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Study on the Enhancement of the Effectiveness of Civic and Political Education for College Students by Utilizing Cloud Computing Technology to Realize the Integration of Digital Educational Resources

Lanlan Huang[1,*]
[1] College of Marxism, Huizhou University, Huizhou, Guangdong, 516007, China
Corresponding authors: (e-mail: 19065468459@163.com).

Abstract For the current demand of personalized and intelligent construction of Civic and Political Education in colleges and universities, this paper takes the integration of digital Civic and Political Education resources as the research goal. The hardware framework of the Civic and Political Resource System containing five core components is designed, and under the framework, the application of cloud computing technology in Civic and Political Education is sorted out. The improved PBFT consensus algorithm is selected to optimize the time delay of the Civic and Political Resource System, increase the throughput and the communication capacity, and thus improve the consensus efficiency of the system's Civic and Political Resources within the education alliance. For the data security problem during resource transmission, proxy re-encryption technology is adopted to guarantee the safe storage and access of digital resources of Civic and Political Education. Finally, the Civic and political resources system based on the improved PBFT consensus algorithm is built. Under the number of 4000 concurrent users, the TPS of uploading and downloading of Civic and political resources of this system reaches 268 entries/s and 382 entries/s respectively, which has good load capacity and shows excellent stability performance.

Index Terms PBFT Consensus Algorithm, Cloud Computing Technology, Civic Government Resource System, Proxy Re-Encryption Technology, Data Security

I. Introduction

Cloud technology, as a latest information technology developed on the basis of computer technology and Internet technology, has unique advantages in resource integration and data mining development and utilization [1]. At this stage, in order to comply with the development needs of the digital economy era, colleges and universities put forward the intelligent education response strategy under the technological background to optimize the curriculum education path with intelligent technology and digital resources to meet the talent cultivation needs of higher vocational colleges and universities in the new era [2]-[4]. However, the digital educational resources in colleges and universities are independent of each other and difficult to collaborate, and most of the resources are limited to the campus intranet use, with a low degree of sharing [5], [6]. This has caused a waste of resources in a certain program and led to the duplication of educational resources [7]. Therefore, the dynamic expansion of resources and the sharing of teaching resources can be handled with the help of cloud computing resource management model, which provides a solution for the centralization and integration of teaching resource management construction in colleges and universities, and at the same time, it can also make the imbalance in the distribution of digital educational resources to a certain extent be balanced [8]-[11]. At the same time, cloud computing is relatively cheap and convenient, not only can reduce the cost of hardware and software in the construction of educational resources, but also convenient for teachers and students to use at any time and anywhere, which plays an important role in the wisdom of colleges and universities [12]-[14].

Cloud computing technology background also puts forward new challenges for the work of ideological education [15]. For the boring teaching effect and low utilization efficiency of educational resources in the current civic education model, the use of cloud computing technology can realize the data multi-platform sharing uploading and pulling, and can understand the learning situation in all aspects, and design the classroom content in a targeted way, which greatly improves the efficiency of civic education and expands the influence of civic education [16]-[18]. By following the law of civic education and improving digital information literacy with the times, we can maximize the use of technology to promote the transformation of civic education in colleges and universities to digitalization, so as to better meet the requirements of the new era of “cultivating morality and educating people”.

This paper firstly elaborates the core components of the overall hardware and the corresponding work content in the Civic and Political system resources. Based on the hardware architecture, it organizes the application path of cloud computing technology in the field of ideological education. Secondly, the improved PBFT consensus algorithm is introduced, and the working principle and operation process of the algorithm are discussed in detail. At the same time, it also explains the proxy re-encryption technology, realizes the process of safe storage and access to the Civic and Political Education resources, and combines to construct the Civic and Political Education resource system based on the improved PBFT consensus algorithm. We design resource transmission experiment and data security storage experiment again to test the overall performance and security performance of the designed system. Finally, the system is applied to actual Civics classroom teaching to evaluate and analyze the feasibility of the system.

II. Integration of cloud computing technology and digital educational resources for civics and politics

II. A.Overall hardware architecture design

In order to meet the actual demand for digital resources in the Civic Education of colleges and universities, this paper designs the hardware architecture of the regional shared Civic Learning Resources of Colleges and Universities. Figure 1 shows the overall hardware architecture design of this cloud-based platform in detail. This architecture mainly consists of five core components: cloud server, load balancing device, web server, database server and cloud storage.

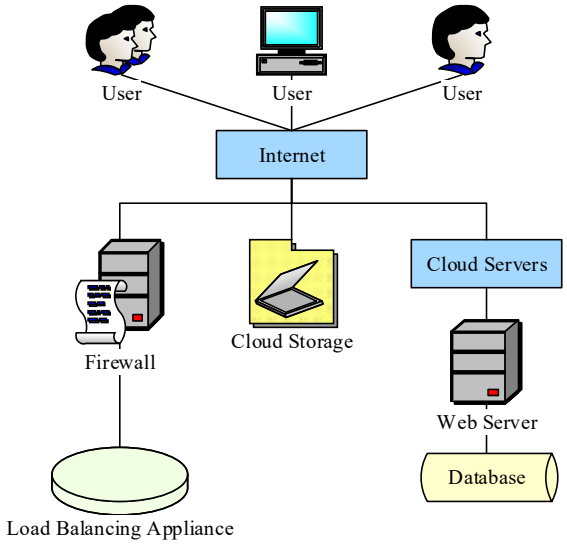


Figure 1: The overall hardware architecture of the platform

The cloud server is the core of the whole architecture and is responsible for handling a large number of computing and storage tasks. It is characterized by high performance and high reliability, which can ensure fast access and efficient processing of Civic and Political teaching resources. Load balancing equipment is responsible for reasonably distributing user requests to each Web server to ensure the stability and response speed of the system.

The Web server is the window for users to interact with the Civic and Political Teaching Resource Platform, and it is responsible for receiving user requests and returning corresponding resources. The database server stores all kinds of information about the Civic and Political Teaching Resources, such as metadata, access records, etc., to provide data support for the normal operation of the platform.

The cloud storage is the storage center in the whole architecture, which adopts distributed storage technology, can accommodate massive Civic and political teaching resources, and ensure the security and reliability of the data. Through cloud storage, centralized management and efficient sharing of Civics teaching resources can be realized, providing convenient services for Civics teaching.

II. B.Application of Cloud Computing Technology in the Field of Civic Education

(1) Teaching resource sharing and data management

First, teaching resource library. Teachers can store teaching resources, such as courseware and teaching videos, in the cloud for easy sharing and use, which enhances information exchange and sharing among teachers and between teachers and students. Second, data storage and processing. Schools can store student data such as grades and attendance records in the cloud, providing safe and reliable data management for easy access by students and teachers.

(2) Cooperation and Collaboration to Reduce Cost and Increase Efficiency

Cloud computing provides online collaboration tools, such as shared documents and online discussion boards, to promote cooperation and interaction between teachers and students. At the same time, cloud computing reduces the cost of teaching, making it unnecessary for teaching units to invest in large amounts of infrastructure and hardware, reducing maintenance costs and resource waste. Overall, cloud computing technology brings more convenience, flexibility and efficiency to the application in education, promotes the transformation of the education model, and improves the quality and efficiency of teaching.

III. Civic resource system based on improved PBFT consensus algorithm

III. A. PBFT algorithm flow

PBFT algorithm is the basis of the consensus algorithm of the coalition chain, and adopts the partial synchrony system synchronization model, which realizes the solution of the Byzantine problem under the premise of limited nodes and ensures a certain performance. The digital education resources sharing blockchain based on the coalition chain needs higher throughput and lower latency, so this paper selects the improved PBFT consensus algorithm, and the PBFT algorithm process is mainly as follows:

(1) Consensus node role division: client, responsible for submitting requests to the master node. The master node, packages the request submitted by the client and generates the block to initiate this consensus. Replica nodes, mainly involved in the consensus of each block, in each consensus process, there must be multiple replica nodes to participate together.

(2) View Replacement: A node is selected as the master node to participate in the consensus through rotation or randomized algorithm, and the node continues to act as the master node when the consensus is reached successfully. As long as the master node is not switched, it is called a view, and the view replacement protocol has three main stages (View-Change), (View-Change-ack), and (New-View).The principle of PBFT view replacement protocol is shown in Figure 2.

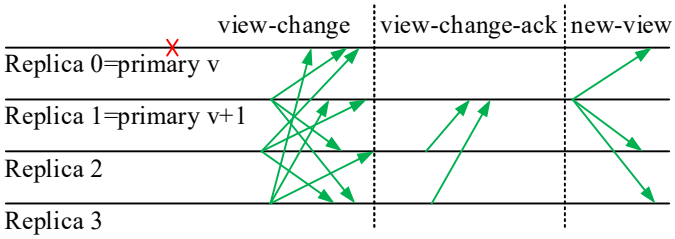


Figure 2: The principle of PBFT view Replacement Protocol

III. B. Secure storage of data

After the transaction request sent by the client is reached by consensus, the university administrator node can then use its own public key to encrypt and store the uploaded Civics digital education resources in the IPFS database.In this paper, we realize the secure storage and access of Civics digital education resources in the university through the use of proxy re-encryption technology, and the main processes are as follows.

(1) Initialization: input the security parameter n and set the parameter q, as in equation (1).

$$q = poly(n) \tag{1}$$

Choose two random matrices $A \in Z_q^{n\times n}$, $X \in Z_q^{nk\times n}$, where $k = \lceil \lg q \rceil$. A and X constitute the public parameter (PP).

(2) Generate public-private key pairs: choose the noise matrix R, $S \in \psi_s^{n\times l}$, $E \in \psi_s^{k\times l}$, where s satisfies $s = \delta q$, $0 < \delta < 1$, l denotes the length of the transaction message, ψ_s satisfies Gaussian distribution, P_1, and P_2 are calculated as Eqs. (2)-(3).

$$P_1 = R - AS \tag{2}$$

$$P_2 = -X + E \tag{3}$$

Get the public key $P = (P_1, P_2) \in \left(Z_q^{n\times l}, Z_q^{nk\times l}\right)$, private key S.

(3) Encryption algorithm: choose e_1, $e_2 \in \psi_s^{n\times l}$, $e_3 \in \psi_s^{l\times l}$ noise vectors and compute the ciphertexts c_1, c_2 as in Eqs. (4)-(5).

$$c_1 = e_1 A + e_2 \in Z_q^{l\times n} \tag{4}$$

$$c_2 = e_1 P_1 + e_3 + m\lfloor q/2 \rfloor \tag{5}$$

(4) m is the information for the user to make an access request: $m \in \{0,1\}^l$. Encrypt the information of the access request and output the ciphertext C as in equation (6).

$$C = (c_1, c_2) \in Z_q^{l\times(n+l)} \tag{6}$$

(5) Re-encryption key generation: choose $e_4 \in \psi_s^{nk\times nk}$, $e_5 \in \psi_s^{nk\times l}$ noise vectors, and ψ_s satisfies Gaussian distribution. The re-encryption key is computed as in Eqs. (7)-(8):

$$rk_{A\to B} = Q = \begin{bmatrix} e_4 X & e_4 P_2 + e_5 + Power2(S_A) \\ 0 & I_{l\times l} \end{bmatrix} \tag{7}$$

$$Power2(S_A) = \begin{bmatrix} S_1 & \cdots & \cdots & \cdots & Sl \\ 2S_1 & \cdots & \cdots & \cdots & 2Sl \\ \vdots & \cdots & \cdots & \cdots & \vdots \\ 2^{k-1}S_1 & \cdots & \cdots & \cdots & 2^{k-1}Sl \end{bmatrix} \in Z_k^{nk\times l} \tag{8}$$

(6) Re-encryption algorithm: the ciphertext C_A is converted to C_B by the re-encryption key $rk_{A\to B}$ as in equations (9)-(10).

$$C_B = (c_{1B}, c_{2B}) = [Bits(c_1) \mid c_2] \square rk_{A\to B} \in Z_q^{l\times(n+l)} \tag{9}$$

$$Bits(c_1) = \left[b_{1,1}\cdots b_{n,1} \middle| b_{1,2}\cdots b_{n,2} \middle| \cdots \middle| b_{1,k}\cdots b_{n,k} \right] \in \{0,1\}^{l\times nk} \tag{10}$$

(7) Data decryption: as in equation (11).

$$m = [c_1 \; c_2] \begin{bmatrix} S_B \\ I_{l\times l} \end{bmatrix} \tag{11}$$

where $m = (m_1, \cdots, m_l)$ and $m_i = 0$ when $m_i \le \lfloor q/4 \rfloor \bmod q$, otherwise $m_i = 1$.

IV. Evaluation and application analysis of the Civic Resources System (CRS)

IV. A. System performance testing

In this paper, we use JMeter to test the upload storage and download performance of the designed Civic Resource System.JMeter is a powerful open source performance testing tool that supports multiple protocols. JMeter is a powerful open-source performance testing tool that supports multiple protocols. By configuring the POST and GET methods and parameters of HTTP requests, the upload and download operations of data can be simulated. Different concurrent user numbers are set to simulate real user scenarios to ensure that the platform's performance meets the expected demand.

JMeter aggregation report is used to analyze the test results, and throughput is used as a key indicator. Taking the performance of the test system in processing 1MB files under different numbers of concurrent users as an example, Figure 3 shows the load performance test results of the Civic Government Resource System under different numbers of concurrent users.

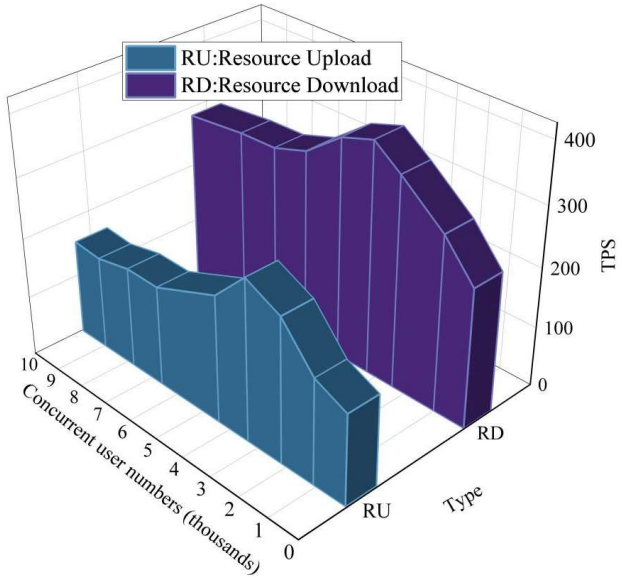
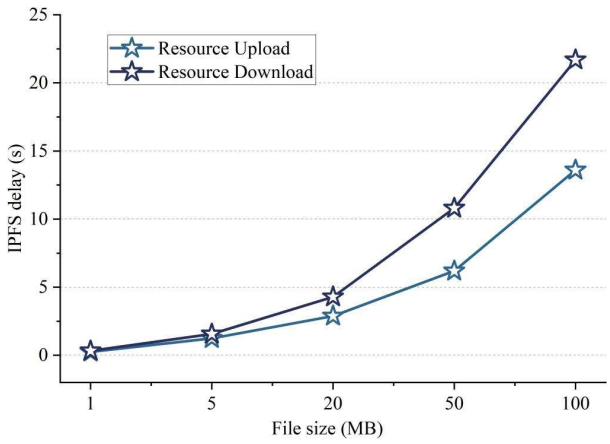


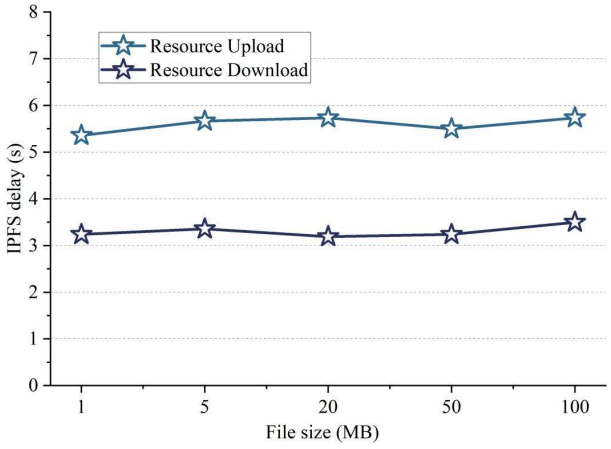
Figure 3: System load performance test

The test results in Fig. 3 show that with the increasing number of concurrent users, the TPS of resource upload and download show a trend of first increasing, then decreasing, and then gradually stabilizing. With 4000 concurrent users, the system shows good load capacity, and the TPS of resource upload and download reaches 268 and 382 items/s. At low load, the system can handle a higher number of requests, but with the increase of the number of users, the system may have a resource bottleneck, which leads to a decrease in TPS. The processing capability of the system can be further improved by increasing server resources or optimizing network configuration to enhance user experience.

This paper further evaluates the performance of resource files of different sizes (1MB, 5MB, 20MB, 50MB and 100MB) during uploading and downloading under the condition that the number of concurrent users is 4,000, in order to validate the applicability of the cloud computing technology combined with the Civic Resources System. The test focuses on analyzing the upload and download delays of files and the time of resource interaction confirmation in the campus network. Figure 4 demonstrates the impact of different file sizes on the performance of resource sharing.



(a) Comparison of FPS latency in different file sizes



(b) Comparison of resource interaction delays of different file sizes

Figure 4: System performance comparison of different file sizes

Fig. 4(a) shows the comparison of upload and download latency for files of different sizes in the campus network. The results show that the latency grows as the file size increases, and the download latency is generally higher

than the upload latency. This is due to the fact that the Civic Resource System divides files into small pieces for distributed storage and transmission, so when downloading large files from the Civic Resource System, it is necessary to retrieve and reassemble the complete file from multiple nodes, which leads to an increase in the download latency. Although the latency varies with different operation categories and file sizes, the overall latency is kept at 25.00s and below, and the overall performance is good.

Figure 4(b) shows the resource interaction latency corresponding to different file sizes. It can be seen that the resource interaction latency for resource uploading and downloading is relatively stable. In the upload process, it is necessary to write the relevant information of the resources into the library, so the transaction latency is relatively high, between 5-6s. The download process mainly involves the interactive query operation with the existing resources, so it has a lower latency of only 3-4s.

IV. B. Tests for secure storage of data

IV. B. 1) Preparation of educational resources

In order to comprehensively and thoroughly evaluate the practical effects of the Civics Resource System proposed in this paper in the conservation of educational resources, a series of diversified Civics educational resources have been carefully prepared in this paper, and the educational materials used are (a) text materials, (b) picture materials, (c) video lessons, (d) audio materials, (e) courseware PPTs, (f) e-books, (g) interactive software installation packages, (h) case studies, and (i) exercise sets.

These resources cover a variety of data types and formats common to the process of Civic Education, aiming to comprehensively simulate the resource protection and sharing needs in real Civic Education scenarios. Table 1 is a detailed extended description of the list of Civic Education resources prepared for this experiment.

Table 1: List of educational resource preparations

Serial number	Resource type	File size
(a)	Text information	5.6GB
(b)	Picture material	30.5GB
(c)	Video course	70.3GB
(d)	Audio data	15.7GB
(e)	PPT	5.9GB
(f)	Electronic book	10.00GB
(g)	Interactive software installation package	8.21GB
(h)	Case analysis	8.69GB
(i)	Problem sets	3.47GB

IV. B. 2) Encryption speed

In this section, similar algorithmic systems:(M1) Chaotic mapping-based adaptive encryption method for privacy database and (M2) association rule-based encrypted transmission method for curriculum teaching resources are selected as comparison methods. The encryption speed experiments of the three methods on Civics digital resources are designed to evaluate the effectiveness of the proposed Civics resource system based on the improved PBFT consensus algorithm on data security storage. Table 2 demonstrates the encryption speed performance of the three methods on different types of Civics education resources.

Table 2: Comparison of encryption speeds among the three methods

Serial number	Textual method (MB/s)	(M1) (MB/s)	(M2) (MB/s)
(a)	169.6	140.9	117.5
(b)	315.1	268.4	221
(c)	811.8	715.7	564.1
(d)	418.5	369.8	313.6
(e)	220.7	199.2	167.9
(f)	197.4	180.6	150.2
(g)	468	414.9	340.5
(h)	268.6	2176.3	200.4
(i)	139.1	121	98.8

The encryption speed of this paper's method on different types of educational resources shows significant advantages. For (a) textual materials, despite the relatively small amount of data, this paper's method still achieves a faster encryption speed of 169.6 MB/s, which far exceeds that of the comparison methods, reflecting the high

efficiency of the algorithm in processing small data. For visual teaching resources such as (b) picture materials and (e) courseware PPT, this paper's method also realizes a significant increase in encryption speed while ensuring encryption quality, which is of great significance for improving the efficiency and security of Civic and Political Education resources in network transmission. It is worth noting that the encryption speed of this paper's method even realizes a leap increase when dealing with data-intensive resources such as (c) video courses and (d) audio materials. The encryption speed of (c) video course reaches up to 811.8MB/s, and (d) audio material also reaches 418.5MB/s, which is far beyond the comparison methods. The method in this paper not only greatly optimizes the user experience so that users can access the encrypted Civic and Political Education resources faster, but also provides strong technical support for the wide dissemination and efficient use of Civic and Political Education resources.

IV. C. Analysis of application effects

In this section, two classes with the same overall Civics performance performance in the sophomore year of a university are selected as experimental subjects, with 15 students in each of the two classes. One of the classes, assisted by the Civic and Political Resource System designed in this paper, starts the Civic and Political course learning, and is the experimental class (E). The other class adopts the ordinary learning method to carry out the Civic and Political course learning, and is the control class (C). The comparison of the performance of the control class before the experiment (C1), the performance of the control class after the experiment (C2) and the performance of the experimental class after the experiment (E2) is shown in Fig. 5. It is calculated that there is no significant difference between the performance of the control class before the experiment of (C1) and the performance of the control class after the experiment of (C2) at P=0.67>0.05. And after the experiment, the mean value of the performance of (E2) experimental class (23.40) was significantly higher than the mean value of the performance of (C2) control class (21.41).

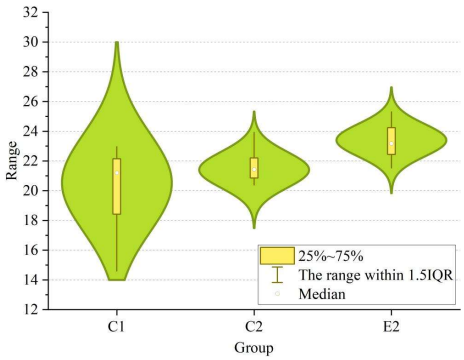


Figure 5: Comparison of grades before and after the experiment

In order to further explore the impact of the designed Civic Policy Resource System on the level of college students' Civic Policy, a comparison of the performance scores of the two classes in the core values dimension after the experiment was launched is shown in Fig. 6. It was calculated that there was no significant difference between the core values scores of the experimental class of (E2) and the scores of the control class of (C2) after the experiment with P=0.051>0.05. The mean value of the core values scores of the (E2) experimental class (23.13) was slightly higher than the scores of the (C2) control class (22.13).

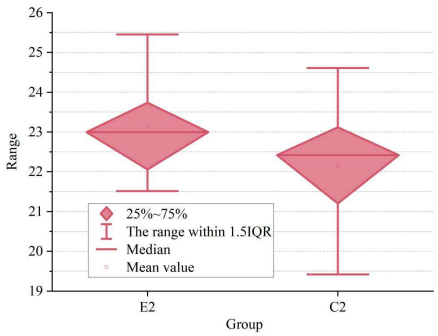


Figure 6: The manifestation of the core values dimension after the experiment

Comprehensive analysis of the above content shows that the Civics resource system based on the improved PBFT consensus algorithm has a more significant improvement effect in the actual Civics classroom teaching, but the performance is less prominent when it comes to the more in-depth and complex aspects such as core values. The cultivation of core values is a long-term and continuous process, and although the teaching has a certain positive impact on students, it cannot completely change their original sense of core values. Therefore, the teaching of Civics in the curriculum is very necessary and needs to be insisted on for a long time.

V. Conclusion

In this paper, a set of Civic Resource System based on improved PBFT consensus algorithm is proposed. The system shows excellent performance in terms of encryption speed, security, adaptability and stability, in which the TPS of uploading and downloading of civic and political resources can still reach 268 items/s and 382 items/s, respectively, in the scenario of 4,000 concurrent users, and the resource download delay under different transmission pressures only reaches up to 4 s and resource upload delay reaches up to 6 s. At the same time, the encryption speed of educational resources for different categories can reach up to 811.8 MB/s. In the application experiments, the designed civic and political resource system can effectively assist the level of university students in civic and political affairs. The encryption speed of educational resources reaches up to 811.8MB/s. In the application experiment, the designed Civics Resource System can effectively assist college students in improving their Civics level, and the average value of students' grades under its assistance is 23.40, which is significantly higher than the average value of students' grades using general teaching methods (21.41).

With the support of cloud computing technology, the research in this paper provides an effective reference program for the personalized and precise improvement and optimization of the school's Civic and Political Education.

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