Analysis of Cheating in Exams Based on Difference Equation Model

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Abstract. The problem of cheating in exams is a serious social problem, and cheaters have done huge damage to the social public order. How to reduce or even eliminate cheaters? Researchers have analyzed from different angles, most of the research is from the perspective of game theory or evolutionary game theory. However, game theory and evolutionary game theory have the disadvantage of not being able to quantitatively examine the changes in the number of cheaters and supervision. Aiming at the deficiencies of game theory and evolutionary game theory, this paper establishes the evolution model of the cheating problem of the differential equation model, analyzes the balance point and characteristics of the coexistence evolution model of different actors of cheaters and regulators, and examines the behavior of cheaters along with supervision. Changes in the number; the influence of different factors on the changes in the number of cheaters is analyzed, and on this basis, a comparison of anti-cheating strategies is made. After comparing the effects of the two different anti-cheating strategies of 'blocking' and 'blocking', it is concluded that 'blocking' can reduce cheaters more than 'blocking', and corresponding policy recommendations are given. Considering that it is difficult to obtain the data of cheaters and supervisory behaviors, the model was simulated using MATLAB, and the simulation results verified the correctness of the analysis.

1. Introduction

Because cheaters have caused great damage to the public order of society, it has always been a concern by society. How to reduce cheaters and maintain social fairness and justice? Researchers have researched from different perspectives. Xiaohui Hou et al [1-10], analyzed the influencing factors of college students' cheating from the perspectives of psychology and pedagogy and gave three directions from school, student, and teacher. Recommendations for system construction are mostly based on theory and have no model support; many theorists have analyzed cheating behavior from the perspective of game theory and made relevant recommendations [11-15], recent researchers have learned from evolutionary games From the perspective of theory, it analyzes the game strategies of students, invigilators and school administrators in the examination: Li Hongbo et al. [16] constructed an evolutionary model of the mutual game between students and invigilators based on evolutionary game theory, and simulated initial conditions and rules through numerical simulation Impact on the results; Liu Qin [17] divided students into two categories, good and bad, established a model using evolutionary game theory, analyzed the influencing factors of the evolution of cheating by college students, and put forward corresponding suggestions; considering students and On the basis of the invigilator teacher, Peng Liangjun [18] introduced the impact of the school administrator's incentive management policy on
the invigilation teacher's implementation, and pointed out that too heavy punishment may lead to the invigilator's reduction of punishment. Most of the above scholars have analyzed the individual decision-making game between cheaters and invigilators from the perspective of game theory.

2. Methods
The model is complex, and the analysis is cumbersome, but they did not give answers on the relationship between the number of cheaters and the number of supervised behaviors. For school administrators, the interaction between the number of cheating and the number of school examination supervision behaviors is the issue of concern. Besides, the strategic suggestions they gave are nothing more than strengthening supervision and education: either increasing the intensity of punishment, or increasing the number of supervisions, or strengthening ideological education, they all give suggestions from the perspective of 'blocking', but they did not consider the perspective of 'sparse' advise. A differential equation is a mature theory, and it has successfully solved many practical problems. For example, the prey-predator model has been used in the research of anti-piracy product strategy and coal safety supervision strategy [19-20], but the difference equation is used to solve the comparison of problems. Rarely, the use of different equations to analyze cheating problems has not yet been seen. This article intends to establish the evolution model of college students' cheating problem based on the differential equation model, analyze the balance point and characteristics of the coexistence evolution model of different actors, analyze the influence of different factors on the number of cheating, and compare the anti-cheating strategies of 'sparse' and 'blocking'. Combined with the actual situation, gave a strategy of blocking rather than sparse: that is, schools should strengthen examination management to reduce potential cheaters.

3. Model introduction and construction
This article studies the cheating phenomenon of fixed examination time, such as college students' final examination, various qualification examinations, and so on. This article analyzes the phenomenon of cheating from two aspects: one is the number of cheating; the other is the number of supervisors' supervision of examinations. Supervisors' examination supervision behaviors include arranging teacher invigilation and inspection tour. Make the following assumptions:

1. In each exam, some candidates are not fully prepared for the exam due to various reasons. This part of the candidates has a greater motivation to cheat. This part of the number of students is called the number of potential cheaters. Let this number be; the administrator should pay attention in practice If there is no proctor, there must be cheating. At the same time, it is necessary to consider maintaining the authority of the exam. Therefore, the number of potential cheating supervision behaviors is.

2. Assume that the relationship between the number of cheating and the number of examination supervision behaviors is linear. As the number of cheating person increases, the administrator will inevitably increase the number of examination supervision behaviors. Let the number of examination supervision acts be directly proportional to the number of cheating persons; on the contrary, if cheating supervision acts increase, the number of cheating persons will inevitably decrease, and the increase of the number of cheating persons will be inversely proportional. For the number of examination supervision behaviors, the ratio is.

3. If there is no examination supervision behavior, the number of cheating will increase exponentially and reach its maximum value. Set the growth rate of the number of cheating without supervision as; if no one cheats, the administrator will inevitably reduce the number of examination supervision; Out of cost considerations, managers also tend to reduce the number of examination supervision. The reduction rate of supervisor examination supervision when there is no cheating is set.

4. Assuming that statistics are started from a certain time in a certain year, set this time. Based on the above assumptions, the discrete model is established as follows:

\[
\begin{align*}
\left\{ \begin{array}{l}
    x_{n+1} - x_n &= ax_n - by_n + k \\
    y_{n+1} - y_n &= -cy_n + dx_n + l
\end{array} \right.
\]

(1)
Among them, represents the number of cheating on the first exam, represents the number of supervision on the second exam, including the number of invigilators, the number of inspectors, and so on. Indicates the growth rate of the number of cheating people without examination supervision; Indicates the deterrence of the examination supervision behavior on cheating students, that is, the deterrence strength; Indicates the natural reduction rate of the examination supervision behavior when no one cheats; Indicates the feedback coefficient of the examination supervision behavior on the number of cheating, Can be seen as the school's response to changes in the number of cheating students as shown in Fig 1. They are the number of potential cheaters among students and the number of potential supervisory behaviors in the school. Organize available

\[
\begin{align*}
x_{n+1} &= (a+1)x_n - by_n + k \\
y_{n+1} &= (1-c)y_n + dx_n + l
\end{align*}
\]

(2)

Figure 1. Numerical simulation diagram of a cheating system

4. Model analysis

4.1. Model stability analysis

According to the stability theory of difference equations

\[
P \left( \frac{ck - bl}{bd - ac} \frac{dk - al}{bd - ac} \right)
\]

(3)

It should be satisfied at this time, and the corresponding linearization matrices are:

\[
h(b) = \frac{b}{x} \frac{\partial x^*}{\partial b} = - \frac{bl(bd - ac) + d(ck - bl)}{ck - bl} = - \left( \frac{bl(bd - ac)}{ck - bl} + d \right) < - (bl + d)
\]

(4)

4.2. Qualitative analysis

Qualitative analysis of the model According to the analysis of the equilibrium point of the above equation (1), the following conclusions as fellow:

(1) From the stable condition of the equilibrium solution, it can be seen that when the intensity of the manager’s response to cheating and the deterrence intensity of the examination supervision behavior is greater than the self-growth rate of the cheating number and the self-decreasing rate of the supervision behavior, the cheating number will be Keep it stable, otherwise the number of cheaters will reach its maximum.

(2) From equation (2) if the equilibrium solution of the model, and is stable under equation (1), if it exists, it will always be (0); this means that if the examinees are all right, there are no cheating ideas and actions, and the administrator fully trusts the examinees, cheating in the exam will never happen, and the administrator does not need to adopt any exam supervision behavior.

(3) It can be seen that due to potential cheaters and potential supervisory behaviors, the system cannot be stabilized. Therefore, even if no one cheats at a certain time, the administrator cancels all examination supervision behaviors, but due to the existence of potential cheaters, the administrator has to arrange
examination supervision behavior again, and the system finally stabilizes in a limited solution. It can be seen that due to the existence of potential cheaters, examination supervision is indispensable, which is also a true portrayal of reality. The impact of model parameter changes on the number of cheaters

\[
\frac{\partial x}{\partial a} = \frac{a(ck - bl)}{(bd - ac)^2} > 0
\]

\[
\frac{\partial x}{\partial b} = \frac{-l(bd - ac) + d(ck - bl)}{(bd - ac)^2} < 0
\]

\[
\frac{\partial x}{\partial c} = \frac{k(bd - ac) + a(ck - bl)}{(bd - ac)^2} > 0
\]

Therefore, when the number of potential cheaters decreases by 1%, the number of cheaters will decrease by more than 1%. This shows that reducing the number of potential cheaters is the top priority.

3 Model simulation as equations (1) cannot find analytical solutions and lack relevant data, MATLAB is used for numerical simulation. 3.1 Analysis of normal simulation model the initial parameters of the model are

\[a = 0.02, b = 0.4, c = 0.12, d = 0.2, k = 50, l = 5, x_1 = 20, y_1 = 2\]

as shown in Fig 2:

Figure 2. Simulation diagram of potential cheaters added

Figure 3. Simulation diagram of increased cheating punishment intensity

It can be seen that the system stabilized at a value in about ten years. To analyze the influence of the initial value on the system, adjust to, the stable value of the system remains unchanged, which shows that the system is not sensitive to the initial value.

4.3. Analysis of potential cheaters and potential supervisors

When the potential cheaters are doubled to, it can be seen from Figure 2 that the system is still stable. However, it can be seen that the equilibrium solution becomes, which is approximately doubled; when the equilibrium solution becomes. After different values, it can be seen that potential cheaters have a huge impact on the equilibrium point of the number of cheaters, and it increases in direct proportion: when the number of potential cheaters doubles, the number of cheaters and examination supervision behavior approximately doubles, of which the number of cheaters slightly increases More than doubled.
If other parameters remain unchanged when the potential supervision behavior is doubled, we can see that the equilibrium solution is, which has not changed much from the original, and we can see that the potential supervision ability has a relatively small impact on the number of students cheating.

4.4. Analysis of enhanced punishment intensity model

Investigate the impact of cheating management measures on the number of cheating. When other factors remain unchanged, if the intensity of punishment for cheaters is increased, such as changing from verbal warnings to cancellation of grades, it is obvious that the deterrent to cheaters will increase at this time. At this time, the increase in the model will double when the system goes through After a severe shock, it stabilized, and the ratio of reduction was more than doubled. It can be seen that when other factors remain unchanged, increasing the intensity of punishment is a good way to reduce the number of cheaters.

5. Results

Increase the model analysis of inspection and supervision behavior Investigate the impact of cheating management measures on the number of cheating. When other factors remain unchanged, if the number of examination supervision behaviors is increased, for example, large-class proctoring is changed to small-class proctoring, and the number of patrol examinations is increased. At this time, the increase in the model, when doubled, the system stabilizes after a short-term shock and shrinks somewhat, but it is smaller than when the penalty intensity is increased. When inspecting and monitoring behaviors are increased, the deterrence of cheaters will inevitably increase. Therefore, when the consideration is also increased, for example, when the increase is 0.5, the equilibrium solution becomes, the number of cheating persons decreases greatly, but the decrease is smaller than increasing the intensity of punishment. Analysis of the inherent growth rate model of cheaters If other factors remain the same, the unsupervised growth rate of the cheater doubles, and we can see that the equilibrium solution is, which is larger than the original equilibrium solution, but the increase is smaller; then adjust the increase by ten times too, and the equilibrium solution as shown in Fig 4:

![Figure 4. Simulation diagram of increased examination supervision behavior](image)

The increase is not large, which shows that this parameter has little effect on the number of cheaters. If other factors remain unchanged, double the self-decreasing rate of supervisory behavior to, and the equilibrium solution is, which has little change from the original equilibrium solution, which shows that the two have little effect on the system. Based on the above factors, the following suggestions are made:

(1) Managers should formulate policies to reduce potential cheaters. To reduce potential cheaters, candidates must be fully prepared before the exam. First, inform the test time in advance so that candidates have sufficient time to prepare; second, disclose the scope and difficulty of the test, so that candidates are fully prepared for the content of the test; third, the actual situation of the candidates should be fully investigated when setting questions, and there must be distinguished the degree of difficulty should be moderate. (2) Managers should maintain a certain intensity of punishment for cheating. Under other conditions unchanged, increasing the intensity of punishment for cheaters can indeed greatly reduce the number of cheaters and the number of examination supervision and
management behaviors. However, if other factors also change, for example, some increase the intensity of punishment while increasing the procedures for identifying cheaters need to be photographed, on-site confirmation, etc.; this increases the cost of cheating arrests, resulting in fewer people caught cheating, which will result in uncertain policy effects. Therefore, while increasing the intensity of punishment, school administrators should not formulate complicated identification procedures. (3) The manager should maintain a certain amount of examination supervision. Increasing the number of examination supervision has indeed reduced the number of cheaters. To the extreme, every teacher invigilates one student, which will stop cheating. But considering the practical constraints such as cost, this strategy is not realistic. The administrator should discuss the maximum number of candidates for each invigilator, and reasonably arrange the number of examination supervision. (4) Publish the list of those caught cheating, publicly punish the cheaters, increase the deterrence against cheating, and help reduce the natural growth rate of cheating. It is necessary to increase the expectation of being caught for cheating. If caught cheating and not dealt with, it will greatly undermine the deterrence of punitive measures.

6. Conclusion
Suppressing cheating is a systematic project, which requires consideration of various factors and a combination of various methods to achieve better results. Blindly considering the "blocking" aspect, that is, increasing the intensity of punishment or increasing the number of punishments, although it can reduce the number of cheating in a short time, it is not sustainable. To better solve the problem of cheating, we should start from the perspective of ‘sparse’ and focus on reducing the number of potential cheaters. From a manager’s point of view, establishing an appropriate assessment system, conducting precise investigations of candidates, and making propositions that meet both the test objectives and the reality of the candidates are the most effective and simplest measures. In reality, many of the propositions are not deterred by candidates, and they are often based on test objectives. This leads to inaccurate propositions, increases potential cheaters, and exacerbates the occurrence of cheating. Of course, the blocking measures are not sustainable, but it is necessary to maintain a certain degree of deterrence. The punishment for cheating should not be too low, and there must be a certain deterrent to increasing the cost of cheating, but it cannot be adjusted frequently. For cheaters, you must have the courage to find one, deal with one, and deal with it under regulations, without lowering the punishment standard or even not being punished. As far as invigilators are concerned, they are the direct discoverers of cheaters, and their management should be relaxed, and cumbersome cheating measures should not be used to discourage them. There is no guarantee that students will pass any exam, so cheaters do not exist. But as long as we can take sufficient measures, we will be able to gradually reduce cheating and create a good teaching and learning environment.

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