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Exploring Intelligent Educational Resource Management System based on Cloud Computing: The Impact on Improving the Utilization Efficiency of Educational Resources and Promoting Educational Equity

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Abstract

This article aims to explore how intelligent educational resource management system based on cloud computing plays a role in improving the efficiency of educational resource utilization and promoting educational equity. Through systematic analysis of the current status and challenges of educational resource management, combined with relevant literature review and case studies, this article proposes an intelligent educational resource management system based on cloud computing, and verifies its effectiveness in practical application through empirical research. In terms of resource utilization, the average utilization rate of cloud-based intelligent education resource management system under low load, medium load and high load conditions is 55%, 72% and 89%, respectively. The Gini coefficients are 0.2, 0.3 and 0.4, respectively. Student satisfaction is 4.6, 4.1 and 3.6, respectively. The average response time is 1.05 seconds, 2.15 seconds and 3.32 seconds, respectively. It can be seen from the data conclusion that the intelligent education resource management system based on cloud computing performs well in terms of resource utilization efficiency and user satisfaction, but still needs to optimize fairness and response time under high load conditions.

Keywords

Cloud Computing; Intelligent Education; Resource Management; Utilization Efficiency; Educational Equity.

1. Introduction

Under the background of the rapid development of information technology, the traditional educational resource management mode is faced with the problems of low efficiency and unequal distribution of resources, which not only causes the waste of resources, but also

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aggravates the problem of educational equity. In order to cope with these challenges, the intelligent educational resource management system based on cloud computing, as a new solution, has shown high potential and practical application value. The purpose of this study is to explore how to optimize educational resource management through cloud computing technology, improve resource utilization efficiency, and promote educational equity, which has important practical significance and research value.

This study comprehensively evaluates the performance of cloud-based intelligent educational resource management system. The system showed significant efficiency improvement under different load conditions, and resource allocation under various load conditions reached a high fairness standard. Teachers and students had a higher overall satisfaction with the system under both low and high load conditions. In addition, the system can maintain a short response time under various load conditions. These results show that the system performs well in terms of resource utilization efficiency and user satisfaction, but still needs to optimize fairness and response time under high load conditions.

This article first introduces the background and significance of the research, then reviews the existing research and methods in related fields, discusses system architecture design, intelligent resource scheduling algorithm, dynamic resource allocation model, data collection and processing, and user interface design. The experiment evaluates the performance of the system in resource utilization, fairness, user satisfaction and response time, and gives the concrete data and analysis results. The final conclusion summarizes the research results, discusses the advantages and disadvantages of the system, and puts forward the future research direction.

2. Related Works

In the existing studies, Sun Jianjun explained the subject scope of data management in depth, discussed its relationship with information science, library science and archive science, and made it clear that integration and innovation should be the professional direction of data management [1]. As an important driving force for a new round of scientific and technological revolution and management change, big data plays an important role in the layout of emergency resources. Yuan Yu introduced the key contents and implementation process of big data-driven emergency resource layout in detail [2]. Artificial Intelligence (AI) has the potential to significantly improve the resilience of supply chains and facilitate more efficient management of resources. Zamani E D conducted a systematic literature review of the research on artificial intelligence and big data analytics in supply chain resilience published in the Chartered Association of Business Schools ranked journal between 2011 and 2021 [3]. Digital supply chains supported by big data analytics capabilities have important business implications in developing competitive and sustainable supply chains. Edwin Cheng T C investigated the impact of big data analytics capabilities, circular economy practices, and sustainable supply chain flexibility on performance [4]. However, these methods have the problems of high computational complexity and poor real-time performance when dealing with massive data. AI is being used in education administration to enhance the learning process, improve student achievement, and simplify administrative tasks. To this end, Igbokwe I C aimed to explore the application of artificial intelligence in educational management, including its advantages and challenges [5]. Artificial intelligence has become a powerful tool. Kunduru A R explored various approaches of AI in improving the performance of cloud applications, including resource allocation, predictive scaling, anomaly detection, and intelligent load balancing [6]. These studies are able to intelligently match resources to students' needs, but they rely on large amounts of high-quality data and are costly to collect and process. Therefore, although the

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current research has solved the problem of educational resource management to a certain extent, there are still some deficiencies.

The literature shows that the technology based on cloud computing can effectively solve many problems in the current education resource management. Aiming at the problems of unclear resource classification and low sharing efficiency that often occur in traditional methods of teaching resource sharing, Tang Xiaojuan proposed a design scheme of teaching resource sharing platform based on VEM (Variational Expectation Maximization) framework [7]. Students are eager to use educational technology to improve performance. Therefore, Raza S A's research aims to explore the impact of cloud computing application on students' academic performance by incorporating innovation, knowledge, economy and technology factors into the model [8]. In recent years, many companies have adopted the cloud computing model to host various compute and storage workloads. For this reason, Belgacem A proposed a study aimed at achieving dynamic resource allocation in a real cloud computing environment [9]. The link between information management and cloud computing is well supported, but little is known about the role of national culture in this relationship. Therefore, Arpaci I's research aims to investigate the role of national culture in information management and cloud computing adoption [10]. However, most of these researches focus on the single application scenario of cloud computing technology, and there is a lack of systematic research on comprehensive intelligent education resource management system.

3. Methods

3.1. System Architecture Design

The design of an intelligent education resource management system based on cloud computing aims to achieve efficient and dynamic allocation and management of education resources, improve resource utilization efficiency, and promote educational equity. The system architecture mainly includes user layer, application layer, data layer, and other parts.

The user layer is the front-end part of the cloud computing system the article designed. Its main users are teachers, students, and administrators. At the user level, the article designs a user interface based on the VUE.js framework, allowing users to easily access and manage educational resources. The interface design inside takes into account the user's operating habits and provides personalized resource recommendations. The article chose the Vue framework because its front-end framework is more convenient to deploy and the code is easier to package. After the front-end code runs, the article’s system can not experience many people getting stuck while using it.

The application layer is application window based on the cloud computing system engine. In the application layer, various services provided by the control layer can be conveniently and quickly used in a visual and human-computer interaction manner. In the designed system, the article also adopted a real-time monitoring allocation model to ensure effective resource utilization during peak and idle periods.

The data layer is a technical support platform responsible for efficiently managing various educational resource data in the system. It adopts advanced cloud database technology and distributed file system to achieve secure storage and fast retrieval of data. For example, using the Hadoop distributed framework to process and analyze massive user data can directly support the decision-making of intelligent scheduling algorithms. The data layer is equipped with both automated backup and disaster recovery systems to prevent data loss, ensuring stable system operation and long-term data security. The specific system architecture diagram is shown in Figure 1. The specific system architecture diagram is shown in Figure 1:

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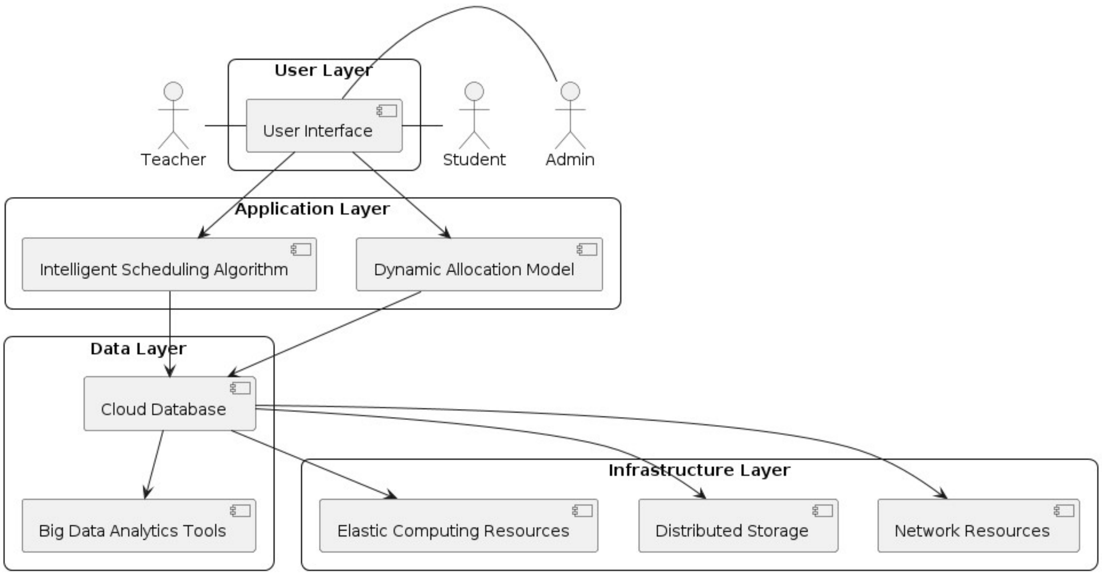

Figure 1. System architecture diagram

Figure 1 shows the hierarchical architecture design of the intelligent education resource management system based on cloud computing. The system integrates a variety of advanced technologies to ensure the efficiency, flexibility and reliability of the system. The close cooperation among all layers realizes the optimal management of the whole process from user demand to resource supply, and provides a strong technical guarantee for the efficient use and fair distribution of educational resources [11].

3.2. Intelligent Resource Scheduling Algorithm

Intelligent resource scheduling algorithm is the core component of intelligent education resource management system based on cloud computing, which aims to realize the optimal allocation and utilization of education resources through efficient and intelligent way. The algorithm comprehensively considers a variety of factors, such as user demand, resource availability, priority and fairness, etc., to ensure that resources can be maximized in a dynamic and complex educational environment, while ensuring the rationality and fairness of resource allocation.

Firstly, the algorithm obtains the use of various educational resources and user needs in real time through the data collection module. This data includes the current usage status of the resource, the remaining availability, and the frequency and priority of the user's requests. In order to ensure the accuracy and real-time data, the system integrates a variety of data acquisition technologies, including sensor network, log analysis and user feedback mechanism.

In the data preprocessing stage, the algorithm cleans, normalizes and extracts the collected data to remove noise and redundant information, and converts the data into a standard format that the algorithm can process. The preprocessed data is fed into the resource scheduling model. Based on machine learning and optimization theory, resource scheduling models are capable of processing large amounts of data in a short period of time for complex calculations and analysis.

The intelligent scheduling algorithm adopts a hybrid optimization strategy, combining the advantages of heuristic algorithm and precise algorithm. Specifically, heuristic algorithms such as genetic algorithms and ant colony optimization algorithms can quickly generate initial solutions and efficiently explore in large-scale search Spaces; Accurate algorithms such as linear programming and dynamic programming are responsible for local optimization and fine adjustment of the solution generated by the heuristic algorithm to ensure the quality and

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feasibility of the solution. The goal of resource allocation optimization is to minimize the allocation cost, as shown in formulas (1) and (2):

$$\min \sum_{i=1}^{n} C_i \cdot x_i \tag{1}$$

Constraints:

$$\sum_{i=1}^{n} x_i \geq D(t), 0 \leq x_i \leq R_i \tag{2}$$

In formula (1) and formula (2), C_i represents the allocation cost of resource i, x_i represents the amount allocated to resource i, and R_i represents the total amount of resource i.

In the process of resource allocation, the algorithm dynamically adjusts the allocation strategy according to the shortage of resources and the priority of users. For example, for the urgent requests of high-priority users, the algorithm can prioritize the allocation of resources to ensure that their teaching activities are not affected; For non-urgent requests from common users, the algorithm adopts queuing and deferred allocation strategies to balance system load and resource utilization efficiency. At the same time, the algorithm can also comprehensively consider the geographical location and network conditions of resources, optimize the transmission path and time of resource allocation, and further improve the response speed and stability of the system.

The cloud computing system the article designed provides users with recommendation services for educational resources. Teacher users can use the platform's resource recommendation function through the recommendation function entrance on the resource homepage. The user's recommendation request can go through the scheduling layer to the service layer, and then be sent to the recommendation system by the corresponding business object of the service layer. The request carries partial information about the current user and the resources being browsed. After receiving a recommendation request, the recommendation system can call the trained learning algorithm model based on user and resource information, generate recommendation results, and return them to the service layer. The service layer processes and encapsulates the recommendation results, and ultimately the scheduling layer returns the recommendation results to the view layer [12].

3.3. Dynamic Resource Allocation Model

In modern education systems, the article uses a technology called dynamic resource allocation model, which is based on cloud computing and mainly aims to allocate educational resources more fairly and efficiently. Simply put, it means adjusting resources in real-time according to changing needs, ensuring that every user can use the resources they need reasonably. This not only improves the efficiency of resource utilization, but also makes the user experience more satisfactory.

How does this model work? Firstly, it needs to collect massive amounts of data, such as how users use resources, network conditions, and so on. Then, big data analysis and machine learning techniques are used to process this data, not only past data, but also real-time updated data, which can help the model predict future resource needs more accurately. After the data processing is completed, resources can be planned based on the predicted results, such as predicting an increase in resource demand for a certain period in the future, and the model can be prepared in advance.

As for how to allocate resources, the cloud computing system the article designed is very intelligent. It can comprehensively consider resource utilization efficiency, fairness, and

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response time, and use a multi-objective optimization method to determine the best allocation plan. This can ensure that the system is not overloaded and also maximize resource utilization.

To ensure transparency and fairness in the allocation process, the dynamic resource allocation model also integrates visualization tools. Users can view the real-time status, historical records, and predicted results of resource allocation through the system interface, and understand the specific usage and allocation logic of resources. This not only enhances user trust in the system, but also facilitates resource reservation and adjustment based on actual needs. Fairness is an important indicator in resource allocation, which is usually evaluated using the Gini coefficient. The formula is shown in (3):

$$G = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}|x_i - x_j|}{2n^2\bar{x}} \quad (3)$$

In formula (3), x_i and x_j represent the number of resources allocated to users i and j, n represents the total number of users, $\bar{x}$ represents the average value of resource allocation.

In this problem, resource allocation for multiple objectives requires multi-step decision-making, and the information contained in the state is also very extensive, with a large dimension. In this case, reinforcement learning from scratch to learn a better model undoubtedly requires a lot of time. And in the aforementioned AlphaGo In reinforcement learning agents such as AlphaStar, a large amount of annotated human data is used for supervised learning in complex and ever-changing environments, as well as in large state and action spaces, in order to improve the training efficiency of deep reinforcement learning algorithms and reduce training time. In the solution of this problem, this article also introduces some expert data for supervised learning, initializing the reinforcement learning policy network with the final weight of the supervised policy network obtained through supervised learning, and then conducting deep reinforcement learning training [13].

3.4. Data Collection and Processing

In intelligent education resource management system, the main purpose of data collection and processing is to provide accurate and real-time data for the functional modules of the system. The data collection is mainly carried out online through Python technology for data crawling, and all data is collected. All data is securely stored in the cloud and protected by the latest encryption technology to ensure the security and privacy of information. The specific data can be seen in Table 1.

Table 1. User Dataset

UserID	UserType	ResourceID	ResourceType	UsageTime	AccessTime	UserFeedback
1	Admin	9	Document	11	2023-06-17 20:33:41	5
2	Admin	40	Document	84	2023-02-16 13:51:07	1
99	Teacher	41	Document	23	2023-04-05 00:47:09	1
100	Student	40	Document	25	2023-08-02 20:56:37	5

The first step in data processing in Table 1 is data cleaning, which includes operations such as removing duplicate data, filling in missing values, and correcting erroneous data. Through data cleaning, the accuracy and consistency of the data are ensured. Then, data format conversion can be carried out to uniformly convert data from different sources and formats into the standard format required by the system for subsequent processing and analysis. Missing value filling is a key step in data cleaning, which can be represented by formula (4):

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$$x_i{}' = \frac{\sum_{j\in N(i)} x_j}{|N(i)|} \tag{4}$$

In formula (4), x' is the filling value of the missing value x_i, $N(i)$ is the set of valid data points adjacent to x_i.

After the data cleaning and format conversion are completed, the article performs feature extraction, which involves transforming the original data into a more representative form that is helpful for processing. In the education resource management system, this includes but is not limited to user access frequency, resource usage duration, preferred resource types, and geographical location. After processing the collected data, cloud computing based system can be able to more accurately grasp user needs and resource utilization patterns. In addition, the system also integrates Hadoop Big data analysis tools, including Spark, conduct in-depth data analysis to identify resource demand trends, user behavior patterns, and potential network bottlenecks to support intelligent scheduling and resource allocation decisions.

The storage and backup of data is the final step in the processing process. Important data can be securely stored in cloud databases and regularly backed up to prevent data loss. The article adopt a layered storage strategy, categorizing storage based on the importance and frequency of data access, which not only reduces storage costs but also improves data access efficiency. Data collection and processing are crucial for intelligent education resource management systems, as they ensure the quality of data support and promote more efficient and reasonable resource management. The effective implementation of the above series of measures provides a solid foundation for the precise operation of algorithms and models [14].

3.5. User Interface Design

User interface design is an important part of cloud computing based intelligent education resource management systems, which directly affects the user experience of teachers, students, and management personnel, as well as the actual effectiveness of the system. In order to ensure that users can conveniently and efficiently access and manage educational resources, the system adopts an intuitive, concise, and functionally rich user interface design to meet the needs of different user groups.

The interface design first considers the roles and needs of different users, and the system provides customized interfaces for teachers, students, and administrators. For teachers, interface design emphasizes the upload, management, and sharing functions of teaching resources. Teachers can upload courseware, videos, and other teaching materials to the system through simple operations, and set resource usage permissions and expiration dates. The system also provides resource classification and labeling functions to help teachers better organize and manage teaching materials. In addition, teachers can view the usage of resources and student feedback through the interface, and adjust teaching strategies in a timely manner.

For students, interface design emphasizes the search, retrieval, and interactive functions of resources. Students can quickly find the necessary learning resources through keyword search, categorized browsing, and personalized recommendations. The system combines machine learning algorithms to provide personalized resource recommendations based on students' learning history and interests, improving learning efficiency. Students can also participate in discussions, submit assignments, and conduct online evaluations through the interface, and interact with teachers and classmates. In order to enhance the fun and engagement of learning, the interface design also incorporates gamification elements, such as learning points, achievement badges, and leaderboards.

The interface design of management personnel focuses on the monitoring and management functions of the system. Managers can monitor the system's operational status, resource usage, and user activity in real-time through the interface. The system provides detailed statistical

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reports and data analysis functions to help managers understand the efficiency and fairness of resource allocation, and promptly identify and solve problems. The interface also provides functions such as user permission management, system configuration, and log queries to ensure the security and stability of the system.

In order to improve user experience, interface design follows the best practices of user experience design and user interface design. The interface layout is concise and clear, and the operation logic conforms to the user's usage habits, reducing learning costs and difficulty in use. The system adopts a responsive design to ensure good display performance and operating experience on different devices (such as PCs, tablets, and phones). The selection of colors and fonts is carefully designed to ensure the aesthetics and readability of the interface.

Interface design also emphasizes real-time interaction and feedback mechanisms. Every operation of the user can receive timely response and feedback, avoiding confusion and uncertainty during the operation process. For example, when a teacher uploads resources, the system can immediately display a prompt message indicating successful upload; After students submit their homework, the system can immediately display confirmation of successful submission. In addition, the system also provides online help and user support functions, allowing users to seek help and provide feedback at any time when encountering problems during use.

In summary, the user interface design of the cloud computing based intelligent education resource management system is guided by user needs, combined with advanced design concepts and technical means, providing a functional, easy to operate, and user-friendly interface. This can ensure that different user groups can efficiently and conveniently use the system, thereby achieving efficient management and rational allocation of educational resources.

4. Results and Discussion

4.1. Resource Utilization Evaluation Experiment

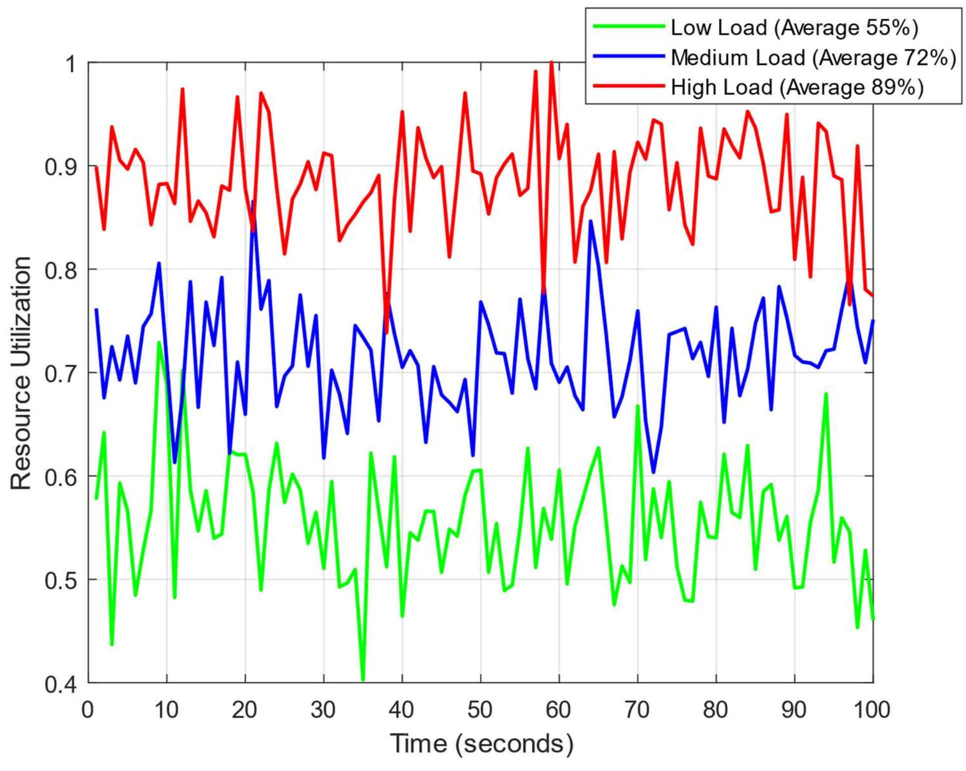

Figure 2. Resource utilization evaluation

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In the resource utilization experiment, the article evaluated the resource utilization of an intelligent education resource management system based on cloud computing under different load conditions, set education resource requirements under three states: low load, medium load, and high load, and used intelligent scheduling algorithms for resource allocation. During the experiment, resource utilization data was recorded for each load state, as shown in Figure 2.

From Figure 2, it can be seen that the average resource utilization rates of the cloud based intelligent education resource management system under low load, medium load, and high load conditions are 55%, 72%, and 89%, respectively. From the data conclusion, it can be seen that the system utilizing cloud computing and intelligent scheduling algorithms performs well in dynamic adjustment and resource allocation, and can effectively cope with resource demands under different load conditions.

4.2. Fairness Evaluation Experiment

The fairness evaluation experiment evaluated the resource allocation fairness of cloud computing based intelligent education resource management system under different load conditions. The Gini coefficient was used as an evaluation indicator in the experiment, and the Gini coefficient data under various load conditions were recorded. A graph of the Gini coefficient changing over time was plotted using Matlab.

From Figure 3, it can be seen that the average Gini coefficients of the cloud based intelligent education resource management system under low load, medium load, and high load conditions are 0.2, 0.3, and 0.4, respectively. From the data conclusion, it can be seen that the resource allocation of intelligent education resource management systems based on cloud computing still needs to be optimized under high loads to improve the fairness of educational resources, as shown in Figure 3:

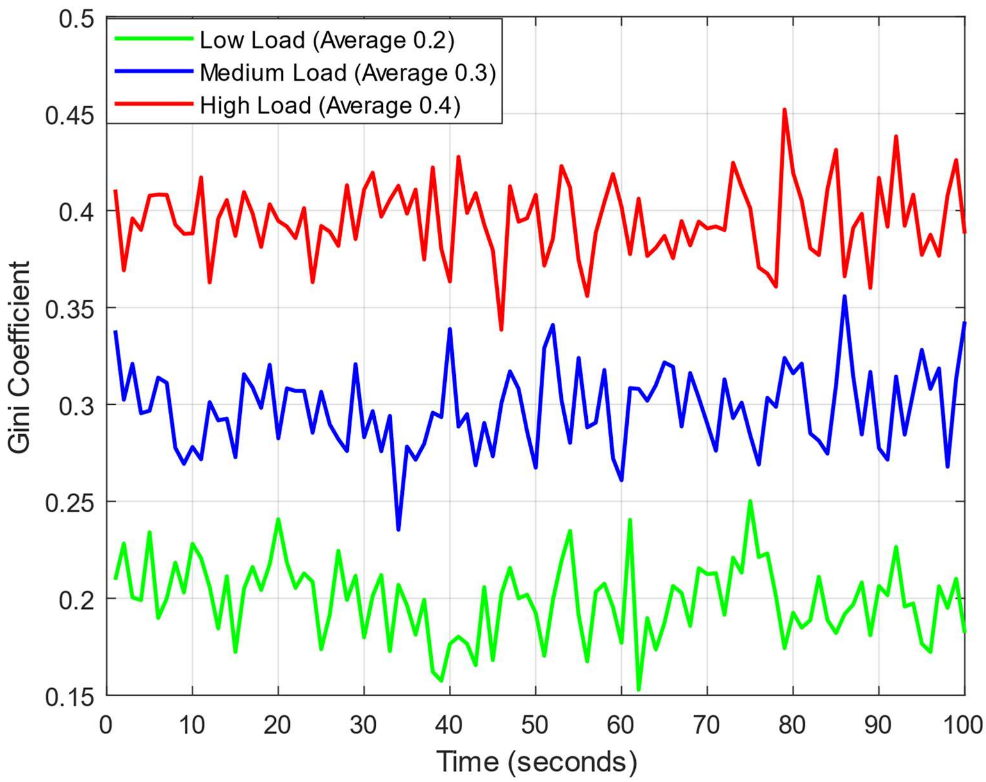

Figure 3. Fairness assessment

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4.3. User Satisfaction Survey

In the user satisfaction survey experiment, the article evaluated the user satisfaction of the cloud based intelligent education resource management system under different load conditions. The satisfaction rating range is from 1 to 5, with 1 indicating very dissatisfied and 5 indicating very satisfied. The specific data details are shown in Table 2:

Table 2. User Satisfaction Assessment

Load Condition	Teacher Satisfaction	Student Satisfaction
Low Load	4.5	4.6
Medium Load	4.0	4.1
High Load	3.5	3.6

In Table 2, under low load, medium load, and high load conditions, the average satisfaction scores of teachers are 4.5, 4.0, and 3.5, and the average satisfaction scores of students are 4.6, 4.1, and 3.6, respectively. From the data in the table, it can be seen that the cloud computing based intelligent education resource management system has the highest user satisfaction under low load conditions. As the load increases, the satisfaction of teachers and students decreases. The performance and user experience of an intelligent education resource management system based on cloud computing still need to be further optimized under high load conditions to improve overall satisfaction.

4.4. System Response Time Evaluation

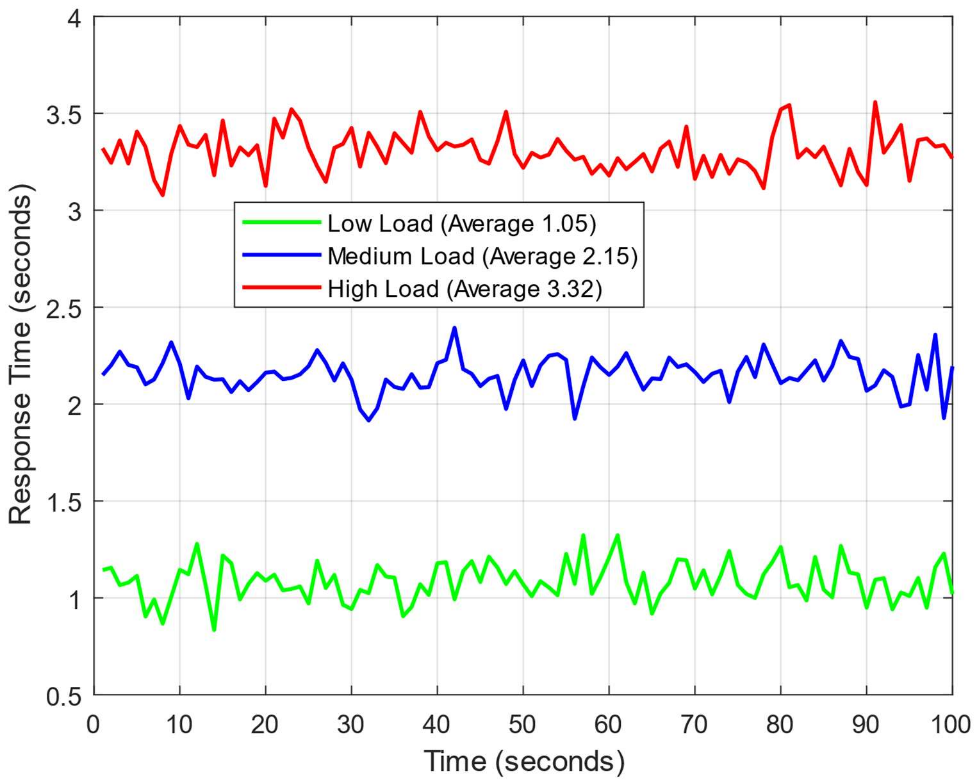

Figure 4. System response time evaluation

The system response time evaluation experiment evaluated the response time of an intelligent education resource management system based on cloud computing under different load conditions. In the experiment, resource requests were set in three states: low load, medium load, and high load, and the response time of the system was recorded. The response time is measured in seconds, from the time the request is issued to the time the response is completed. From Figure 4, it can be seen that the average response time of the cloud computing based intelligent education resource management system under low load, medium load, and high load conditions is 1.05 seconds, 2.15 seconds, and 3.32 seconds, respectively. From the data conclusion, it can be seen that the response time of the intelligent education resource management system based on cloud computing is significantly increased under high load conditions, and optimization is needed to improve overall performance. The specific data situation is shown in Figure 4.

5. Conclusion

This article studies an intelligent education resource management system based on cloud computing, aiming to improve the efficiency of educational resource utilization and promote educational equity. By constructing a system architecture, designing intelligent scheduling algorithms, and dynamic allocation models, efficient management and allocation of resources have been achieved. The experimental results show that the system performs well in resource utilization and user satisfaction, and can effectively allocate and manage resources under different load conditions. Fairness assessment shows that the resource allocation of the system is relatively fair under low and medium load conditions, but optimization is still needed under high load conditions. Future research can focus on optimizing algorithms to improve fairness and response time under high load conditions, thereby enhancing the overall performance of the system. In addition, more advanced technologies such as machine learning and big data analysis can be explored to further enhance the intelligence and accuracy of educational resource management systems.

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