ISSN 2663-8169 Vol. 8, Issue 5: 55-63, DOI: 10.25236/IJNDE.2026.080508

Music Therapy Based on Artificial Intelligence Technology for Students' Mental Health Response and Automatic Efficacy Evaluation System

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Abstract: *As the academic burden grows, students' mental health problems are becoming more apparent. Music is a natural, safe and accepted art form, and is widely used in psychotherapy. The traditional assessment frameworks are however not suitable to measure the impact of music therapy (MT) on the mental health of students, accurately and efficiently. To compensate for this, an evaluation system of music therapy effectiveness based on support vector machine algorithms has been built. This system will automatically track and evaluate students psychological reactions to MT and adjust the MT therapy programme in real-time to provide optimal therapeutic outcomes. As experimental subjects, the students who participated in this study were students who took MT for the first time in the third year of junior high school, third year of senior high school and fourth year of college. MT sessions were held and students' psychological response data was regularly collected and compared with data from traditional evaluation methods. The final experimental outcomes showed that the AI-based MT evaluation system can attain an average evaluation accuracy of 91.25%, evaluation time of 9 minutes and 58 seconds, and cost of 42.46 USD. Overall, these findings are better than the traditional methods of evaluation for their accuracy, efficiency and cost-effectiveness.*

Keywords: *Artificial Intelligence, Music Therapy, Student Mental Health, Efficacy Evaluation System*

1. Introduction

MT is a treatment method that uses music and music activities to help improve individual physical and mental health. It is applied to many different mental health problems, including depression, anxiety, post-traumatic stress disorder, autism spectrum disorder, etc. With the intensification of educational competition, many students are facing enormous academic pressure. They need to constantly study, take exams, and also face expectations from parents, teachers, and society, leading to psychological problems such as anxiety and depression among students. Although MT has been gradually applied to the treatment of students' mental health in recent years, traditional MT evaluation systems cannot accurately evaluate the therapeutic effect and make appropriate adjustments. As AI technology continues to develop, AI technology has been widely used in the construction of various assessment systems. By introducing AI technology, an efficient and accurate evaluation system for the efficacy of MT for students' mental health has been established, providing reference and reference for the exploration of MT in students' mental health issues.

MT has a positive impact on helping students overcome mental health problems, so many people have conducted relevant research on how MT can solve mental health problems. de Witte Martina conducted a comprehensive study on a large number of empirical MT studies and conducted a multi-level meta-analysis, including 47 studies, 76 response measures, and 2747 participants. The final research outcomes indicated that MT had a significant overall impact on psychological stress [1]. Finnerty R et al. explored the effectiveness of online group music therapy in alleviating stress and anxiety among undergraduates, and emphasized the feasibility and foresight of digital intervention in the mental health management of college students. This provides strong support for the application of music therapy in the context of distance education [2]. Palazzi Ambra mentioned that MT in the neonatal intensive care unit has been proven to regulate the physiological response of premature infants and improve the mental health of mothers. He investigated the effects of MT on maternal anxiety, postpartum depression, and stress. The final experimental results indicated that MT improved the mental health of postpartum women [3]. Jiang N used a mixed density neural network to quantitatively

ISSN 2663-8169 Vol. 8, Issue 5: 55-63, DOI: 10.25236/IJNDE.2026.080508

analyze the impact of music therapy on the physiological stress response of college students, and innovatively introduced machine learning methods to achieve accurate identification and prediction, providing a theoretical basis and algorithmic support for the construction of an intelligent music therapy evaluation system [4]. Although these studies have proven that MT does have a positive effect on improving mental health, they only use traditional manual methods to analyze experimental data, and can only roughly evaluate the efficacy of MT.

Many studies have explored the multiple values of music therapy in promoting mental health from multiple dimensions, including social psychology, cultural differences, intervention effects on specific populations, and educational scenarios. Tuastad et al. revealed through qualitative research that participating in music group activities in the context of mental rehabilitation can help reduce patients' stigmatization perceptions, emphasizing that the identity transformation from "patient" to "performer" has a positive significance for mental rehabilitation, and expanding the understanding of the application of music therapy at the social and psychological level [5]. Liao et al. compared the effects of traditional Western music therapy and five-element music therapy through a cross-cultural randomized controlled trial, emphasizing the regulatory role of cultural background in music therapy and promoting the development of localized treatment models [6]. Reschke-Hernández et al. found in a randomized crossover clinical trial that music singing intervention can significantly improve the social and emotional well-being of dementia patients more than verbal communication, providing strong empirical support for mental health care for the elderly [7]. Chauhan and Jain systematically analyzed the dual role of music in promoting learners' mental health and academic achievement, pointing out that music can not only effectively regulate emotions, but also have a positive impact on learning performance, suggesting that music and psychological intervention strategies should be more widely integrated in the education system [8]. Overall, these studies have enriched the theoretical system of music therapy and provided important basis for psychological intervention practices in multiple scenarios and among multiple populations. Although it provides important insights into the application of music therapy in different groups and cultural contexts, there are still some shortcomings. The sample size of many studies is limited, lacking long-term and large-sample empirical data support. Some studies adopt qualitative or cross-sectional designs, which makes it difficult to fully reveal causal relationships and mechanisms.

This article introduces the problems of traditional methods for evaluating the effectiveness of MT on students' mental health, the application of artificial intelligence related algorithms in music efficacy evaluation systems, and the evaluation system. Through the analysis of experimental data, the effectiveness of the artificial intelligence based MT effectiveness evaluation system in treating students' mental health was evaluated.

2. Evaluation of MT Efficacy

2.1 Problems in Traditional Efficacy Evaluation

MT can effectively alleviate anxiety and stress, and it is also used to treat psychological disorders such as Alzheimer's disease [9-10]. There are three problems with traditional evaluation methods:

(1) Evaluation of accuracy

The traditional efficacy evaluation system relies on the subjective judgment of doctors, who are easily influenced by factors such as patients' appearance, language ability, and cultural background. Patients' subjective feelings are too strong, making it difficult to ensure the accuracy and objectivity of the evaluation results.

(2) Evaluation of efficiency

When using traditional assessment systems, doctors need to repeatedly understand the patient's condition, medical history, symptoms, and other information, and develop personalized treatment plans based on this information. This requires a lot of time and effort, and is prone to problems such as low data quality and inaccurate analysis results.

(3) Evaluation of costs

The evaluation process includes multiple stages such as patient recruitment, design and development of evaluation tools, implementation and recording of evaluations, each of which requires the participation of professional personnel. The traditional method of evaluating the efficacy of MT

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requires regular follow-up of patients and timely adjustment of treatment plans, which require a significant amount of manpower and resources. Traditional methods obtain accurate evaluation results through data collection and analysis, which requires professional data analysts to perform data processing and statistical analysis, greatly increasing evaluation costs.

2.2 AI Technology

As AI technology continues to evolve, this technology has been integrated into everyday life in many forms [11-12]. AI has many subfields, such as ML, deep learning, and computer vision [13]. Among them, the tremendous success of ML has sparked a new wave of AI applications [14]. For example, ML algorithms can be used to evaluate the efficacy of MT by analyzing patients' mental health response data to predict the trend of efficacy changes in different MT regimens. At the same time, ML algorithms can also be used to evaluate the effectiveness of different treatment methods and select the optimal treatment plan. In this study, a support vector machine (SVM) is employed to evaluate the efficacy of MT by analyzing physiological and behavioral responses during the therapy process.

The sample data set includes various kinds of indicators, such as emotion, behavior, and physiological signal. Each sample is represented by a feature vector and a label representing the therapeutic effect. SVM builds a separating hyperplane in a higher dimensional space, where the samples are best divided according to their therapeutic effect. The basic idea is to maximize the margin between the hyperplane and the nearest sample from each category. And these nearest samples are called support vectors. Generally, the larger margin represents more probably the performance of separating different categories. To realize this idea, SVM uses some mathematical constraints to make all samples to be correctly classified and the norm of weight vector defining the hyperplane be minimized. By solving the constrained optimization problem, SVM will be able to output a hyperplane that can accurately divide different categories of multi-dimensional indicator data, and then obtain an evaluation of the therapeutic effect automatically. Then, according to the evaluation of the therapeutic effect made by the music therapist, he/she can adjust the MT plan of the student at an opportune time and thus obtain the best therapeutic effect.

2.3 MT Evaluation System

The MT efficacy evaluation system based on the AI technology is an application which uses the ML and data analysis methods for MT efficacy evaluation. Doctors and patients can have a better understanding of the effectiveness of MT through analyzing the evaluation system and make timely treatment plans adjustment to enhance treatment effectiveness.

(1) Stress testing module

The stress testing module is an important component of the MT efficacy evaluation system, which utilizes AI technology to evaluate the effectiveness of MT interventions in reducing individual stress and anxiety levels. This module uses ML algorithms to analyze physiological data collected before, during, and after testing, and generates stress curves for each student receiving treatment. These physiological indicators mainly include heart rate variability (HRV), skin conductance response (SCR), cortisol levels, etc. Heart rate variability can determine autonomic nervous system activity and cardiovascular risk in different populations. By quantifying the individual stress levels at each treatment stage using these data, different MT intervention plans are formulated based on different stress levels, and physiological indicators are continuously monitored during the treatment to track the changes in stress and anxiety levels.

(2) Heart rate module

The autonomic nervous system can regulate the body's response to stress and anxiety, and when the body feels stress and anxiety, the heart rate increases. This module includes a prediction trial phase, a treatment phase, and a post testing phase. During the pre-test phase, baseline heart rate data needs to be collected to determine the initial heart rate variability and resting heart rate of students. Students continuously monitor heart rate data while receiving different MT interventions during the treatment phase. After the testing is completed, the heart rate module analyzes the heart rate data collected at each stage through ML algorithm to evaluate the effectiveness of MT intervention.

(3) Emotional state module

The emotional state module uses ML algorithms to analyze emotional state data to evaluate the

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effectiveness of different MT interventions in improving students' mental health. This module is divided into three stages: prediction experiment stage, treatment stage, and post testing stage. During the prediction experiment stage, data on students' baseline emotional states is collected to determine their initial emotional conditions. During the treatment phase, different MT intervention plans are developed based on the current emotional state of students, and emotional state data is continuously monitored to track changes in students' emotional states. Finally, in the post test stage, emotional state data was collected again to evaluate the long-term effectiveness of MT interventions.

(4) Blood oxygen monitoring module

When people are under high pressure, such as in an emergency or in an emotional state such as anxiety and fear, their heart rate and respiratory rate may speed up, resulting in the body needing more oxygen to supply organs and tissues. Therefore, in this case, people's oxygen saturation may fall below 90%. The blood oxygen concentration module uses ML algorithms to analyze the blood oxygen concentration data collected during the pre test, treatment, and post test stages. During the pre testing phase, baseline blood oxygen concentration data is collected to determine the initial blood oxygen levels of students. Then, based on the MT plan received by the students during the treatment phase, continuous monitoring of blood oxygen concentration data is carried out to track changes in blood oxygen levels. Finally, the therapeutic effects of current MT are evaluated.

3. Workflow of the AI-based MT Evaluation System

In order to ensure the systematic operation of the proposed evaluation system, the whole process can be divided into four major stages: data acquisition, data preprocessing, model-based evaluation, and feedback adjustment. In the first stage, students' physiological, emotional, and behavioral indicators are collected before, during, and after the music therapy intervention. These indicators include heart rate, heart rate variability, blood oxygen saturation, stress response, emotional state, and subjective psychological feedback. Compared with traditional manual evaluation, this multi-source data collection process provides a more comprehensive basis for judging the actual therapeutic response of students.

In the second stage, the second stage, the collected data are cleaned and normalized to eliminate the impact of missing values, abnormal values and individual differences. Because the students' age may lead to different baseline values of physiology and different levels of emotions, normalization is needed to make the data of different groups comparable. Finally, the system selects representative features from original data, including the heart beat difference before and after intervention, the variation trend of stress indicators, the degree of emotion improvement, and the stability of physiological feedback during the treatment process.

In the third stage, the SVM model is used to classify the therapeutic response according to the extracted features. The model identifies whether the intervention effect is poor, average, or good, and provides an automatic evaluation result. Finally, in the feedback adjustment stage, music therapists can adjust the music type, intervention duration, rhythm, frequency, and therapeutic plan according to the system output. Therefore, the system is not only an evaluation tool, but also a decision-support tool for optimizing personalized music therapy.

4. Evaluate System Effectiveness Experiments

MT is a treatment method that promotes physical and mental health and recovery through music and music activities. MT has the functions of reducing stress, relieving anxiety, improving emotions, enhancing self-esteem and confidence. This article conducted a comparative experiment to verify the effectiveness of the artificial intelligence based MT evaluation system in treating students' mental health. The efficacy evaluation system based on artificial intelligence technology will be used as the experimental group, and the control group will be based on the traditional MT efficacy evaluation method. This comparative experiment focuses on evaluating the accuracy, efficiency, and cost of MT efficacy. The experimental subjects include students in their third year of junior high school, third year of high school, and fourth year of university. The specific situation is shown in Table 1.

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Table 1. Selected subjects for the experiment

Grade	Number of male	Number of female	Age group
The third grade of junior high school	5	5	15-17
The third grade of senior high school	4	6	17-19
The fourth grade of college	6	4	21-23

As shown in Table 1, 10 pupils from the junior high school third grade and the senior high school third grade, and the fourth grade of college were selected for the experiment. The age range of the selected students of the third grade of junior high school was between 15 and 17 years old, with 5 boys and 5 girls each. The age range of the selected students of the third grade of senior high school is between 17 and 19 years old, with 4 males and 6 females. The age range of the selected students of the fourth grade of college is between 21 and 23 years old, with 6 males and 4 females.

Before the formal experiment, all participants were informed of the experimental purpose, evaluation process, and data collection procedures. The experiment was carried out in three stages. The first stage was the pre-test stage, in which baseline psychological and physiological data were collected from each student.These data were used to indicate the initial mental health status of the participants and to provide a reference for later comparison. The second stage was the stage of music therapy. In this stage, students were exposed to music therapy in an environment with relatively stable conditions, and their physiological and emotional responses were continuously recorded by the evaluation system. The third stage was the post-test stage. In this stage, the system analyzed the changes of stress level, heart rate, emotional state and blood oxygen concentration.

In order to make the comparison more reliable, the experimental group and the control group were evaluated under the same general experimental conditions. The main difference was that the experimental group used the AI-based evaluation system, while the control group relied on traditional manual evaluation methods. The comparison focused on three indicators: evaluation accuracy, evaluation efficiency, and evaluation cost. These three indicators were selected because they directly reflect whether the proposed system can improve the practical application value of music therapy evaluation.

(1) Evaluation of accuracy

Accuracy is crucial for evaluating the efficacy of MT. Accurate evaluation helps to determine the most effective components of MT, serves as the foundation for establishing MT, and also helps to improve the quality of MT interventions. If the evaluation is not accurate, it is impossible to determine whether the treatment is effective or whether adjustments to the treatment plan are necessary. To verify the actual effectiveness of the MT efficacy evaluation system based on AI technology in terms of evaluation accuracy, 10 students who received MT for the first time in the third grade in both junior high and senior high education, and the fourth grade of college were selected for MT experiments. The specific experimental data is illustrated in Figure 1.

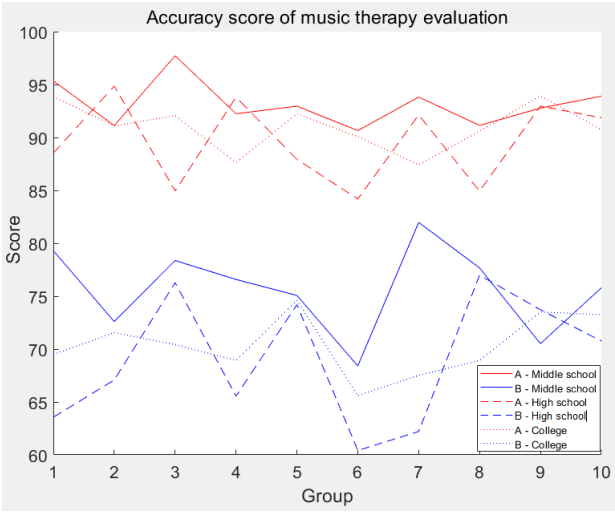

Figure 1. Accuracy evaluation of MT efficacy

Note: In Figure 1, A represents the experimental group, which is an AI-based MT efficacy evaluation system; B is the control group, which is based on traditional MT efficacy evaluation methods.

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Table 2. Rating criteria and rating situation

Score range	60-74.99	75-89.99	90-100
Grade	Bad	Average	Good
Category	Bad	Average	Good
AI evaluation system	0	7	23
Traditional evaluation methods	21	9	0

As shown in Figure 1, by conducting MT experiments on a total of 30 students, including students in either the junior high school or the senior high school third grade , and the fourth grade of college, it can be found that the AI-based MT efficacy evaluation system scored much higher in terms of efficacy evaluation accuracy than traditional MT efficacy evaluation methods. From Figure 1, it can be observed that the accuracy score of the AI-based MT efficacy evaluation system in the third grade of junior high school student group was generally higher than that in the third grade of senior high school and the fourth grade of college student groups, indicating that the system may be more popular in the third grade of junior high school student group. Among the 10 students in the third grade of junior high school, the highest score of the AI-based MT efficacy evaluation system in efficacy evaluation accuracy was 97.72 points. Among the 10 students in the senior high school third grade, the highest score for evaluation accuracy was 94.86 points. Among the 10 students in the fourth grade of college, the highest score for evaluation accuracy was 93.95 points. The average evaluation accuracy score of these 30 students was 91.25 points through calculation. For traditional MT efficacy evaluation, the highest accuracy score for efficacy evaluation among 10 students in third grade junior high school was 81.97 points. Among the 10 students in the third year of senior high education, the highest score for evaluation accuracy was 76.98 points. Among the 10 students in the fourth grade of college, the highest score for evaluation accuracy was 74.61 points. The average evaluation accuracy score of these 30 students was 71.69 points through calculation. In addition, as shown in Table 2, the grading rules and grading situation in Table 2 can be seen that the AI-based MT efficacy evaluation system had only 7 moderate level evaluations in terms of efficacy evaluation accuracy, 23 excellent evaluations, and no poor evaluations. However, based on traditional music evaluation methods, the number of evaluations with poor accuracy reached 21, with only 9 moderate evaluations and 0 excellent evaluations.

(2) Evaluation of efficiency

Evaluating efficiency can shorten the treatment cycle and reduce costs. By quickly and accurately evaluating the treatment effect, doctors can adjust the treatment plan in a timely manner, avoid ineffective treatment and repeated attempts, and thus save time and costs. In addition, evaluating efficiency can also improve patient engagement and satisfaction, enhancing the sustainability of treatment outcomes. Finally, evaluating efficiency can promote the development and innovation of MT. To verify the evaluation efficiency of MT based on AI technology in the evaluation system of students' mental health efficacy, an experimental investigation was conducted on the evaluation efficiency of the experimental group and the control group. The specific experimental data is shown in Figure 2.

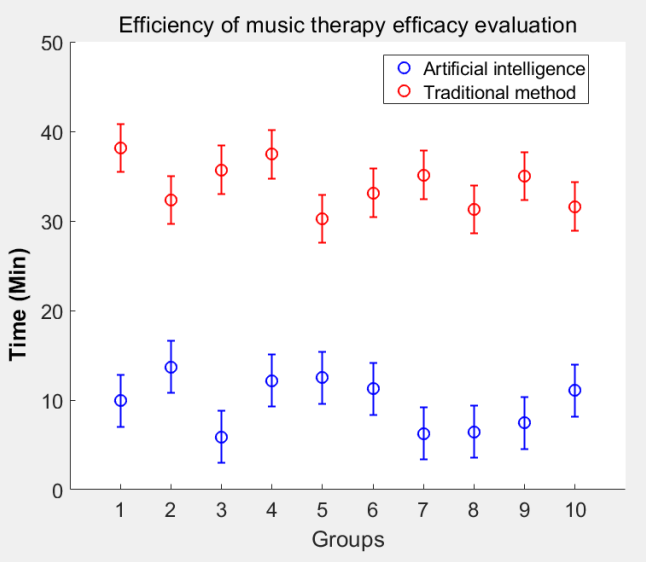

Figure 2. Efficiency of MT efficacy evaluation

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As shown in Figure 2, the AI-based MT efficacy evaluation system greatly shortened the evaluation efficiency of traditional MT evaluation methods. From Figure 2, it can be seen that the evaluation system based on AI took the shortest time of 5 minutes and 50 seconds, while the longest time was 13 minutes and 57 seconds. The average overall evaluation time was 9 minutes and 58 seconds. From the experimental data of traditional MT efficacy evaluation methods, it can be seen that the shortest evaluation time based on traditional MT efficacy evaluation methods was 30 minutes and 25 seconds, and the longest evaluation time was 38 minutes and 16 seconds. The average overall evaluation time was 34 minutes. Based on the above experimental data, it can be concluded that the AI-based MT efficacy evaluation system had a significant improvement in efficacy evaluation efficiency compared to traditional MT efficacy evaluation methods.

(3) Cost assessment

Evaluating the cost-effectiveness of MT can help doctors manage MT programs more scientifically and effectively, reducing medical costs. During the treatment process, doctors adjust the treatment plan in a timely manner by analyzing and evaluating the system, thereby improving the treatment effect. To verify the effectiveness of the AI-based system in reducing evaluation costs, this study compared the costs of the proposed system with those of traditional MT efficacy evaluation methods. The detailed results are presented in Table 3.

Table 3. Comparison of evaluation costs between the AI-based system and traditional methods

Evaluation method	Highest cost (USD)	Lowest cost (USD)	Average cost (USD)
AI-based MT efficacy evaluation system	49.91	35.57	42.46
Traditional MT efficacy evaluation methods	98.31	83.85	91.82

As shown in Table 3, the AI-based MT efficacy evaluation system consistently incurred lower costs across all metrics. Its average cost was 42.46 USD, less than half that of the traditional methods (91.82 USD). Even the highest cost recorded for the AI system (49.91 USD) was considerably lower than the lowest cost of the traditional approach (83.85 USD). These results confirm that the AI-based evaluation system offers significant advantages in reducing evaluation expenses.

(4) Discussion of Experimental Results

The experimental results show that the AI-based MT efficacy evaluation system has obvious advantages over traditional evaluation methods. On the one hand, the higher the accuracy of the evaluation, the less subjective judgment will have impact on the system. Traditional evaluation is frequently based on the experience of the doctor or therapist and various evaluators can provide different evaluations for the same student. In contrast, the AI-based system analyzes the therapeutic responses of students based on the multi-dimensional data, making the evaluation process more objective and stable.

Secondly, the time savings in evaluation shows the efficiency of the proposed system. Typical assessment involves multiple communications, manual recording, and subjective interpretation, potentially adding to the therapists' amount of work. Automatic analysis of physiological and emotional information is possible with the help of the AI-based system, thus providing the therapist with rapid evaluation results and to enable them to make necessary changes in their intervention plan in time. For example, in school mental health, many students might require psychological assistance during a short time.

Third, the cost of the evaluation is reduced, indicating that the system has potential for practical application. The system can provide a reduction in re-evaluation by manual assessment and professional statistical processing and therefore reduce the overall cost of music therapy evaluation. Thus, it might be appropriate for other educational institutions such as schools, counselling centres, which require effective and affordable mental health support tools.Furthermore, the outcomes also show that the value of the proposed system is not merely numerical in terms of improvement in the accuracy, timeliness and cost. Most importantly, the system offers a continuous evaluation mechanism of music therapy. Traditional evaluation typically occurs at fixed times and slight changes in students' psychological or physiological states may be overlooked by the therapist. In contrast, the AI-based system can record and analyze responses data during the process of intervention, thereby capturing dynamic changes in stress, emotion, and physical response. This is a continuous monitoring mechanism and therefore, the evaluation is more sensitive and timely. It also facilitates the creation of individual music therapy plans as students with varied stress levels, emotional states and physiological responses

ISSN 2663-8169 Vol. 8, Issue 5: 55-63, DOI: 10.25236/IJNDE.2026.080508

will benefit from varying types of music, time in music therapy interventions and adjustment strategies. Hence, the proposed system can enhance not only the evaluation process itself, but the music therapy intervention decision making process as well. It further reinforces the value of using the technology of artificial intelligence for supporting students' mental health management.

5. Conclusions

This study focuses on the effectiveness evaluation system of MT based on artificial intelligence technology, and explores its application and effectiveness in the treatment of students' mental health. The research results indicate that the system is competitive to the traditional system in terms of accuracy, efficiency and cost control using comparative approach of experimental parameters. As for the accuracy test result, artificial intelligence systems, which can process data automatically, greatly enhance the accuracy of the results of the test, and manual tests are not subject to subjective bias. As far as efficiency is concerned, the system can quickly analyze large amounts of data and thereby significantly decreasing the time for the evaluation and increasing the timeliness of treatment. Using the system helps to reduce the professional human resources needed in the evaluation process and the overall evaluation cost. This study indicates that by introducing advanced technological means, traditional treatment methods have been more efficiently applied and promoted in practice, opening up new avenues for maintaining and improving students' mental health.This study has some limitations, however. On one hand, there are limited numbers of participants and only the students of three educational stages are included. Further research should extend the sample size and incorporate students from a variety of areas, schools and psychological backgrounds. Second, this study mainly focuses on short-term evaluation results. The long term outcomes of music therapy in students' mental health should be further monitored in follow-up experiments. Third, SVM works well for the current evaluation task, but future studies may involve using other machine learning and deep learning models including random forest, neural networks and ensemble learning techniques to further enhance the adaptability and robustness of the evaluation system.

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