44} = -C_{gh} + C_{gl} + N_{gb} - P_m \tag{21}$$

$$c_{22} - c_{24} = -C_{gh} + C_{gl} + N_{ga} - P_m \tag{22}$$

$$a_{24} - a_{44} = a_{14} - a_{34} = -(a_{34} - a_{14}) = B_{sh} - B_{sl} - C_{sh} + C_{sl} + P_{sa} \tag{23}$$

When $E_1(0, 0, 0, 0)$ is a stable local equilibrium point, the four eigenvalues of this point are negative. If the following inequalities are satisfied: $b_{34} - b_{44} < 0$, $c_{42} - c_{44} < 0$, $a_{24} - a_{44} < 0$, 则 $b_{44} - b_{34} > 0$, $a_{34} - a_{14} > 0$, $a_{44} - a_{24} > 0$.Consequently, it can be inferred that when any one of the other three points is stable, the other points are not stable. This implies that at most only one of the four local equilibrium points is stable.

Table 5. Analysis of equilibrium point stability conditions

Serial number	Prerequisite	Equilibrium point	eigenvalue (math.) λ_1	eigenvalue (math.) λ_2	eigenvalue (math.) λ_3	eigenvalue (math.) λ_4	Stability
Case 1	(19) < 0 (21) < 0 (23) < 0	E_1(0，0，0，0)	−	−	−	−	Stabilise
		E_2(1，0，0，0)	+	−	−	−	Instability
		E_5(1，0，0，1)	U	−	−	+	Instability
		E_{15}(0，0，0，1)	U	U	−	+	Instability
Case 2	(19) > 0 (23) < 0	E_1(0，0，0，0)	+	U	−	−	Instability
		E_2(1，0，0，0)	−	−	−	−	Stabilise
		E_5(1，0，0，1)	U	−	−	+	Instability
		E_{15}(0，0，0，1)	U	U	−	+	Instability
Case 3	(20) < 0 (23) > 0	E_1(0，0，0，0)	U	U	−	+	Instability
		E_2(1，0，0，0)	U	−	−	+	Instability
		E_5(1，0，0，1)	−	−	−	−	Stabilise
		E_{15}(0，0，0，1)	+	U	−	−	Instability
Case 4	(20) > 0 (22) < 0 (23) > 0	E_1(0，0，0，0)	U	U	−	+	Instability
		E_2(1，0，0，0)	U	−	−	+	Instability
		E_5(1，0，0，1)	+	−	−	−	Instability
		E_{15}(0，0，0，1)	−	−	−	−	Stabilise

Source: Authors` own work.

Case 1: Stability occurs when Equation $(19) < 0, (21) < 0, (23) < 0$. Equilibrium $E_1(0,0,0,0)$ corresponds to a state where media engage in distortion, governments abstain from oversight, netizens remain inactive, and schools adopt passive responses. Such stability arises primarily under weak regulatory regimes characterised by low penalties for media misconduct P_m and school passivity P_{sa} . When penalties are insufficient to deter misconduct, the system gravitates toward this equilibrium. Conversely, stringent penalties significantly reduce the likelihood of this outcome, as stakeholders face higher risks for noncompliance.

Case2: Equation $(19) > 0, (23) < 0$, the equilibrium point $E_2(1,0,0,0)$ has stability, that is, (the media real report, the government regulation is absent, the netizens do not participate, the school's negative response) to become a stable strategy combination. If the government's punishment for the school's negative response is smaller and the punishment for the media's distorted reporting is larger, i.e. P_m is larger and P_{sa} is smaller, then the four-way evolution game is likely to enter this stable state.

Case 3: Equation $(20) < 0, (23) > 0$, the equilibrium point $E_5(1,0,0,1)$ has stability, i.e. (media truthful reporting, lack of government regulation, netizens' non-participation, and schools' active response) becomes a stable strategy combination. If the government's punishment is greater, i.e., P_m、$P_{sa}$is greater, then the four-way evolutionary game is likely to enter this stable state.

Case 4: Equation $(20) > 0, (22) < 0, (23) > 0$, equilibrium point $E_{15}(0,0,0,1)$ has stability, i.e. (distorted media reports, lack of government regulation, lack of netizens' participation, schools' active response) becomes a stable strategy combination. The government's punishment for the school's negative response is larger, and the punishment for the media's distorted reporting is smaller, i.e., when P_{sa} is larger and P_m is smaller, the four-way evolutionary game is likely to enter this stable state.

4. Results and discussion

Based on the practical implications of benefit-cost interactions in the four-party game involving net media, students, universities, and the government, parameter values were assigned as shown in Table 6.

Table 6. Parameter assignment

Parametric	Starting value	Parametric	Starting value	Parametric	Starting value
C_{sh}	12	B_m	2	P_m	7
C_{mh}	3	B_n	8	P_{sa}	3
C_n	2	B_{gh}	5	P_{sb}	4
C_g	9	B_{ma}	3	N_{sa}	7
C_{gl}	4	B_{sl}	4	N_{na}	2
C_{ml}	1	B_{nl}	6	N_{ga}	5
C_{gh}	7	B_{gl}	3	N_{sb}	1
C_{sl}	3	B_{mb}	2	N_{nb}	8
B_{sh}	8	B_{mc}	7	N_{gb}	6

Source: Authors` own work.

4.1 Influence of media's initial strategy on evolutionary paths

Setting x = 0.1 and x = 0.9 to represent the two states of truthful reporting and distorted reporting by the media, respectively, we simulate and analyse the evolutionary process of different initial strategies adopted by the government, netizens, and schools in a three-dimensional space. When x = 0.1, indicating that the media primarily engages in distorted reporting, the simulation results are presented in Figure 1. The evolutionary trajectory shows that the rate of increase in netizen participation (z) is higher than the rate of increase in government regulation (y). Moreover, a higher initial value of w (i.e., a greater proportion of proactive responses from schools) further accentuates this trend.

This suggests that government regulation tends to lag behind public concern when the media disseminates distorted reports. The openness and immediacy of the internet facilitate rapid information dissemination, allowing distorted reports to spread widely and generate discussions in a short period of time. In such an information-rich online environment, government regulators require time to detect issues, assess situations, and formulate responses. Additionally, effective regulation often depends on the coordination and cooperation of multiple government departments. However, bureaucratic barriers, interdepartmental communication challenges, and procedural inefficiencies can significantly slow down regulatory responses, further delaying corrective action in response to misinformation.

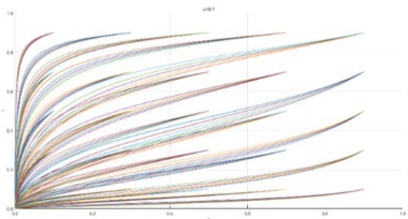

Figure 1. Top view of the effect of media's initial probability on the evolutionary path (x = 0.1)

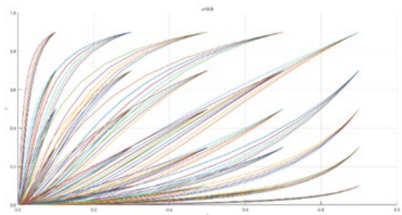

Figure 2. Top view of the effect of media's initial probability on the evolutionary path (x=0.9)

Source: Authors` own work.

When the initial value of x is 0.9, i.e., the media's initial strategy is mainly truthful reporting, the simulation results are shown in Figure 2, and the above evolution becomes weaker, i.e. the speeds of netizen participation and government regulation converge under truthful media reporting.

4.2 Influence of initial government strategy on evolutionary paths

Setting y = 0.1 and y = 0.9 to represent the two states of government regulation in place and government regulation absent, respectively, we simulate and analyse the evolutionary process of different initial strategies adopted by the media, netizens, and schools in a three-dimensional space. When the initial value of y is 0.1, indicating that the government's initial strategy is primarily regulation in absentia, the simulation results are presented in Figure 3. In the absence of government regulation, some media outlets prioritise producing and publishing highly engaging content to maximise ratings, click-through rates, and advertising revenue. Since sensationalised and emotionally charged reports tend to attract more public attention, certain media organisations deliberately choose to publish distorted reports as part of their strategy.

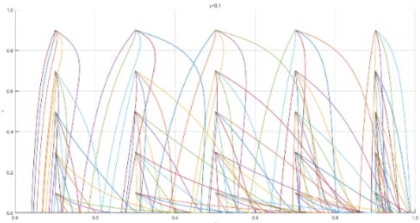

Figure 3. Top view of the effect of government's initial probability on the evolutionary path (y=0.1)

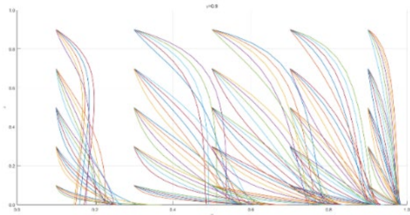

Figure 4. Top view of the effect of government's initial probability on the evolutionary path (y=0.9)

Source: authors` own work.

When the initial value of y is 0.9, indicating that the government's initial strategy is primarily to regulate in place, the simulation results are presented in Figure 4. Under strict government regulation, the media are more inclined to report truthfully, with almost no instances of inaccurate reporting. By establishing and enforcing standards and norms for news reporting, the government can encourage media platforms and journalists to uphold professional ethics and integrity, conduct in-depth investigations, and verify information before publication. This, in turn, enhances the accuracy and reliability of news reporting. Additionally, when government regulation is in place, media platforms become more conscious of their social responsibility and the importance of public trust. This heightened awareness encourages greater caution in reporting, prompting media outlets to avoid publishing unverified or misleading information.

4.3 Influence of netizens' initial strategy on evolutionary paths

To represent the two states of netizens' participation in public opinion, we set $z = 0.1$ for non-participation and $z = 0.9$ for active participation. The evolution of different initial strategies adopted by the media, the government, and schools is then simulated and analysed in a three-dimensional space.

When $z = 0.1$, meaning the initial strategy of netizens is predominantly non-participation, the simulation results are presented in Figure 5. The larger the value of w, the faster the rate at which y decreases relative to the rate at which x increases. This indicates that a higher initial proportion of schools actively responding to public opinion leads to a more rapid decline in the proportion of government regulation, compared to the increase in the proportion of truthful reporting by the media.

In other words, when netizens choose not to participate, schools that take proactive measures – such as problem-solving, information disclosure, and active communication with stakeholders – tend to enhance the efficiency and effectiveness of their responses to public opinion issues. As a result, public opinion crises are largely managed appropriately, reducing the need for external regulation. This effective response subsequently lessens the necessity for government intervention.

On the other hand, the media, driven by commercial interests and other external factors, may compromise the accuracy of their reports in the absence of netizen participation. However, if schools provide transparent and accurate information, the media may be more inclined to report truthfully to uphold their credibility and fulfil their social responsibility.

When z = 0.9, indicating that netizens actively participate, the simulation results are shown in Figure 6. Under these conditions, y decreases at a slower rate, meaning the decline in government regulation is less rapid. As netizen participation increases, public scrutiny and oversight of educational public opinion intensifies, exerting greater pressure on the government. In response to public expectations and demands, the government may feel compelled to enhance its regulatory efforts, thus slowing down the reduction in the proportion of government intervention.

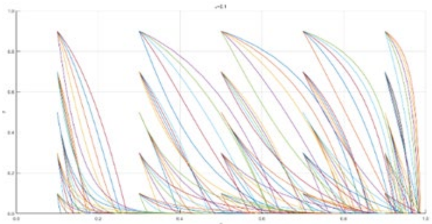

Figure 5. Top view of the effect of netizen's initial probability on the evolutionary path (z = 0.1)

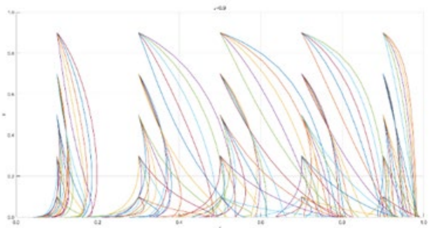

Figure 6. Top view of the effect of netizen's initial probability on the evolutionary path (z=0.9)

Source: authors` own work.

4.4 Influence of initial school strategies on evolutionary paths

Setting w = 0.1 and w = 0.9 to represent the two states of a school's response to public opinion – negative and positive, respectively – the evolution of different initial strategies adopted by the media, the government, and netizens is simulated and analysed in a three-dimensional space.

When w = 0.1, indicating that the school's initial strategy is primarily a negative response, the simulation results are presented in Figure 7. In this scenario, the netizens' participation strategy (z) is not influenced by the media or the government, and the school fails to respond to public opinion events, opting instead to remain silent or delay its response.

Netizens, however, often exhibit a high degree of spontaneity and independence in their engagement with public opinion. Their participation is driven by personal values, interests, access to information, and subjective judgments, rather than being directly influenced by the attitudes or actions of the media and government (Gayle, Wang, & Fang, 2023). They actively discuss public affairs based on their own perspectives.

At the same time, the media tend to prioritise truthful reporting. As the "fourth power" in democratic governance, the media serves as a structural force in monitoring social affairs, uncovering the truth, and protecting public interests. When schools react negatively to public opinion and fail to acknowledge or address issues, the media plays a crucial investigative role, compelling both educational institutions and the broader education system to confront and rectify existing problems through truthful and objective reporting.

When w = 0.9, meaning the school's initial strategy is predominantly a positive response, the simulation results are shown in Figure 8. In this case, netizens' decision to participate in discussions on educational public opinion is influenced by media coverage. The media plays a key role in shaping public perception, guiding the direction of discourse, and stimulating public participation.

When media reports are comprehensive and in-depth, providing well-rounded information, background context, and highlighting the severity or urgency of an issue, they amplify netizens’ demand for transparency and accountability. As a result, netizens become more engaged and more likely to participate in public discussions on education-related issues.

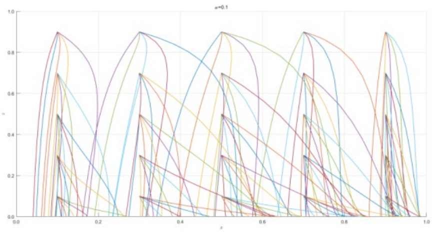

Figure 7. Top view of the effect of school’s initial probability on the evolutionary path (w=0.1)

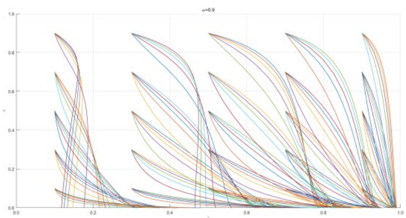

Figure 8. Top view of the effect of school’s initial probability on the evolutionary path (w=0.9)

Source: authors` own work.

4.5 Impact of government regulatory costs

The other parameters are kept unchanged and assigned C_g= {2, 6, 12}, respectively, and the simulation results of replicating the system of dynamic equations evolving over time 200 times are shown in Figures 9 and10.

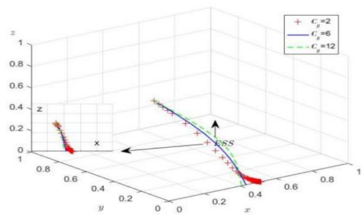

Figure 9. Front view of the effect of government regulatory costs on the evolution of the game

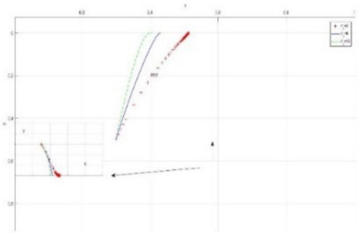

Figure 10. Top view of the effect of government regulatory costs on the evolution of the game

Source: authors` own work.

As shown in the figure, during the evolutionary process, an increase in government regulation costs (C_g) leads to a decline in both the probability of truthful media reporting and netizen participation in discussions. As regulatory costs rise, the government may reassess the role of social actors in shaping public opinion and reprioritise its resources. This could result in greater investment in monitoring and public opinion management systems, while simultaneously reducing support for the media and public communication efforts. Consequently, the media may decrease their coverage of truthful reporting due to a lack of government support and financial resources. On the other hand, netizens may resort to self-censorship, fearing potential legal risks or penalties associated with heightened government oversight and regulatory costs. This self-censorship can lead to reduced engagement in public discussions, ultimately lowering the overall level of participation in public discourse.

5. Conclusions

This study develops a game-theoretic framework to analyse the collaborative governance of education public opinion, incorporating four key stakeholders: the media, government, netizens, and schools. Using evolutionary game modelling and MATLAB simulations, the study identifies key equilibrium points and strategy dynamics that shape the stability and responsiveness of public opinion governance systems. The findings highlight four critical insights:

(1) Government Regulation is Key: Strong regulatory policies and penalties effectively curb media misinformation and school mismanagement (Lei et al., 2020), contributing to stability in public discourse.

(2) School Responsiveness Matters: Educational institutions play a crucial role in mitigating negative public sentiment by implementing proactive public communication strategies (Wen, 2022; De la Cruz & Mergoni, 2024).

(3) Media's Role in Public Opinion Shaping: Ethical journalism and truthful reporting are essential for preventing misinformation cascades, which can destabilise education public opinion (Bozkurt, 2024; Lin & Wang, 2024).

(4)Netizens Influence the System's Stability: Rational public engagement and digital literacy among netizens determine the extent of online discourse polarisation (Couture et al, 2023).

Despite its contributions, this study has several limitations. It does not incorporate real-world empirical validation of the model, which could provide additional robustness to the findings. Additionally, the computational complexity of the simulations is not explicitly analysed, which may impact scalability in large-scale applications. Future research should focus on:

(1) Integrating AI-driven sentiment analysis for early detection of public opinion trends.

(2) Real-world validation of the model using education-related social media case studies.

(3) Exploring hybrid governance strategies, combining game theory and machine learning, to improve policy adaptability in dynamic online environments.

By providing a quantitative foundation for public opinion governance, this study contributes to enhancing stakeholder decision-making processes, ensuring more transparent and effective education policy responses.

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