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Quantitative Analysis of Factors Influencing Secondary School Students' Satisfaction with the "Double Reduction" Policy: A Perspective on EGRA

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Abstract: *Since the implementation of the "Double Reduction" policy, the academic burden of students has been greatly reduced. However, limited body of literatures exist that empirically investigates the efficacy of implementing the "Double Reduction" policy. To address this gap, a survey was conducted among 441 secondary school students in Chengdu, Sichuan Province. The study employed Entropy-weighted Gray Relational Analysis (EGRA) to prioritize the factors associated with satisfaction with policy implementation. Subsequently, Importance-Performance Analysis (IPA) quadrant diagram was utilized to categorize and analyze the factors into four quadrants for comprehensive summary. The research indicated that: (1) Homework duration, examination frequency and examination form are the three most important factors. (2) Personalized homework, stratified homework, practical homework, examination form and homework duration are the five key factors in the IPA improving region, which can significantly enhance student satisfaction and boost their learning efficiency. (3) Examination frequency and Intelligent homework and other 10 factors in the advantage and maintaining region, students' satisfaction is higher, and the policy reform effect is more obvious. The results are crucial for policymakers to further promote and implement the "Double Reduction" policy effectively.*

Keywords: *Satisfaction; Entropy-weighted gray relational analysis; Importance-Performance Analysis*

1. Introduction

In recent years, the learning burden of Chinese students has become heavier and heavier. The expenses on extracurricular tuition have become a heavy burden for families and parents are becoming increasingly anxious [1]. These problems have seriously affected the educational ecology and the physical and mental development of students [2]. Therefore, in July 2021, the General Office of the Central Committee of the Communist Party of China and the General Office of the State Council issued a "Double Reduction" policy, the full name of which is "Opinions on Further Reducing the Burden of Students' Homework and Off-campus Training in Compulsory Education." It is clearly pointed out that we should vigorously improve the quality of school teaching and ensure that students can learn well in school. The implementation of the "Double Reduction" signifies that China's education is transitioning towards high-quality and connotative development following continuous reforms. This shift entails abandoning the score-oriented view, thereby transitioning to a genuinely people-oriented educational practice [3]. Our research aims to identify and analyze the key factors that influence student satisfaction following the implementation of the policy. This research will serve as a reference and foundation for the actual execution of the "Double Reduction" initiative, thereby enhancing student satisfaction. It is a crucial pathway for the successful implementation of the policy strategy. The study seeks to answer the following questions:

(1) What are the factors influencing satisfaction with the implementation of the "Double Reduction" policy?

(2) Is the selection of these factors reliable?

(3) What are the key factors that contribute to satisfaction or dissatisfaction?

(4) How do these factors interrelate with each other?

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(5) What are the implications of these findings for improving the current situation?

To address these queries, we developed a framework of factors influencing satisfaction by drawing from existing literature and the current state of policy implementation. Subsequently, a questionnaire was designed. The responses to the questionnaire were processed and analyzed using EGRA. The reliability of the system of influencing factors was assessed, and the key determinants of students' satisfaction with the "Double Reduction" were identified. Based on this, an IPA quadrant diagram was constructed, and recommendations for optimization were proposed to assist decision-makers in further advancing the policy implementation and facilitating the long-term realization of the policy goal.

2. Literature review and framework development

Satisfaction is a "gray concept" with clear boundaries but vague connotations [4]. The assessment of students' contentment with the "Double Reduction" policy's execution is a subjective perception and evaluation of its implementation, highlighting the disparity between students' anticipations and actual outcomes. Previous research on satisfaction has predominantly employed gray relational analysis (GRA), linear regression analysis, and structural equation modeling. Among these methods, GRA employs multivariate analysis to ascertain the degree of mutual influence between factors. This approach enables a comprehensive assessment of the contribution of each indicator to the data's change, based on the geometric similarity of the indicator factors. This methodology is not constrained by sample size or regularity, making it particularly suitable for questionnaire analysis [5]. The Entropy Weight Method is an objective assignment technique. Information entropy, which serves as a measure of the level of disorder in a system, can be employed to assign weights to indicators in a multi-indicator evaluation system. This method not only assesses the amount of information contained in the data but also determines the weights of the indicators [6]. Since the magnitude of the effect of each factor on student satisfaction after the implementation of the "Double Reduction" is unknown, and the magnitude of the effect is unlikely to be consistent, it is necessary to weight the factors. To enhance the authenticity and efficacy of the findings, this research extends beyond a singular qualitative or quantitative study. Instead, it integrates the scientific grey system theory, colloquially known as GRA method, with a dependable approach for information entropy. By fusing qualitative and quantitative research methods, this study reorients the evaluation paradigm.

Table 1: Satisfaction factors framework

	Factors	Describe
x_1	Homework duration	The time required to complete the homework.
x_2	Stratified homework	According to the difference of students ' knowledge level, the homework is arranged in layers.
x_3	Practical homework	Social practice, social questionnaire, engaged in special subject research, etc.
x_4	Personalized homework	Homework tailored according to the characteristics of students.
x_5	Homework difficulty	The degree of difficulty of homework.
x_6	Online resources	Various educational resources on the web.
x_7	Home-school resources	Various educational resources for home-school collaboration for student development.
x_8	Moral education resources	Moral education first, people-oriented all kinds of educational resources.
x_9	Intelligent homework	Homework that can be automatically or semi-automatically reviewed online using the machine.
x_{10}	After-school service	Services derived from solving the problems of " time difference " between early school and late. work and reducing the burden of extracurricular expenses.
x_{11}	Examination frequency	The frequency of school organization knowledge level identification.
x_{12}	Examination form	Modalities for the organization of the examination.
x_{13}	Score attention	Examination results notification and processing methods, etc.
x_{14}	System thinking	A way of thinking that comprehensively weighs various factors in solving problems.
x_{15}	Learning points	The focus of students ' academic evaluation.
x_{16}	Home-school boundary	The boundaries between home and school responsibilities for student education.
x_{17}	Home environment	Family hardware environment, family atmosphere, family style and family instructions, etc.
x_{18}	Time management	Effective use and distribution of time, reduce variability.
x_{19}	Home-school cooperation	Schools and parents share the responsibility for the growth of students.

The rational and effective implementation of policies is influenced by a multitude of factors, often leading to deviations in the process [7]. Evaluating the variables impacting student contentment post-"Double Reduction" policy's implementation is a crucial approach to comprehend its efficacy. The selection of policy influencing factors should be done from multiple dimensions. Zeng and Zhang (2023) argued that factors such as homework numbers, homework difficulty, personalized homework, after-school service, and home environment have an important impact on students' academic stress from a student perspective [8]. Zhu and Luo (2023) posit that several factors significantly influence the successful implementation of the policy [9]. These include home-school communication, academic supervision, academic counseling, and parental anxiety. Additionally, research found that educational resources such

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as Intelligent homework as essential reference factors [10]. This study adheres to the four principles of scientificalness, accessibility, independence, and generalizability in constructing the indicator system. Furthermore, it incorporates the actual learning situation of junior high school students following the implementation of the policy. Ultimately, nineteen factors that influence junior high school students' satisfaction with the current status of "Double Reduction" implementation were selected as the basic framework (Table 1).

3. Research methodology and design

3.1. Research methodology

In this study, Entropy-weighted Gray Relational Degree model (EGRA) was used to calculate the weights of the factors affecting “Double Reduction” satisfaction, and the calculation steps are shown below [11][5].

Step 1: Select the reference series (dependent variable) and the comparison series (independent variable). The reference series is defined as the average value of each student's questionnaire data on the satisfaction of "Double Reduction" as X_0. There are m rows and n columns for the whole data, m is the number of questionnaires and n is the number of influencing factors. Here m=441, n=19. The reference series is:

$$X_0 = (X_{01}, X_{02}, X_{03} \cdots X_{0n}) \tag{1}$$

The comparison series is:

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \tag{2}$$

Step 2: Dimensionless processing of data. We take the number in each row and divide it by the data in the first row, where i ranges from 0 to m and j ranges from 0 to n:

$$z_{ij} = \frac{x_{ij}}{x_{i1}} \tag{3}$$

The result of initializing the original questionnaire data is Z. The reference sequence also needs to be initialized:

$$Z = \begin{bmatrix} z_{00} & z_{01} & \cdots & z_{0n} \\ z_{10} & z_{11} & \cdots & z_{1n} \\ \vdots & \vdots & \vdots & \vdots \\ z_{m0} & z_{m1} & \cdots & z_{mn} \end{bmatrix} \tag{4}$$

Step 3: Calculate the relational coefficients for each influence factor. The homogenized Z_0 was used as the reference sequence and Z_j as the comparison sequence, where ρ = 0.5:

$$\xi_{ij} = \frac{\min\limits_i \min\limits_j \left|Z_{0i} - Z_{ij}\right| + \rho \max\limits_i \max\limits_j \left|Z_{0i} - Z_{ij}\right|}{\left|Z_{0i} - Z_{ij}\right| + \rho \max\limits_i \max\limits_j \left|Z_{0i} - Z_{ij}\right|} \tag{5}$$

Step 4: Calculate the gray relational degree (GRD) and weight of each factor. The GRD of students' satisfaction with the policy is the average value of each column correlation coefficient:

$$t_j = \frac{1}{m} \sum_{i=1}^{m} \xi_{ij} \tag{6}$$

Step 5: The Entropy Weight Method is used to calculate the weight. Calculate the entropy weight e_j and weight w_j of each factor:

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$$e_j = -\frac{1}{\ln n}\sum_{i=1}^{m}\frac{X_{ij}}{\sum_{i=1}^{m}X_{ij}}\ln(\frac{X_{ij}}{\sum_{i=1}^{m}X_{ij}}) \tag{7}$$

$$w_j = \frac{1-e_j}{\sum_{j=1}^{n}1-e_j} \tag{8}$$

Step 5: Calculate the Entropy-weighted Gray Relational Degree (EGRD):

$$r_j = w_j t_j \tag{9}$$

3.2. Questionnaire design and distribution

Based on the framework of factors, we designed a questionnaire entitled "Middle School Students' Satisfaction with the Present Situation under 'Double Reduction'". The questionnaire was divided into two parts: the basic part and the formal questionnaire. The basic part encompasses three aspects. The formal questionnaire utilized a seven-point scale to assess students' satisfaction. Respondents were asked to rate their level of satisfaction on the scale, ranging from strongly satisfied to strongly unsatisfied. The scores ranged from 7 to 1, with higher scores indicating greater satisfaction. A total of 19 questions were included in the scale, labeled as x_1 through x_{19} (Table 1). The questionnaires were distributed to secondary school students of Sichuan, China via online and paper formats, resulting in a recovery rate of 466 questionnaires. After removing invalid responses (those completed in less than 20 seconds and those with a standard deviation of scale question options equal to 0), a total of 441 valid questionnaires were obtained, yielding an effective rate of 94.6%.

3.3. Reliability and validity test of questionnaire

The study utilized SPSS 26.0 to assess the reliability of the 441 valid questionnaires collected. The purpose of the reliability analysis was to evaluate the consistency and dependability of the questionnaire. The Cronbach's alpha was 0.946>0.8. Validity refers to the extent to which a measurement tool accurately measures the characteristic it is designed to measure. The exploratory factor analysis results revealed that the KMO value was 0.955 (>0.8), Bartlett's test of sphericity had an approximate chi-square value of 5221.151, and the probability value of Sig.=0.000 (<0.05) at a degree of freedom (df) of 171, which rejected the original hypothesis. This indicates a significant correlation between the variables. The analysis of commonality was 0.378 to 0.714, suggesting that most of the information in the indicators can be extracted. Through the above analysis, it was found that the reliability and commonality of the questionnaire passed the test, effectively reflecting the basic situation of students' satisfaction.

4. Data analysis and results

4.1. Descriptive statistical analysis

4.1.1. Demographic Information Statistics

To comprehend the fundamental information of the subjects, the study employed SPSS26.0 for a statistical analysis of their basic details. In terms of gender distribution, female constituted 53.3% and male accounted for 46.7%, exhibiting no disparity between the proportions of male and female. Regarding grade distribution, seventh-grade students comprised 31.7%, eighth-grade students accounted for 31.6%, and ninth-grade students made up 36.7%, presenting a balanced distribution of grades. Concerning the "Double Reduction" knowledge channels' distribution, 50.8% were disseminated by schools, 39% were informed through the Internet, and 10.2% were shared by friends and relatives. This indicates that schools play a leading role in the implementation of the policy.

4.1.2. Descriptive analysis of variables

To assess the importance and variability of the observed variables in determining actual satisfaction levels, the study conducted a statistical analysis of their means and standard deviations. The standard deviation ranged from 1.503 to 2.037, indicating stable performance across the variables. The satisfaction level for Online resources (5.34±1.726), system thinking (5.32±1.524), and Home-school boundary (5.31±1.634) exceeded 5.3. Notably, these aspects experienced significant changes after the "Double

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Reduction" reform, resulting in higher student satisfaction. On the other hand, practical homework (4.89±1.784), examination form (4.87±1.769), and homework difficulty (4.53±1.860) all fell below 4.9, suggesting that students enrolled in these schools have low satisfaction with these aspects. Furthermore, there has been little improvement in these areas following the policy reform, highlighting substantial room for enhancement.

4.2. Entropy-weighted Gray Relational Analysis(EGRA)

4.2.1. Raw data initialization processing and difference series calculation

The raw data were 441 students. Due to space constraints, the study randomly selected the findings of 8 students for presentation. The actual calculation was done with 441 students. Table 2 shows the questionnaire responses of the 8 students selected. The columns represent the students, numbered from S1 to S8, and the rows represent the factors affecting the students' satisfaction with the implementation of "Double Reduction", numbered from x_1 to x_{19}. The raw data are initialized by dividing the values in the first column by those in each subsequent column, using the first column as the standard. The first column serves as the parent series, whose values are averaged across each row and then used for initialization. The subtraction sequence involves subtracting the reference sequence value from the value of each row, followed by finding the absolute value. To calculate the two-level minimum difference, we first identify the minimum value within each row, and then find the minimum value among these row-wise minimums. Symbol a denotes the minimum value of each column after initializing the 441 questionnaires, while b represents the maximum value. Consequently, the final result of the two-level minimum difference is 0. Similarly, the two-level maximum difference is 0.921 (Table 2).

Table 2: Satisfaction subtraction sequence.

	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	*a*	*b*
Δx_1	0.00	0.04	0.36	0.15	0.18	0.09	0.05	0.42	0.00	0.832
Δx_2	0.00	0.04	0.14	0.16	0.10	0.06	0.05	0.10	0.00	0.808
Δx_3	0.00	0.12	0.02	0.01	0.06	0.06	0.05	0.07	0.00	0.850
Δx_4	0.00	0.04	0.14	0.16	0.10	0.10	0.12	0.10	0.00	0.802
Δx_5	0.00	0.21	0.14	0.16	0.06	0.10	0.05	0.07	0.00	0.910
Δx_6	0.00	0.12	0.31	0.01	0.06	0.06	0.12	0.27	0.00	0.655
Δx_7	0.00	0.04	0.02	0.16	0.10	0.10	0.05	0.10	0.00	0.548
Δx_8	0.00	0.12	0.14	0.18	0.06	0.06	0.05	0.10	0.00	0.799
Δx_9	0.00	0.04	0.31	0.01	0.10	0.10	0.12	0.10	0.00	0.802
Δx_{10}	0.00	0.36	0.36	0.39	0.10	0.03	0.35	0.43	0.00	0.766
Δx_{11}	0.00	0.04	0.07	0.01	0.10	0.09	0.05	0.28	0.00	0.738
Δx_{12}	0.00	0.04	0.02	0.01	0.10	0.10	0.05	0.07	0.00	0.850
Δx_{13}	0.00	0.12	0.36	0.18	0.06	0.06	0.12	0.07	0.00	0.901
Δx_{14}	0.00	0.04	0.14	0.01	0.10	0.10	0.05	0.10	0.00	0.921
Δx_{15}	0.00	0.12	0.19	0.16	0.06	0.06	0.12	0.40	0.00	0.811
Δx_{16}	0.00	0.04	0.07	0.01	0.04	0.06	0.05	0.00	0.00	0.645
Δx_{17}	0.00	0.04	0.36	0.01	0.06	0.06	0.05	0.10	0.00	0.638
Δx_{18}	0.00	0.04	0.07	0.29	0.04	0.06	0.05	0.15	0.00	0.713
Δx_{19}	0.00	0.19	0.36	0.15	0.04	0.09	0.19	0.00	0.00	0.755

4.2.2. Calculate the grey relational coefficient and relational degree

Using Formula (5), the gray relational coefficient values for each student under each factor can be calculated. Similarly, using formula (6), the average gray relational coefficient of each column can be obtained to determine the gray correlation value of the factors with the status quo after the implementation of "Double Reduction". A higher correlation value signifies a stronger link between the comparison series and the reference series, implying that the factor is more important. The results of the calculations reveal that among the factors affecting students' satisfaction with the current situation after the implementation of the policy, the five most significant factors are: home-school boundary (0.819), home-school resources(0.799), home-school cooperation(0.798), time management(0.796) and stratified homework(0.791). On the other hand, the five factors with lower correlations are after-school service(0.674), homework difficulty(0.726), online resources(0.770), system thinking(0.773) and score

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attention(0.774). Considering that the common degree of homework difficulty is only 0.378, and the GRD is low, and after-school service has rotated factor loadings less than 0.45 in all dimensions, indicating a low level of differentiation in this topic, the remaining 17 factors were used for subsequent analysis after deleting these two factors.

4.2.3. Calculate the Entropy-weighted Gray Relational Degree (EGRD)

After eliminating the two factors, the GRD was recalculated. The EGRD can be obtained by multiplying the correlation of students' satisfaction with the 17 factors related to the implementation of the policy with the weights of their factors, as per equation (9). The weight calculation process is based on equations (7) and (8). Here, '*e*' represents the entropy weight of the 17 satisfaction factors, '*d*' is calculated as 1-e, '*w*' is the weight, '*t*' is the correlation degree, '*r*' is the weighted correlation degree, and sorting refers to the result of sorting according to the size of *r*. The larger *r* is, the higher the ranking.

Table 3: The EGRD of each factor.

Factor	*e*	*d*	*w*	*t*	*r*	Rank
x_1	0.983	0.017	0.091	0.772	0.070	1
x_2	0.988	0.012	0.065	0.791	0.051	5
x_3	0.987	0.013	0.070	0.778	0.055	4
x_4	0.988	0.012	0.066	0.776	0.051	6
x_6	0.989	0.011	0.057	0.768	0.044	9
x_7	0.992	0.008	0.042	0.799	0.034	16
x_8	0.991	0.009	0.051	0.784	0.040	13
x_9	0.990	0.010	0.054	0.788	0.043	10
x_{11}	0.987	0.013	0.070	0.790	0.055	2
x_{12}	0.987	0.013	0.070	0.782	0.055	3
x_{13}	0.989	0.011	0.061	0.775	0.047	7
x_{14}	0.992	0.008	0.043	0.772	0.033	17
x_{15}	0.989	0.011	0.059	0.778	0.046	8
x_{16}	0.991	0.009	0.051	0.821	0.042	11
x_{17}	0.991	0.009	0.050	0.786	0.040	14
x_{18}	0.991	0.009	0.048	0.798	0.039	15
x_{19}	0.991	0.009	0.051	0.800	0.040	12

5. Discussion

To delve deeper into students' satisfaction with the policy following the implementation of “Double Reduction”, and to generate targeted recommendations for enhancement, this study employed IPA to scrutinize the data [12]. The factors were categorized into four regions: dominance, maintenance, opportunity, and improvement, based on their EGRA values and satisfaction scores (Figure 1). A higher EGRA value indicates a more crucial factor, while a higher mean satisfaction score signifies greater student contentment with that factor. The vertical axis represents the average satisfaction score, with a cut-off of 5.08, while the horizontal axis represents the weighted gray correlation, with a cut-off of 0.05.

Advantage region: Factors situated in this quadrant exhibit a high EGRD value and a high level of satisfaction. One such factor, examination requency, is prominently featured. This is primarily manifested through the reduction in the number of exams conducted in schools post the "Double Reduction" policy implementation. This shift indicates a heightened satisfaction among students regarding the current exam frequency in schools. By conducting fewer academic level quality tests, schools can effectively gauge the learning status of their students while significantly alleviating examination-related stress on them.

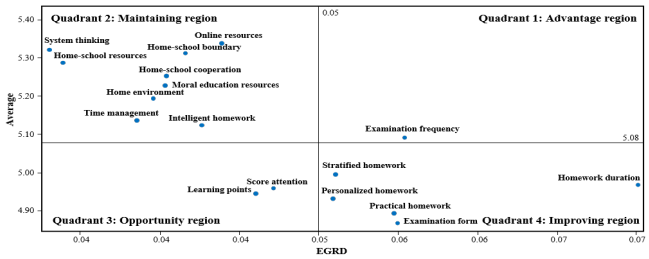

Figure 1: The IPA of Satisfaction and EGRD.

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Mataining region: This region comprises nine factors that exhibit low EGRD values but high levels of satisfaction. These factors include intelligent homework, time management, home environment, home-school cooperation, home-school resources, moral education resources, online resources, home-school boundary, and systems thinking. The implementation of the "double reduction" has fostered closer connections between schools and families, resulting in a more harmonious relationship between home and school environments. Consequently, student satisfaction has increased significantly. Despite their relatively low importance, these factors still play a crucial role in students' personal development and learning abilities. Maintaining these factors is essential for enhancing student satisfaction with the policy initiative.

Opportunity region: Factors located in this quadrant correspond to small EGRD values and low satisfaction. It mainly contains two influences, learning points and score attention. Students are dissatisfied in these two factor, which belong to the area that needs special attention in the follow-up. For example, in terms of learning points, different teachers have different understanding and teaching styles of the same knowledge point, and there are also subtle differences in the focus of the knowledge they explain. However, due to the differences in knowledge blindness among students, some students may still be slightly confused after the teacher has finished teaching them. The same applies to the score attention. Some schools place too much emphasis on scores, which leads to excessive pressure and overburdening of students, and a decline in academic performance instead of an increase. However, before and after the "Double Reduction", the changes in this area were relatively small, and student satisfaction was low. In this regard, schools and teachers should pay particular attention to the differences between students and try to teach at different levels. Slightly dilute the decision-making role of scores, pay attention to the process evaluation of students, so as to enhance students' satisfaction with the "Double Reduction".

Improving region: This region lies in the factors situated within the quadrants corresponding to high EGRD values but low satisfaction levels. These factors encompass five aspects: personalized homework, stratified homework, practical homework, examination form and homework duration. This suggests that these elements are crucial to the surveyed students and should be emphasized. However, despite the policy initiative, these aspects have not undergone significant changes, resulting in unsatisfactory outcomes. Consequently, students' dissatisfaction with the "Double Reduction" has escalated to a certain extent. Most students believe that some teachers have not done enough in designing assignments. For instance, when assigning homework, they fail to incorporate stratification, neglect to assign practical and personalized tasks, and maintain lengthy homework durations, which hinders some students from completing their assignments on time. Research indicates that for students with intermediate or above academic levels, altering the amount of homework does not impact their academic performance. Conversely, the quality of homework assigned by teachers significantly influences students' academic performance [13]. Therefore, teachers need to focus on enhancing the quality of homework during later stages of teaching. Tailoring instruction to cater to different students' actual needs can be explored. Additionally, reducing the amount of student homework appropriately can improve the efficiency of student homework and further alleviate the burden of student homework [9].

6. Conclusions

In this paper, we employed the EGRA model and the EGRD-satisfaction IPA quadrant diagram to investigate the factors influencing secondary school students' satisfaction within the context of "Double Reduction". Our findings indicate that homework duration, examination frequency, and examination form are the three most significant factors. Schools should tailor their measures to the actual situation and shift away from a score-only approach. Additionally, five factors, such as personalized homework, stratified homework, practical homework, examination form and homework duration, require immediate improvement. It is crucial to note that reducing student burden does not necessarily mean decreasing homework volume. Teachers should enhance classroom efficiency, implement personalized and tiered teaching methods, and diversify homework types and levels. Meanwhile, ten factors, including examination frequency and intelligent homework, have shown positive results, and schools should maintain these advantages. To address the current "Double Reduction" reform focus, we propose a comprehensive education concept that emphasizes holistic development and integrates five aspects of education. Specific implementation practices are required for in-depth reform in students' homework and examinations. By decentralizing authority to teachers and empowering students, we can truly achieve reduced burden and increased efficiency.

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