

Entropy Weight Method Based Assessment of Mental Health in Middle School Students

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Abstract: With the progress of education and social development, mental health issues among middle school students are increasingly gaining attention. This study employs the entropy weight method to assess the mental health of middle school students, establishing a mental health capability index system and quantifying relevant data. Case data analysis reveals that social activities and parental relationships have the greatest impact on students' mental health, while study time, academic burden, and school atmosphere have relatively smaller effects. The research helps understand the mental health status of students and provides a basis for formulating reasonable educational strategies, thus promoting the comprehensive development of students.

Keywords: Middle School Students' Mental Health; Indicator System; Composite Weight; Entropy Weight Method

1. Introduction

With the rapid development of society and the intensification of educational competition, middle school students face significantly increased academic pressure and psychological challenges [1]. Mental health has become an important factor affecting students' academic performance and personal development [2]. In recent years, mental health issues among middle school students, such as depression, anxiety, and interpersonal relationship disorders, have occurred frequently. These issues not only affect their learning outcomes but may also adversely impact their long-term development [3]. Therefore, paying attention to and assessing the mental health of middle school students is crucial for promoting their comprehensive development and mental well-being [4-6].

Existing research on the assessment of middle school students' mental health [7-10] is mostly limited to qualitative analysis and lacks a comprehensive quantitative analysis method based on data and science. The entropy weight method, as an effective data analysis method, objectively reflects the importance of various evaluation indicators by determining their weights and is widely used in quantitative analysis across various fields. This study attempts to apply the entropy weight method to the assessment of middle school students' mental health, aiming to establish a scientific and reasonable assessment system to quantify students' mental health status. By analyzing the weights of different mental health indicators, it is possible to more accurately reveal the factors affecting middle school students' mental health, providing a scientific basis for interventions by schools and parents.

2. Establishment of Indicator System

To assess the mental health of junior high school students, it is necessary to establish a set of assessment indicators. By sharing the factors that influence the mental health of middle school students, various indicators for assessing the mental health of junior high school students are refined and illustrated in Figure 1.

2.1 Academic Pressure

Academic pressure, such as exams and excessive homework, causes emotional instability, anxiety, and depression among middle school students, reducing their self-esteem and confidence, and affecting their social skills. Studies show that academic pressure is positively correlated with psychological qualities; students under greater pressure exhibit poorer emotional regulation, lower self-esteem, and higher anxiety.

Weekly study time directly impacts students'

performance; too much time can lead to fatigue and anxiety, while too little may result in insufficient learning. Properly managing study time is crucial for alleviating academic stress. Excessive academic burden, such as multiple courses, high difficulty, and a large amount of homework, is a primary source of academic stress, causing anxiety and pressure among students and significantly impacting their psychological health. Exam stress, including the pursuit of high scores, frequent testing, and mastering a large amount of knowledge in a short time, causes significant tension in middle

school students, negatively affecting their academic and psychological health. Motivation, particularly an interest and passion for knowledge, helps middle school students actively cope with academic stress and maintain their motivation to learn, positively affecting their psychological health. Effective learning methods, such as proper time management, memory techniques, and problem-solving skills, improve learning efficiency and grades, helping students reduce academic stress and positively impact their psychological health.

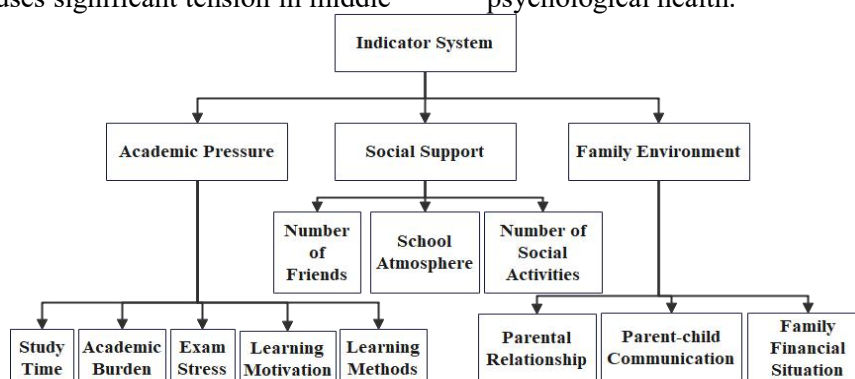


Figure 1. Evaluation Indicator System

2.2 Social Support

Social support is one of the significant factors influencing the psychological health assessment outcomes of middle school students. The number of friends has a significant impact on middle school students' psychological health. More social connections help them better cope with academic pressure and reduce anxiety and depression, positively affecting their psychological health. The number of social activities deeply influences middle school students' psychological health. Frequent social interactions can enhance psychological resilience, emotional regulation abilities, and self-esteem. An active social life helps students exhibit more positive psychological health characteristics. A supportive and inclusive school atmosphere is crucial for the psychological health of middle school students. It fosters positive social relationships among students and provides necessary support from teachers and peers, significantly promoting the development of their psychological health.

2.3 Family Environment

The family environment is also one of the significant factors influencing the

psychological health assessment outcomes of middle school students. The harmony and stability of parental relationships are crucial for the psychological health of middle school students, providing a safe and harmonious home environment that helps them develop a healthy mental state. Studies show that harmonious parental relationships help middle school students maintain good psychological health. Effective parent-child communication helps middle school students establish close emotional ties with their family, providing emotional support and enhancing problem-solving abilities, thereby significantly promoting their psychological health and adaptability. The stability of the family's financial situation is crucial for the psychological health of middle school students. Financial difficulties can increase psychological burden and stress, affecting their self-esteem and overall mental health.

3. The Basic Principle of the Entropy Weight Method

3.1 Overview of the Entropy Weight Method

The basic principle of the entropy weight method is based on the concept of information

entropy. Information entropy is a measure of the concentration of information, representing the maximum extent of information in a random variable where the sum of the probabilities of each value equals one. The smaller the information entropy, the more concentrated the information; conversely, the more dispersed the information. The entropy weight method calculates the information entropy of each indicator and then determines the weights of these indicators, thereby facilitating multi-criteria decision-making.

3.2 Steps of the Entropy Weight Method

3.2.1 Data normalization

$$r_{ij} = \frac{x_j - x_{\min}}{x_{\max} - x_{\min}}, \quad (1)$$

Where x_j represents the value of the j -th indicator, x_{\max} represents the maximum value of the j -th indicator, x_{\min} represents the minimum value of the j -th indicator, and r_{ij} represents the normalized value.

If there are m items to be evaluated and n evaluation criteria, forming a standardized original data matrix $R = (r_{ij})_{m \times n}$.

$$R = \begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{pmatrix}. \quad (2)$$

Where r_{ij} is the evaluation value of the i -th item under the j -th criterion. The weight (prior probability) p_{ij} of the i -th item under the j -th criterion is calculated as follow.

$$p_{ij} = \frac{r_{ij}}{\sum_{i=1}^m r_{ij}} \quad (0 \leq r_{ij} \leq 1). \quad (3)$$

Thus, a weight matrix of the data can be established.

$$P = \{p_{ij}\}_{m \times n}. \quad (4)$$

3.2.2 Calculation of information entropy for each criterion

The entropy weight e_j for the j -th criterion is calculated by

$$e_j = -k \sum_{i=1}^m p_{ij} \cdot \ln p_{ij}. \quad (5)$$

The constant k in the formula (5) is

$$k = \frac{1}{\ln m}. \quad (6)$$

The information utility value d is

$$d_j = 1 - e_j. \quad (7)$$

3.2.3 Determination of the weights of each criterion

Using the entropy weight method to estimate the weights of each criterion essentially involves calculating the value coefficient of the information for each criterion. The higher the value coefficient, the greater the importance of the criterion in the evaluation (or the greater the weight, contributing more to the evaluation result).

The formula for calculating the entropy weight w_j of the j -th index is as follows:

$$w_j = \frac{(1 - e_j)}{\sum_{j=1}^n (1 - e_j)} = \frac{d_j}{\sum_{j=1}^n d_j}. \quad (8)$$

3.2.4 Calculation of the comprehensive weight β_j for each index

Based on the evaluation value r_{ij} of the i -th item under the j -th index, combined with the entropy weight w_j of the index, the comprehensive weight of index j can be obtained as follows.

$$\beta_j = \sum_{i=1}^m w_j \cdot r_{ij}, i = 1, 2, \dots, n. \quad (9)$$

4. Case Analysis

Taking the actual survey situation of three students in the second grade of middle school as an example: Xiao Hong, Xiao Ming, and Xiao Fang. Xiaohong studies 37 hours per week, spends 28 hours on homework, considers her exam stress high, has low learning motivation, and poor study methods. Xiaohong has 8 good friends, participates in social activities twice a month, her school's atmosphere is average, her parents have a good relationship, she interacts with her parents 35 times a week, and her family's economic situation is moderate. Xiaoming studies 42 hours per week, spends 17 hours on homework, considers his exam stress low, has strong learning motivation, and average study methods. Xiaoming has 4 good friends, participates in social activities once a month, his school's atmosphere is good, his parents have a poor relationship, he interacts with his parents 15 times a week, and his family's economic situation is poor. Xiaofang studies

58 hours per week, spends 12 hours on homework, considers her exam stress high, has strong learning motivation, and good study methods. Xiaofang has 2 friends, participates in social activities once a month, her school's atmosphere is poor, her parents have a poor relationship, she interacts with her parents 8 times a week, and her family's economic situation is good.

Based on the actual survey situation of the above three students, an entropy weight analysis will be conducted. The detailed process of the mental health evaluation is shown in Figure 2.

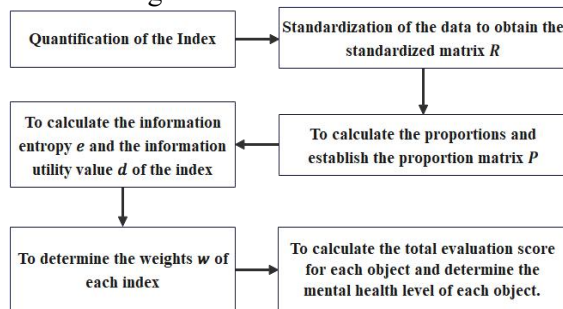


Figure 2. Flowchart of the Entropy Weight Method for Mental Health Evaluation

4.1 Quantification of the Index

According to the classification by education industry experts, a questionnaire survey was conducted on various indicators of students, divided into five levels, with levels 1 to 5 corresponding to 1 to 5 points respectively. After quantification, Table 1 to Table 3 are obtained.

Table 1. Quantitative Survey of Academic Stress

	Study Time	Academic Burden	Exam Stress	Learning Motivation	Study Methods
Xiao Hong	2	4	4	2	2
Xiao Ming	3	2	2	4	3
Xiao Fang	5	1	5	5	5

Table 2. Quantitative Survey of Social Support

	Number of Friends	School Atmosphere	Number of Social Activities
Xiao Hong	3	2	3
Xiao Ming	2	1	4
Xiao Fang	1	1	1

Table 3. Quantitative Survey of Family Environment

	Parental Relationship	Parent-child Communication	Family Financial Situation
Xiao Hong	4	4	3
Xiao Ming	1	2	2
Xiao Fang	1	1	5

4.2 Standardization of the Data

There are a total of 11 indicators, which are Weekly Study Time, Academic Burden, Exam Stress, Learning Motivation, Study Methods, Number of Friends, Social Activities, School Atmosphere, Parent-Child Relationship, Parent-Child Communication, and Family Economy. Among them, Weekly Study Time, Academic Burden, and Exam Stress are indicators where smaller values are better, and thus they are considered negative indicators. Therefore, the formula used is:

$$r_{ij} = \frac{x_{\max} - x_j}{x_{\max} - x_{\min}} \tag{10}$$

Standardized Data are showed from Table 4 to Table 9.

Table 4. Standardized Data of Academic Stress

	Study Time	Academic Burden	Exam Stress	Learning Motivation	Study Methods
Xiao Hong	1	0	0.33	0	0
Xiao Ming	0.67	0.67	1	0.67	0.33
Xiao Fang	0	1	0	1	1

Table 5. Standardized Data of Social Support

	Number of Friends	School Atmosphere	Number of Social Activities
Xiao Hong	1	1	0.67
Xiao Ming	0.5	0	1
Xiao Fang	0	0	0

Table 6. Standardized Data of Family Environment

	Parental Relationship	Parent-child Communication	Family Financial Situation
Xiao Hong	1	1	0.33

Xiao Ming	0	0.33	0
Xiao Fang	0	0	1

4.3 To Calculate the Proportions

Table 7. The Proportions of Academic Stress

	Study Time	Academic Burden	Exam Stress	Learning Motivation	Study Methods
Xiao Hong	0.6	0.01	0.25	0.01	0.01
Xiao Ming	0.4	0.4	0.75	0.4	0.25
Xiao Fang	0.01	0.6	0.01	0.6	0.75

Table 8. The Proportions of Social Support

	Number of Friends	School Atmosphere	Number of Social Activities
Xiao Hong	0.67	1	0.4
Xiao Ming	0.33	0.01	0.6
Xiao Fang	0.01	0.01	0.01

Table 9. The Proportions of Family Environment

	Parental Relationship	Parent-child Communication	Family Financial Situation
Xiao Hong	1	0.75	0.25
Xiao Ming	0.01	0.25	0.01
Xiao Fang	0.01	0.01	0.75

According to the following formula, the proportions are calculated.

$$p_{ij} = \frac{r_{ij}}{\sum_{i=1}^3 r_{ij}} \quad (0 \leq r_{ij} \leq 1). \quad (11)$$

4.4 To Calculate the Information Entropy and the Information Utility Value of the Index

The formula for the entropy weight e_j of the j -th indicator is:

$$e_j = -k \sum_{i=1}^3 p_{ij} \cdot \ln p_{ij}, \quad (12)$$

Where $k = 1/\ln 3$.

The formula for information utility value d of

the j -th indicator is:

$$d = 1 - e_j. \quad (13)$$

The Information Entropies and the Information Utility Values of Indexes are showed from Table 10 to Table 12.

Table 10. The Information Entropy and Information Utility Value of Academic Stress

	Study Time	Academic Burden	Exam Stress	Learning Motivation	Study Methods
e_j	0.61	0.61	0.51	0.61	0.51
d	0.39	0.39	0.49	0.39	0.49

Table 11. The Information Entropy and Information Utility Value of Social Support

	Number of Friends	School Atmosphere	Number of Social Activities
e_j	0.58	0.01	0.61
d	0.42	0.99	0.39

Table 12. The Information Entropy And Information Utility Value of Family Environment

	Parental Relationship	Parent-child Communication	Family Financial Situation
e_j	0.01	0.51	0.51
d	0.99	0.49	0.49

4.5 To Determine the Weights of each Index

The entropy weight calculation formula for the j -th indicator is as follows. The calculation results of entropy weight are in Table 13 to Table 15.

$$w_j = \frac{(1 - e_j)}{\sum_{j=1}^{11} (1 - e_j)} = \frac{d_j}{\sum_{j=1}^{11} d_j}. \quad (14)$$

Table 13. The Weights of Academic Stress

	Study Time	Academic Burden	Exam Stress	Learning Motivation	Study Methods
w_j	0.07	0.07	0.08	0.07	0.08

Table 14. The Weights of Social Support

	Number of Friends	School Atmosphere	Number of Social Activities
w_j	0.07	0.02	0.06

Table 15. The Weights of Family Environment

	Parental Relationship	Parent-child Communication	Family Financial Situation
e_j	0.17	0.08	0.08

4.6 To Calculate the Total Evaluation Score for Each Object

The total evaluation score for each object is calculated by:

$$S_i = \sum_{j=1}^n \sum_{k=1}^m w_j \cdot r_{ij}. \quad (15)$$

The scores of Xiao Hong, Xiao Ming and Xiao Fang are 0.66, 0.37 and 0.29 respectively. It can be seen that Xiao Hong scored the highest in this evaluation, Xiao Ming is in the middle, and Xiao Fang scored the lowest. Therefore, we can conclude that Xiao Hong has the highest level of mental health, Xiao Ming is at an average level, and Xiao Fang has the lowest psychological quality.

5. Conclusion

This study constructed an evaluation model for the mental health of middle school students using the entropy weight method, exploring the impact of various factors such as social activities and family environment on students' mental health. The research found that good family relationships and active social activities significantly improve students' mental health, while academic burden and exam pressure have relatively smaller effects. These results provide scientific evidence for schools and parents, helping them to support students' mental health and personal development more effectively.

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