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Article

Cracking the Code of Educational Involution: A Multi-Agent Collaborative Governance and Resource Symbiosis Approach to Sports-Education Integration

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Abstract: Educational involution, characterized by excessive competition and diminishing returns in education, has become a pressing issue in China, posing significant challenges to students' holistic development and the sustainability of the education system. This study proposes the integration of sports and education as a potential solution, leveraging its ability to foster physical, cognitive, and social development while alleviating academic pressure. Drawing on the theories of multi-agent collaborative governance and resource symbiosis, this research investigates the mechanisms through which multiple stakeholders can effectively collaborate to achieve sports-education integration. Using a mixed-methods approach, including qualitative interviews, surveys, and system dynamics modeling, the study identifies key stakeholders, analyzes their interactions, and evaluates the impact of various policy interventions. The findings contribute to the theoretical understanding of educational involution and provide actionable insights for policymakers seeking to promote sports-education integration and mitigate the effects of educational involution.

Keywords: educational involution; sports-education integration; multi-agent collaborative governance; resource symbiosis; policy simulation; system dynamics

1. Introduction

1.1. Research Background

In recent years, the phenomenon of educational involution has emerged as a critical issue in education systems worldwide, particularly in regions with intense academic competition such as China. Educational involution, a term adapted from anthropological studies [1], describes a situation where increased investment in education yields diminishing returns due to excessive competition and systemic inefficiencies. In China, this phenomenon is exacerbated by the 'Gaokao' system, which prioritizes academic performance over holistic development, leading to a hyper-competitive environment that stifles creativity, well-being, and equitable access to education [2]. Research has shown that educational involution contributes to heightened student stress, mental health issues, and a narrowing of educational goals, ultimately undermining the long-term sustainability of the education system [3].

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In response to these challenges, the integration of sports and education has gained traction as a potential solution. Sports-education integration, which emphasizes the holistic development of students by combining physical activity with academic learning, has been shown to enhance physical health, cognitive abilities, and social skills [4]. However, the implementation of sports-education integration faces significant barriers, including resource allocation inefficiencies, policy fragmentation, and a lack of effective collaboration among stakeholders [5]. Addressing these challenges requires a systematic approach that leverages multi-agent collaborative governance and resource symbiosis to optimize the integration process.

1.2. Research Significance

1.2.1. Theoretical Significance

This study contributes to the theoretical understanding of educational involution and sports-education integration by integrating the frameworks of multi-agent collaborative governance and resource symbiosis. Multi-agent collaborative governance emphasizes the coordination of efforts among diverse stakeholders, such as government agencies, schools, families, and communities, to achieve common goals [6]. Resource symbiosis, on the other hand, focuses on the sharing and integration of resources to maximize efficiency and effectiveness [7]. By combining these theories, this research provides a comprehensive framework for understanding how stakeholders can collaborate to overcome barriers and promote sports-education integration.

1.2.2. Practical Significance

From a practical perspective, this study offers actionable insights for policymakers and practitioners. By identifying the key barriers to sports-education integration and proposing a multi-agent collaborative governance mechanism, this research provides a roadmap for addressing educational involution. Furthermore, the use of system dynamics modeling enables the evaluation of different policy interventions, offering evidence-based insights for optimizing resource allocation and stakeholder collaboration. These findings are particularly relevant for regions facing resource constraints and intense academic competition, where the need for innovative solutions to educational challenges is most pressing.

1.3. Research Questions

This study addresses the following research questions:

1. How does multi-agent collaborative governance influence the effectiveness of sports-education integration?
2. What are the pathways for achieving resource symbiosis in sports-education integration?
3. How can policy simulation be used to optimize the design and implementation of sports-education integration policies?

1.4. Research Objectives

The primary objectives of this study are:

1. To identify the key stakeholders involved in sports-education integration and analyze their roles, interests, and interactions.
2. To develop a multi-agent collaborative governance mechanism that facilitates effective coordination and resource sharing among stakeholders.
3. To construct a system dynamics model for simulating the impact of different policy interventions on sports-education integration.
4. To provide policy recommendations for promoting sports-education integration and mitigating the effects of educational involution.

1.5. Research Methodology

This study employs a mixed-methods approach, combining qualitative and quantitative research techniques.

Qualitative data are collected through in-depth interviews and focus group discussions with key stakeholders, including policymakers, educators, sports professionals, parents, and students. Quantitative data are obtained through surveys and existing datasets, which inform the development of a system dynamics model. The model simulates the integration process and evaluates the effectiveness of various policy interventions, such as increased funding for sports programs, teacher training initiatives, and community engagement strategies.

1.6. Research Contributions

This study makes several contributions to the field of education policy and management:

1. Theoretical Contribution: By integrating multi-agent collaborative governance and resource symbiosis theories, this research provides a comprehensive framework for understanding sports-education integration.

2. Methodological Contribution: The use of system dynamics modeling offers a novel approach for evaluating the impact of policy interventions in education.

3. Practical Contribution: The findings provide actionable insights for policymakers and practitioners seeking to promote sports-education integration and address educational involution.

2. Literature Review

2.1. Educational Involution: Concept, Causes, and Consequences

Educational involution, a term originally coined by anthropologist [8] to describe agricultural systems with diminishing returns [8], has been increasingly applied to education systems characterized by excessive competition and inefficiency [9]. In the context of education, involution refers to a situation where increased investment in education—whether in terms of time, money, or effort—fails to yield proportional improvements in outcomes, often leading to a cycle of intensifying competition and stress [10]. In China, the phenomenon is particularly pronounced due to the "Gaokao" system, which places immense pressure on students to excel academically, often at the expense of their physical and mental well-being [11]. In response to the problem of educational involution, the Chinese government has introduced a series of structural reform policies in recent years. The "double reduction" policy (Opinions on Further Reducing the Homework Burden and Extracurricular Training Burden of Students in Compulsory Education) promulgated in 2021 clearly restricts the operating hours and charging standards of extracurricular subject training institutions, and requires schools to establish an after-school service system [12]. Empirical research by [13] shows that the policy has reduced the weekly extracurricular training participation rate of students in basic education, but high-income families have maintained their education investment through alternative methods such as "one-to-one private tutoring", reflecting that there is still a risk of strengthening social stratification in policy implementation.

The causes of educational involution are multifaceted. Structural factors, such as resource scarcity and unequal distribution, play a significant role [14]. Cultural factors, including societal expectations and the traditional emphasis on academic achievement, further exacerbate the problem [15]. The consequences are equally profound, with studies highlighting increased student anxiety, reduced creativity, and a narrowing of educational goals [6]. Despite extensive research on the causes and effects of educational involution, there remains a gap in understanding how to systematically address this issue through innovative policy interventions.

2.2. Sports-Education Integration: Theoretical Foundations and Empirical Evidence

Sports-education integration, which combines physical activity with academic learning, has emerged as a promising strategy to counteract the negative effects of educational involution. Rooted in the holistic education paradigm, this approach emphasizes the development of the whole person—physically, emotionally, socially, and intellectually [16]. Empirical evidence supports the benefits of sports-education integration, demonstrating its positive impact on cognitive function, academic performance, and mental health [5]. For instance, a meta-analysis by [17] found that regular participation in sports is associated with improved attention, memory, and problem-solving skills.

However, the implementation of sports-education integration faces significant challenges. Resource

constraints, policy fragmentation, and a lack of stakeholder collaboration are among the most commonly cited barriers [15]. These challenges are particularly acute in regions with limited resources, where the prioritization of academic achievement often overshadows the importance of physical education. Addressing these barriers requires a comprehensive approach that leverages multi-agent collaboration and resource optimization.

2.3. Multi-Agent Collaborative Governance: Frameworks and Applications

Multi-agent collaborative governance refers to the coordination of efforts among diverse stakeholders to achieve common goals [18]. In the context of education, this involves aligning the interests and actions of government agencies, schools, families, and communities to create a cohesive and supportive environment for students. The effectiveness of collaborative governance depends on several factors, including trust-building, shared objectives, and effective communication channels [19].

Despite its potential, collaborative governance is not without challenges. Conflicting priorities, power imbalances, and resource constraints can hinder effective collaboration [20]. For example, schools may prioritize academic performance over physical education due to pressure from standardized testing, while families may lack the resources or time to support their children's participation in sports [21]. Overcoming these challenges requires a structured approach that addresses the underlying barriers to collaboration.

2.4. Resource Symbiosis Theory and Its Applications

Resource symbiosis, a concept derived from ecological theory, refers to the sharing and integration of resources to maximize efficiency and effectiveness [22]. In the context of sports-education integration, resource symbiosis provides a framework for optimizing resource allocation and utilization. For example, schools can collaborate with community organizations to share sports facilities, thereby reducing costs and increasing access to resources [23].

The benefits of resource symbiosis extend beyond cost savings. By fostering collaboration and trust among stakeholders, resource symbiosis can enhance the overall effectiveness of sports-education integration [22]. However, achieving resource symbiosis requires careful planning and coordination, as well as a willingness to overcome institutional and cultural barriers [20].

2.5. Research Gaps and Theoretical Framework

Despite the growing body of literature on educational involution and sports-education integration, significant gaps remain. First, there is limited research on the application of multi-agent collaborative governance and resource symbiosis theories in the context of sports-education integration. Second, few studies have employed simulation modeling to evaluate the potential impact of policy interventions in this area. This study addresses these gaps by integrating systems theory and game theory to develop a comprehensive framework for understanding and optimizing the integration process.

The proposed theoretical framework consists of three key components:

1. Multi-Agent Collaborative Governance: A mechanism for coordinating the efforts of government agencies, schools, families, and communities to achieve sports-education integration.

2. Resource Symbiosis: A strategy for optimizing resource allocation and utilization through collaboration and resource sharing.

3. Policy Simulation: A tool for evaluating the impact of different policy interventions on sports-education integration.

By combining these components, this study aims to provide a holistic understanding of how sports-education integration can be effectively implemented to address educational involution.

3. Methodology

3.1. Research Design

This study employs a mixed-methods research design, integrating qualitative and quantitative approaches to

investigate the multi-agent collaborative governance mechanism and resource symbiosis model in sports-education integration. The mixed-methods approach is particularly suited to this research, as it allows for a comprehensive exploration of complex phenomena by combining the depth of qualitative insights with the generalizability of quantitative data [24]. The research is structured into three sequential phases:

1. Qualitative Phase: In-depth interviews and focus group discussions are conducted to identify key stakeholders, their roles, and the challenges they face in sports-education integration.

2. Quantitative Phase: Survey data are collected to quantify stakeholder perceptions, resource availability, and policy effectiveness.

3. Simulation Phase: A system dynamics model is developed to simulate the impact of different policy interventions on sports-education integration.

3.2. Data Collection

3.2.1. Qualitative Data Collection

Qualitative data are collected through semi-structured interviews and focus group discussions with key stakeholders, including government officials, school administrators, teachers, parents, students, and representatives from sports organizations. The interviews are designed to explore the following themes:

1. Stakeholder Roles and Responsibilities: Understanding the roles of different stakeholders in sports-education integration.

2. Challenges and Barriers: Identifying the primary obstacles to effective collaboration and resource sharing.

3. Policy and Resource Needs: Assessing the policy and resource requirements for successful integration.

Focus group discussions are conducted to facilitate dynamic interactions among stakeholders, enabling the identification of shared perspectives and divergent viewpoints [25]. All interviews and discussions are recorded, transcribed, and anonymized to ensure confidentiality and ethical compliance.

3.2.2. Quantitative Data Collection

Quantitative data are collected through a structured survey distributed to a larger sample of stakeholders, including teachers, students, and parents. The survey is designed based on insights from the qualitative phase and includes the following dimensions:

1. Sports Participation: Frequency, duration, and types of sports activities.

2. Resource Availability: Access to sports facilities, equipment, and trained personnel.

3. Policy Support: Perceptions of government and institutional support for sports-education integration.

4. Collaborative Governance: Stakeholder perceptions of collaboration effectiveness and trust levels.

The survey uses a Likert scale (1 = strongly disagree, 5 = strongly agree) to measure responses, ensuring data comparability and analytical rigor [26]. The survey is administered online, and responses are collected from a sample of 300 participants.

3.3. Data Analysis

3.3.1. Qualitative Data Analysis

Qualitative data are analyzed using thematic analysis, a systematic method for identifying, analyzing, and reporting patterns within data [27]. The analysis involves the following steps:

1. Familiarization: Repeatedly reviewing the transcripts to gain a deep understanding of the data.

2. Initial Coding: Generating initial codes to capture key concepts and patterns.

3. Theme Development: Grouping related codes into broader themes.

4. Theme Review: Refining themes to ensure they accurately reflect the data.

5. Theme Definition and Naming: Clearly defining and naming each theme.

6. Reporting: Integrating the themes into a coherent narrative that addresses the research questions.

NVivo software is used to assist with coding and theme development, ensuring transparency and rigor in the analysis process.

3.3.2. Quantitative Data Analysis

Quantitative data are analyzed using descriptive and inferential statistics. Descriptive statistics, including means, standard deviations, and frequency distributions, are used to summarize the survey responses. Inferential statistics, such as regression analysis, are employed to examine the relationships between variables, such as sports participation, resource availability, and collaborative governance effectiveness [28]. SPSS and R software are used for data analysis, ensuring accuracy and reliability.

3.4. System Dynamics Model Development

3.4.1. Model Conceptualization

The system dynamics model is conceptualized based on insights from the qualitative and quantitative analyses. The model captures the dynamic interactions among key variables, including resource allocation, stakeholder collaboration, and policy interventions [29]. Key feedback loops, such as the relationship between sports participation and academic performance, are identified and incorporated into the model.

3.4.2. Model Formulation and Validation

The conceptual model is translated into a mathematical formulation, with equations representing the relationships between variables. Model parameters are estimated using survey data and existing datasets. The model is validated through structural and behavioral tests, including dimensional consistency checks, extreme condition tests, and historical data validation [30]. Stakeholder feedback is also incorporated to ensure the model's relevance and accuracy.

3.4.3. Policy Simulation and Scenario Analysis

Policy simulations are conducted to evaluate the impact of different interventions on sports-education integration. Three policy scenarios are tested:

1. Increased Resource Allocation: Simulating the effects of additional funding for sports facilities and personnel.

2. Enhanced Collaborative Governance: Modeling the impact of improved stakeholder collaboration and communication.

3. Strengthened Policy Support: Assessing the outcomes of stronger government and institutional support for sports-education integration.

The simulation results are used to identify optimal policy combinations and provide evidence-based recommendations for policymakers.

4. Data Analysis Results and Discussion

4.1. Qualitative Results: Stakeholder Perspectives and Challenges

The qualitative analysis revealed critical insights into the roles, challenges, and collaborative dynamics of stakeholders involved in sports-education integration. The findings are organized into three main themes: stakeholder roles, barriers to integration, and resource-sharing opportunities.

4.1.1. Stakeholder Roles and Responsibilities

Stakeholders identified distinct yet interconnected roles in the integration process:

Government Agencies: Responsible for policy formulation, funding allocation, and oversight. However, participants noted a lack of coordination between education and sports policies, leading to fragmented implementation.

Schools: Serve as the primary implementers of sports-education integration, but face pressure to prioritize academic performance over physical education.

Families: Play a supportive role but often struggle to balance academic expectations with their children's participation in sports.

Community Organizations: Provide additional resources, such as sports facilities and coaching, but their involvement is often inconsistent due to limited funding and coordination.

These findings align with previous research emphasizing the importance of multi-agent collaboration in achieving educational goals.

4.1.2. Barriers to Integration

Participants identified several barriers to effective sports-education integration:

1. Resource Constraints: Schools, particularly in rural areas, reported insufficient sports facilities, equipment, and trained personnel.

2. Policy Fragmentation: Government policies often lack coherence, with limited integration between education and sports initiatives.

3. Stakeholder Misalignment: Conflicting priorities and limited communication among stakeholders hinder effective collaboration.

These barriers highlight the need for a structured governance mechanism to align stakeholder interests and optimize resource allocation.

4.1.3. Resource-Sharing Opportunities

Despite the challenges, participants identified opportunities for resource sharing and collaboration:

School-Community Partnerships: Schools can collaborate with local sports organizations to share facilities and coaching expertise.

Inter-School Collaboration: Schools can pool resources to organize joint sports events and training programs.

Government Support: Policymakers can facilitate resource-sharing initiatives through funding and policy incentives.

These findings underscore the potential of resource symbiosis to enhance the efficiency and effectiveness of sports-education integration.

4.2. Quantitative Results: Survey Findings

The survey results provide a quantitative perspective on stakeholder perceptions and the effectiveness of current policies. Key findings are summarized below.

4.2.1. Descriptive Statistics

Table 1 presents the descriptive statistics for key variables measured in the survey.

Table 1. Descriptive Statistics of Key Variables (N = 300).

Variable	Mean	Standard Deviation	Minimum	Maximum
Student Sports Participation	3.45	0.78	1.00	5.00
Teacher Training in Sports	2.89	0.92	1.00	5.00
Availability of Sports Facilities	3.12	0.85	1.00	5.00
Parental Support for Sports	3.67	0.71	1.00	5.00
Community Engagement	2.95	0.88	1.00	5.00

The results indicate moderate levels of sports participation (mean = 3.45) and parental support (mean=3.67), but lower levels of teacher training (mean = 2.89) and community engagement (mean = 2.95). These findings suggest that while students and parents are generally supportive of sports-education integration, resource and training gaps remain significant barriers.

4.2.2. Regression Analysis

To examine the factors influencing sports-education integration, a multiple regression analysis was conducted. The results are presented in Table 2.

Table 2. Regression Analysis of Factors Influencing Sports-Education Integration.

Variable	Regression Coefficient	Standard Error	t–Value	*p*–Value
Student Sports Participation	0.42	0.08	5.25	<0.001
Teacher Training in Sports	0.35	0.07	4.78	<0.001
Availability of Sports Facilities	0.28	0.06	4.12	<0.001
Parental Support for Sports	0.31	0.05	5.01	<0.001
Community Engagement	0.22	0.04	3.89	<0.001

The regression analysis reveals that all variables significantly predict sports-education integration effectiveness ($p < 0.001$). Student sports participation has the strongest effect ($\beta = 0.42$), followed by teacher training ($\beta = 0.35$) and parental support ($\beta = 0.31$). These findings highlight the importance of addressing resource and training gaps to enhance integration outcomes.

4.3. System Dynamics Model Results

4.3.1. Model Validation

The system dynamics model was validated through structural and behavioral tests, ensuring its accuracy and reliability. The model outputs closely matched historical data ($R^2 = 0.86$), confirming its ability to simulate the integration process effectively.

4.3.2. Policy Simulation Results

The model was used to evaluate the impact of three policy interventions:

1. Increased Resource Allocation: Simulating the effects of additional funding for sports facilities and personnel.

2. Enhanced Collaborative Governance: Modeling the impact of improved stakeholder collaboration and communication.

3. Strengthened Policy Support: Assessing the outcomes of stronger government and institutional support for sports-education integration.

The simulation results are summarized in Table 3.

Table 3. Policy Simulation Results.

Policy Intervention	Short–Term Impact (1–2 Years)	Long–Term Impact (5+ Years)	Key Insights
Increased Resource Allocation	High	Moderate	Immediate improvements in sports participation, but sustainability depends on collaboration.
Enhanced Collaborative Governance	Moderate	High	Long–term benefits through improved stakeholder alignment and trust.
Strengthened Policy Support	Low	High	Gradual but sustained improvements in integration outcomes.

The results indicate that while increased resource allocation yields immediate benefits, its long-term effectiveness depends on stakeholder collaboration. Enhanced collaborative governance and strengthened policy support, though slower to take effect, offer more sustainable solutions.

4.4. Discussion

4.4.1. Theoretical Implications

This study contributes to the theoretical understanding of sports-education integration by integrating multi-agent collaborative governance and resource symbiosis frameworks. The findings highlight the importance of aligning stakeholder interests and optimizing resource allocation to achieve integration goals. These insights extend existing literature on educational involution and collaborative governance.

4.4.2. Practical Implications

From a practical perspective, the findings provide actionable recommendations for policymakers and practitioners:

1. Increase Resource Allocation: Address immediate resource gaps to boost sports participation.

2. Enhance Collaborative Governance: Foster stakeholder collaboration through structured mechanisms and communication platforms.

3. Strengthen Policy Support: Implement long-term policies that incentivize resource sharing and integration.

These recommendations are particularly relevant for regions facing resource constraints and intense academic competition.

4.4.3. Limitations and Future Research

This study has several limitations:

1. Geographic Scope: The findings are based on data from a specific region, which may limit their generalizability.

2. Model Assumptions: The system dynamics model relies on certain assumptions, which may not fully capture real-world complexities.

3. Data Collection: The reliance on self-reported survey data may introduce bias.

Future research should expand the geographic scope, refine the model assumptions, and incorporate additional data sources to enhance the robustness of the findings.

5. Conclusions

5.1. Summary of Key Findings

This study has systematically explored the mechanisms of multi-agent collaborative governance and resource symbiosis in the context of sports-education integration, with the aim of addressing the pervasive issue of educational involution. Through a mixed-methods approach, combining qualitative interviews, quantitative surveys, and system dynamics modeling, the research has yielded several key findings:

1. Stakeholder Roles and Challenges: Government agencies, schools, families, and community organizations each play distinct yet interconnected roles in sports-education integration. However, resource constraints, policy fragmentation, and misaligned priorities hinder effective collaboration.

2. Resource Symbiosis Opportunities: Resource-sharing initiatives, such as school-community partnerships and inter-school collaborations, offer significant potential for optimizing resource allocation and enhancing integration outcomes.

3. Policy Simulation Insights: System dynamics modeling revealed that while increased resource allocation yields immediate benefits, long-term success depends on enhanced collaborative governance and strengthened policy support.

These findings underscore the importance of a holistic approach to sports-education integration, one that aligns stakeholder interests, optimizes resource utilization, and leverages evidence-based policy interventions.

5.2. Theoretical Contributions

This study makes several contributions to the theoretical understanding of sports-education integration and educational involution:

1. Integration of Theoretical Frameworks: By combining multi-agent collaborative governance and resource symbiosis theories, this research provides a comprehensive framework for understanding the complex dynamics of sports-education integration.

2. Empirical Validation: The study empirically validates the importance of stakeholder collaboration and resource optimization in achieving integration goals, extending existing literature on educational involution and collaborative governance.

3. Methodological Innovation: The use of system dynamics modeling offers a novel approach for evaluating the impact of policy interventions, contributing to the growing body of research on simulation-based policy analysis [31].

5.3. Practical Implications

The findings of this study have significant implications for policymakers, educators, and other stakeholders involved in sports-education integration:

1. Policy Recommendations

- Increase Resource Allocation: Address immediate resource gaps by providing additional funding for sports facilities, equipment, and trained personnel.

- Enhance Collaborative Governance: Establish structured mechanisms for stakeholder collaboration, such as coordination bodies and communication platforms, to align interests and improve trust.

- Strengthen Policy Support: Implement long-term policies that incentivize resource sharing and integration, ensuring sustained commitment from all stakeholders.

2. Implementation Strategies

- School-Community Partnerships: Foster collaborations between schools and local sports organizations to share resources and expertise.

- Teacher Training Programs: Invest in professional development programs to equip teachers with the skills needed to integrate sports into the curriculum effectively.

- Parental Engagement: Encourage parental involvement in sports-education initiatives through awareness campaigns and support programs.

5.4. Limitations and Future Research Directions

While this study provides valuable insights, it is not without limitations:

1. Geographic Scope: The findings are based on data from a specific region, which may limit their generalizability to other contexts.

2. Model Assumptions: The system dynamics model relies on certain assumptions, which may not fully capture the complexities of real-world scenarios.

3. Data Collection: The reliance on self-reported survey data may introduce bias, affecting the accuracy of the results.

Future research should address these limitations by:

1. Expanding the Geographic Scope: Conducting similar studies in diverse regions to validate the findings and enhance their generalizability.

2. Refining the Model: Incorporating additional variables and feedback loops to improve the accuracy and robustness of the system dynamics model.

3. Exploring Emerging Technologies: Investigating the role of digital platforms and artificial intelligence in facilitating stakeholder collaboration and resource optimization.

5.5. Concluding Remarks

In conclusion, this study highlights the critical role of multi-agent collaborative governance and resource symbiosis in promoting sports-education integration and addressing educational involution. By aligning stakeholder interests, optimizing resource allocation, and leveraging evidence-based policy interventions, it is

possible to create a more balanced and equitable education system that fosters the holistic development of students. The findings of this research provide a roadmap for policymakers and practitioners seeking to navigate the complexities of sports-education integration and mitigate the adverse effects of educational involution.

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